Breast Magnetic Resonance Imaging for the Interventionalist: Magnetic Resonance Imaging–Guided Vacuum-Assisted Breast Biopsy

Sandra B. Brennan, MD

Magnetic resonance imaging–guided breast biopsy is an essential component of breast imaging practices offering breast magnetic resonance imaging. Careful planning and preparation allow for an efficient and successful biopsy. Deliberate positioning and controlled compression are keys to a comfortable and cooperative patient. The biopsy is only complete once imaging-histologic correlation has been made by the radiologist.

Tech Vasc Interventional Rad 17:40-48 © 2014 Elsevier Inc. All rights reserved.

Introduction

The superior sensitivity of breast magnetic resonance imaging (MRI), reported to be as high as 94%-100%, means that it can detect cancers occult on other imaging. The use of breast MRI is therefore dependent on the availability of methods to perform biopsy of lesions seen only on MRI. Moreover, because of its lower specificity, ranging from 37%-97%, it also detects additional lesions that may be benign but require biopsy for definitive diagnosis.

To become an accredited center for breast MRI by the American College of Radiology, centers performing breast MRI “must have the equipment to perform…MR imaging–guided intervention, or create a referral arrangement with a cooperating facility.”1 This accreditation requirement has reinforced the role of breast MRI-guided biopsy in centers performing breast MRI.

Indications

MRI-guided breast biopsy is performed if a suspicious lesion is found on breast MRI that has no mammographic or sonographic correlate and for which tissue sampling is required. If a lesion is found on MRI, the patient’s recent mammogram is reviewed to ensure that there are no correlative calcifications or masses that could potentially be targeted for biopsy using stereotactic guidance. For example, in cases with segmental or ductal enhancement, there may be targetable calcifications on the mammogram.

When a suspicious or indeterminate mass is seen on MRI, a targeted ultrasound can be performed regardless of whether a screening-type ultrasound was performed previously. Careful correlation must be made between the MRI and ultrasound finding. It is important to understand the differences in breast positioning (the patient is prone for a breast MRI study and supine oblique for the ultrasound examination) and the effect that will have on lesion location. With the patient prone, the breasts are pendant and uncompressed, so lesions may appear to be located more anteriorly than seen on ultrasound. Before targeted ultrasound is performed, the breast MR images are reviewed to localize the lesion based on the sagittal and axial planes provided by MRI to predict the location. The location of the lesion in terms of clock position, depth, distance from the nipple, surrounding breast tissue, and landmarks are noted.

The lesion characteristics such as size and shape will also help with correlation. There have been many published studies on targeted ultrasound, and the chances of finding a sonographic correlate have been reported to be between 23% and 89%.2-5 The probability of finding an ultrasound correlate is higher for masses rather than nonmasslike enhancement, for larger lesions, and for BIRADS 5 lesions. The probability of malignancy is generally higher for MRI-detected lesions that have a sonographic correlate than for those without.2-4 If the ultrasound finding turns out to be benign, careful correlation must be made with MRI.

Clip placement in the ultrasound lesion undergoing biopsy is essential to facilitate correlation and for

Breast Imaging Section, Department of Radiology, Memorial Sloan-Kettering Cancer Center, New York, NY.
Address reprint requests to Sandra B. Brennan, MD, Breast Imaging Section, Department of Radiology, Memorial Sloan-Kettering Cancer Center, 300 E 66th St, New York, NY 10065. E-mail: brennans@mskcc.org
follow-up. The position of the clip on the postbiopsy mammogram may also help to alert you to a potentially discordant result. Beware of the adjacent breast lesions that may lead to erroneous correlation or clip displacement. Suspicious lesions seen on breast MRI may be wrongly correlated with benign lesions seen on ultrasound. If in doubt about the ultrasound finding, do an MRI-guided biopsy. If the patient has a complex breast with lots of cysts or fibroadenomas, it is often challenging to correlate with the ultrasound, and MRI biopsy is favored.

**Contraindications**

Absolute contraindications would be those related to MRI in general and gadolinium injection, in which case, the patient would likely not be undergoing MRI.

Relative contraindications or rather technical challenges are similar to stereotactic breast biopsy, for example, too thin a breast, too superficial a lesion, or a lesion too close to an implant, pectoralis muscle, or nipple. If the lesion fails to enhance, then biopsy would also be aborted. At our institution, we reported an 8% nonvisualization rate. Hefer et al reported a 13% nonvisualization rate. Provided that there has been no contrast administration mishap and the lesion fails to enhance on delayed sequences, the biopsy can be canceled and short-term follow-up is recommended because the absence of enhancement does not exclude the presence of cancer. Hefer et al found that 4 lesions reappeared on short-term follow-up and 2 of these were cancers.

**Equipment**

**Breast MRI Technique for Biopsy**

At our institution, breast MRI examinations are performed on a 1.5- or 3-T commercially available system (Signa, General Electric Medical Systems, Milwaukee, WI), with the patient prone and the breast positioned within a dedicated surface breast coil and compressed within a grid (Fig. 1). Careful positioning of the patient to ensure the breast is deeply seated within the coil is crucial when performing a biopsy of posterior lesions. Proper positioning of the breast is the key to a successful biopsy and one that is well tolerated by the patient. This is best done by mammography technologists or specially trained MRI technologists. A fiducial marker is placed on the breast (Fig. 2).

Our imaging protocol for the purpose of biopsy includes a localizing sequence followed by a sagittal T1-weighted 3-dimensional fat-suppressed fast spoiled gradient-echo sequence performed before and after a rapid bolus injection of 0.1 mmol/L of gadopentetate dimeglumine (Magnevist, Berlex, Wayne, NJ) per kilogram of body weight, delivered through an indwelling intravenous catheter followed by a saline bolus. The pregadolinium sequence is obtained to ensure the expected location of the lesion is within the boundaries of the grid, that there is optimal fat saturation, and to facilitate subtraction images. The number of postcontrast sequences obtained depends on how rapidly the lesion enhances. For the most part, the lesion is usually identifiable on the first or second postcontrast sequence. If the original diagnostic MRI was acquired in the axial plane or if the lesion was most conspicuous in this plane, then axial postcontrast sequences may also be helpful.

**MRI Breast Biopsy System**

There are many commercially available MRI-compatible biopsy systems on the market (Fig. 3). The basic components of the systems are similar. Most are coaxial systems consisting of an outer plastic introducer sheath that has numeric gradations and a plastic mobile “depth stop” and 2 inner components that are used in sequence. These include a nonferrous metallic, cutting introducer stylet and a plastic obturator. Some obturators have gadolinium at the tip that facilitates accurate tip localization. A plastic square tunneled needle guide helps in precise targeting and forces the biopsy system to remain parallel to the chest wall. The guide fits within one of the squares of the grid depending on the lesion location and the coaxial system, and then fits within

---

**Figure 1** The patient lies prone on the MRI table for an MRI-guided breast biopsy (A). The breast is optimally positioned within a breast coil and compressed by a grid (arrow) (B). A fiducial marker (arrow) is placed on the breast within the grid (C). (Color version of figure is available online.)
one of the tunnels of the needle guide again depending on
the location of the targeted lesion. Biopsies are performed
with one of many commercially available 9-gauge vacuum-
assisted MRI-compatible devices.

MRI-Guided Vacuum-Assisted Breast
Biopsy Technique

Informed consent is obtained before the patient is posi-
tioned. In addition to the standard risks and benefits of
doing a biopsy, particular mention should be made of the
possibility of nonvisualization of the lesion or technical
limitations that may necessitate cancellation of the biopsy.
The importance of immobilization should be emphasized
with the patient.

Determining the lesion location and the desired depth of
the probe is calculated either manually or with the use of a
computer localization software system. The grid is com-
posed of rows and columns of evenly sized and spaced
squares (Fig. 1). Localization software specifies the partic-
ular square to access within the grid and particular hole
within the needle guide (Fig. 3) and the desired depth. The
lesion can be localized manually by comparing the lesion
location with the fiducial marker and the depth calculated
by multiplying the number of slices from the skin to the
lesion by the slice thickness.

The skin beneath the target square is then cleaned, local
anesthetic given, and a vertical skin nick is made with a
scalpel underneath the chosen needle-guide hole (Fig. 4).
The 3-component unit is then inserted securely into the
chosen grid square making sure that the stylet has cleared
the skin incision site. The inner stylet is removed once the
chosen depth has been reached. The plastic obturator is
then placed within the sheath, and an image sequence is
obtained to ensure accurate positioning. This can be done
by comparing the preplacement images to the postplace-
ment images and comparing slice numbers and landmarks
of the targeted lesion. Beware that lesions may be displaced
by blood, local anesthetic, or the “snowplow” effect. This
last set of images is also reviewed to determine the position
of the obturator with respect to the lesion in terms of the
clock position. Directional sampling can then be per-
formed as the biopsy device can be rotated to preferentially
sample in a given clock position. Always remember that

Figure 2  A fiducial marker (arrow) is placed on the breast and acts as a reference point when localizing the target
lesion. Sagittal fat-suppressed images of the breast, with the fiducial marker (long arrow) and grid lines (short
arrow) visible (A and B). If placing a grid on both sides of the breast, it is helpful to place 2 fiducials (arrows) on
opposing grids as seen on the medial side in this sagittal image (C). When doing a bilateral biopsy, a fiducial
marker (arrow) is placed on the lateral aspect of each breast (D). Note how the implant is displaced on this
localizing sequence (E). (Color version of figure is available online.)
the clock position is relative to the patient lying prone, so
the 12-o’clock position represents the patient’s chest wall
but the images are usually acquired sagittal with the
patient’s head representing the 12-o’clock position. Once
you are ready to sample, the obturator is removed and the
biopsy device inserted fully into the introducer sheath
(Fig. 5). The control module of the biopsy device must stay
outside the MRI room with only the foot pedal brought
inside (Fig. 6). On average, 6-12 cores are obtained
depending on the lesion, needle type, and discretion of
the performing radiologist.

Once the samples are obtained, the biopsy cavity is
suctioned and lavaged. By removing blood from the biopsy
cavity, it is easier to determine adequate lesion sampling
on the next set of images. After tissue acquisition, the
biopsy device is removed and the obturator reinserted into
the introducer sheath. The samples are removed from
the tissue collection chamber and placed in formalin
(Fig. 7). A postsampling sequence of images is obtained.
These images are carefully reviewed to determine if the
lesion was accurately targeted and adequately sampled
again by meticulously comparing them with the first
postcontrast sequence (Fig. 8). If the biopsy site changes,
the needle should be repositioned and additional samples
taken.

Once an adequate number of samples have been
retrieved, a titanium clip is placed through the introducer
sheath (Fig. 9). The clip introducer is turned 180° and
then removed along with the introducer sheath. A post-
clip placement set of images may be obtained but is not
entirely necessary. This is at the discretion of the perform-
ing radiologist.

Figure 3 The biopsy system is a single-use disposable coaxial system (ATEC Introducer Localization Set; Suros
Division of Hologic, Indianapolis, IN) (A). It consists of an outer plastic introducer sheath (1), an inner cutting
stylet (2), an inner plastic obturator (3) and a needle guide (4) (B). The coaxial system is placed within a tunneled
needle guide (C and D). A depth stop (arrow) on the introducer sheath helps in determining the depth of the
system (E). The coaxial system and needle guide are then placed within the target square of the grid (F). (Color
version of figure is available online.)
The compression grid is released, and the patient is removed from the breast coil and MRI table. Pressure and ice are held over the biopsy site. Steri-Strips are applied to the incision site, and the patient is transferred to mammography for a postbiopsy mammogram to document clip placement. The patient is given standard postbiopsy instructions and allowed to leave once hemostasis has been achieved.

**Overcoming Technical Challenges**

The physician should review the diagnostic study in advance of the biopsy, and the approach to the target should be determined (ie, medial or lateral). The shortest distance may not always be feasible particularly with very posterior lesions in the medial breast. The sternal bar is lower than the lateral bar, so posteromedial access is limited. In such cases, it is wise to place a grid on both the lateral and medial breast, and the approach can then be decided once the target is localized relative to the grid.

If the breast is thin or the target is superficial, a blunt-ended "Petite" needle may be chosen instead, which also has a shorter biopsy trough (12 mm for the "Petite" vs 20 mm for the "Regular") (Fig. 10). If a medial lesion is accessed from the lateral approach, the Petite needle may also be preferred to avoid piercing the breast on the medial side. If a lesion is very posterior and even beyond the limit of the grid, it is possible to sample the lesion by placing the needle anterior to the lesion and preferentially sampling posteriorly using suction to draw the lesion into the trough. Injecting a generous amount of local anesthesia to create a wheal would also help when the target is superficial. Injecting sufficient anesthesia and using a forward twisting motion when placing the Stylet would help prevent the snowplow effect. Sometimes it is unavoidable, but it is important to recognize that it has occurred to ensure proper targeting. Ensure that all air bubbles have been removed from the local anesthetic.

![Figure 4](image-url) The skin under the target square of the grid is cleaned (A), local anesthetic is infiltrated, and a skin nick is made with a scalpel (B). It is important to ensure the stylet passes through the incision before securing the needle guide in the grid square. (Color version of figure is available online.)

![Figure 5](image-url) Once the lesion has been successfully targeted, the inner plastic obturator is removed and the vacuum biopsy device (Suros Division of Hologic, Indianapolis, IN) placed through the introducer sheath. (Color version of figure is available online.)
syringes to minimize artifact that may make it difficult to accurately determine the position of the obturator tip. Gadolinium-tipped obturators help in this respect.

Speed is essential not only because the contrast washes out but because of patient comfort. The longer the procedure, the more difficult it will be for the patient to remain still.

Complications

There is always a theoretical risk of contrast reaction, albeit rare with gadolinium. Most biopsies are well tolerated. Bleeding and hematoma formation are a risk when doing any 9-gauge biopsy. Usually, bleeding is minimal and easily controlled with pressure and ice. Lidocaine with epinephrine can help in minimizing bleeding during the procedure. After tissue acquisition, we lavage and suction the biopsy cavity to remove any hematoma that may have formed. Applying pressure and ice after the biopsy is usually sufficient to stop bleeding. The patient is advised to wear a tight bra such as a sports bra and to keep it on in bed the night of the biopsy. We also advise against strenuous activity for a few days after the biopsy. The risk of infection is low, and patients are advised against swimming until the incision site has closed.

Follow-Up

Once the pathology from the biopsy is available, the radiologist determines if there is imaging-histologic correlation. That is “do the biopsy results sufficiently explain the imaging findings?” If the result is malignant or is a so-called high-risk lesion, then surgical excision is recommended. If the result is benign, a 6-month follow-up MRI is recommended. Lee et al found that 7% of MRI-guided biopsies were discordant and 30% of those were cancers. Underestimation rates and upgrade rates are higher with MRI biopsy as this patient population is inherently at high risk. Liberman et al reported a 38% underestimation rate in cases of atypical ductal hyperplasia found on MRI-guided biopsy. Lee et al found that following MRI-guided biopsy, Ductal Carcinoma in Situ (DCIS) was upgraded to an invasive cancer in 17% of the cases.
Figure 7 As the samples are taken, they are collected in a chamber from which they are later removed and placed in formalin (A-C). It is important to check the biopsy device to ensure no samples remain inside (D). (Color version of figure is available online.)

Figure 8 Sagittal fat-suppressed T1-weighted postcontrast images from an MRI biopsy with the target lesion (arrow) visualized (A) before sampling, and air artifact and blood seen in the biopsy cavity after sampling (B). (Color version of figure is available online.)
Summary

MRI-guided vacuum-assisted breast biopsy is fast, safe, and accurate. Although it does pose some challenges such as the vanishing target owing to contrast washout, limited access to posteromedial lesions and the snowplow effect most can be overcome. Meticulous preparation, careful positioning, and directional sampling are the key to a successful biopsy. A dedicated experienced team allows for seamless progression of the biopsy.

Figure 9  A biopsy clip is placed to mark the biopsy site (A). This is placed through the introducer sheath (B). (Color version of figure is available online.)

Figure 10  The tip of the 9-gauge "Regular" biopsy needle is pointed and sharp. The needle is 14-cm long with a 2-cm sampling trough (A). The "Petite" is also a 14-cm long 9-gauge needle, but the tip is blunted (B). The sampling trough is also shorter measuring only 1.2 cm. (Color version of figure is available online.)
References


