Recognizing and Interpreting Artifacts and Pitfalls in MR Imaging of the Breast

Haydee Ojeda-Fournier, MD • K. Ann Choe, MD • Mary C. Mahoney, MD

Magnetic resonance (MR) imaging of the breast has evolved into an important adjunctive tool in breast imaging with multiple and ever-increasing indications for its use. As with other types of MR imaging, there are a number of technical artifacts and pitfalls that can potentially limit interpretation of the images by masking or simulating disease. Because of the coils and computer-aided detection software specific to breast MR imaging, there are additional technical considerations that are unique to this type of MR imaging. Motion and misregistration artifacts, wraparound artifact, susceptibility artifact, poor fat saturation, lack of contrast material, and poor timing of the contrast material bolus are some of the artifacts and pitfalls that can make interpretation of breast MR images challenging and lead to misdiagnosis. Other important considerations in proper interpretation of breast MR images include acquisition of a sufficient medical history, knowledge of benign and abnormal lesion enhancement, morphologic versus kinetic assessment, evaluation of areas outside the breast, and positioning. By using the recommended strategies, one can reduce or eliminate common artifacts and pitfalls in breast MR imaging that prevent proper interpretation of the results of this important diagnostic tool.
Introduction
Breast cancer is the most common nonskin malignancy and the second most common cause of cancer death in American women. Mammography has long been established as the only screening study that can reduce breast cancer mortality. Despite this, mammography has significant limitations. Thus, it is imperative that other imaging modalities be studied and developed to complement mammography.

Breast magnetic resonance (MR) imaging has emerged as an important adjunctive tool with multiple and ever-increasing indications. As with all imaging modalities, a thorough understanding of the underlying technology, basic physics, and potential limitations associated with breast MR imaging is imperative to maximizing its utility. Previous publications on general MR imaging physics have described clinically significant artifacts associated with this imaging modality (1–3). Subsequently, several authors have described artifacts and pitfalls encountered in specific anatomic areas such as the abdomen, orbit, and spine (4–6). Despite this, little published literature is available reviewing the artifacts and pitfalls specific to breast MR imaging. In fact, a recent PubMed search yielded only a single reference to a pictorial review of pitfalls in breast MR imaging (7).

The objective of this article is to present a pictorial review of the common artifacts and pitfalls in MR imaging of the breast and recommend strategies that will reduce or eliminate those issues that endanger proper interpretation of the results of this important diagnostic tool. In addition, we review the indications for and general techniques of breast MR imaging, as they are important to the process of recognizing common artifacts, pitfalls, and limitations of MR imaging of the breast.

Indications for Breast MR Imaging
Initially, breast MR imaging was indicated for the evaluation of implant rupture in patients with breast augmentation. At present, MR imaging remains the study of choice for evaluation of implant rupture. Since the introduction of gadolinium and the development of high-resolution MR imaging, multiple studies have shown MR imaging to be of value in evaluating the breast parenchyma for breast cancer. The American College of Radiology has developed a list of current indications for breast MR imaging (8).

In addition to implant evaluation, these current indications include the following: evaluation of newly diagnosed lobular or infiltrating ductal breast cancer to assess extent of disease and to evaluate for possible contralateral disease; problem solving for better lesion characterization; as an adjunct to screening in patients at high risk, including those with a personal history of breast cancer, a previous biopsy with proved high-risk results at pathologic analysis, high-risk genetic markers, or a strong family history; evaluation of residual disease after lumpectomy with positive margins; evaluation of chest wall invasion; evaluation of the breast parenchyma in metastatic disease to the axilla from an unknown primary; assessment of response to neoadjuvant chemotherapy; evaluation of breast cancer recurrence; and evaluation for recurrence in patients who have undergone tissue transfer, such as transverse rectus abdominis myocutaneous (TRAM) or latissimus dorsi flaps.

Breast MR imaging does not replace mammography. MR imaging may be helpful in selected cases where there are unanswered questions after a complete clinical, mammographic, and sonographic evaluation.

Technique of Breast MR Imaging
Contraindications to MR imaging include the presence of indwelling cardiac pacemakers, cochlear implants, certain types of aneurysm clips, and a variety of metals that are susceptible to a high-strength magnetic field. Caution is recommended with the use of gadolinium in patients with moderate to end-stage renal disease. There have been over 90 reported cases of nephrogenic systemic fibrosis developing after the administration of gadolinium contrast material (9). This has led to the Food and Drug Administration and the American College of Radiology recommendations for precautionary measures to be observed in high-risk patients undergoing infusion of gadolinium contrast material.

A variety of imaging protocols can be used to evaluate the breast. The following sequences are performed at our institution in the standard breast protocol: axial T1-weighted gradient echo, axial T2-weighted fat-saturated fast spin echo (SE), and sagittal pre- and postcontrast T1-weighted spoiled gradient echo after administration of a 0.1 mmol/kg dose of gadopentetate dimeglumine. We use both fat suppression and subtraction in the evaluation of dynamic postcontrast images. Although there is no standard recommendation, we advocate bilateral breast imaging for several reasons, including the usefulness of assessing symmetry and evaluation of the contralateral breast in patients with newly diagnosed breast carcinoma (10,11).
Imaging protocols may vary depending on the equipment being used and the radiologist’s preferences. At a minimum, a field strength of 1.5 T, a dedicated breast coil, high resolution and thin section thickness, and gadolinium enhancement are required for MR imaging of the breast. Computer-aided detection systems, which simplify creation of subtraction and maximum intensity projection (MIP) images, kinetic assessment, and three-dimensional reformatting, assist in the interpretation of breast MR images. A recent article by Rausch and Hendrick (12) reviews techniques to optimize breast MR imaging. Finally, the availability of MR imaging biopsy technology is necessary in the development of a breast MR imaging program.

Artifacts

Motion Artifact

A significant artifact in MR imaging is motion (Fig 1). Even with an optimal prescribed protocol, any amount of motion can degrade image quality or even render a study completely nondiagnostic. The resultant reduced signal intensity of a moving structure as well as blurring can obscure lesions. Both physiologic and nonphysiologic movement can cause artifact in the phase-encoding direction. Since there is movement of a structure between the sampling of different lines of k-space (phase encoding), some of the signal from the tissue is displaced in the phase-encoding direction.

Physiologic motion can be caused by fluid, including pleural fluid, bowel fluid, or blood in vessels (Fig 2). Periodic motion from vessel pulsation is specifically referred to as ghosting. The classic appearance is that of duplicated high signal intensity of a normal structure in the phase-encoding direction. Other physiologic motions are attributed to respiration and gastrointestinal peristalsis and can also mimic or obscure lesions. Physiologic motion can be difficult to correct. With a standard sequence, a saturation band can be used to decrease or eliminate ghosting when placed over the moving structure.

Nonphysiologic motion due to patient motion also results in unsatisfactory images. Claustrophobia and patient anxiety contribute to this artifact. Patient motion can be reduced by optimizing patient comfort. This includes providing sedatives, using physical restraints (straps), optimizing examination time, and providing earplugs and blankets or a fan. An explanation of the study and frequent communication with the patient throughout the study also help reduce patient motion.
Figure 2. Artifacts due to physiologic motion. (a, b) Axial (4716/98) (a) and sagittal (4250/98) (b) T2-weighted fat-saturated fast SE images show pulsation artifacts caused by a blood vessel (arrow). This ghosting artifact causes degradation of portions of the images. (c) Axial T2-weighted fat-saturated fast SE image (3150/98) shows an artifact in the phase-encoding direction caused by a small amount of pleural fluid (arrow). This artifact partly obscures visualization of the axilla. (d) Axial T2-weighted fat-saturated fast SE image (5500/98) shows an artifact caused by peristalsis and fluid in the stomach (arrow). This artifact is also seen in the phase-encoding direction and partially obscures portions of the image.

Figure 3. Misregistration artifact. Sagittal post-contrast T1-weighted MIP image (8.9/1.89) shows repeating breast structures, an example of misregistration. This type of motion artifact occurs when there has been motion between pulse sequences, images from which are later subtracted.
Misregistration Artifact

A type of artifact specific to subtraction imaging used in interpretation of breast MR images is misregistration (Fig 3). This type of motion artifact is encountered in subtraction images when there is movement between the images to be subtracted (ie, postcontrast T1-weighted image − precontrast T1-weighted image = subtraction image). The term edge artifact is used to describe the color mapping artifact caused by subtle misregistration that occurs in computer-aided detection (Fig 4). This artifact is identified as a mass appearance in a single section of one plane. Reformatted multiplanar images demonstrate no mass. The edge of the fat-parenchyma interface is color mapped in a planar fashion.

Wraparound Artifact

Aliasing or wraparound artifact results in the appearance of portions of anatomic structures where they do not belong (Fig 5).

Aliasing occurs when there is excited tissue located outside the prescribed imaging field of view. Tissues that are outside the imaging field of view are also excited as part of the image acquisition process, resulting in positional misregistration. Simply stated, owing to the cyclic nature of frequency functions (ie, 10° is viewed as the same as 370°) in the Fourier transform process, the tissues outside the prescribed imaging area are misregistered as being located within the reconstructed image.

Although aliasing occurs in both the phase- and frequency-encoding directions, aliasing in the frequency-encoding direction is commonly suppressed by using a frequency filter or by oversampling (3,13). Therefore, aliasing (or wraparound) is of practical importance in the phase-encoding direction. In three-dimensional acquisitions, this is important in the section-selection direction, which is also phase encoded. Aliasing in the phase-encoding direction can be minimized by increasing the field of view, which compromises resolution (for a given matrix size), or by oversampling in the phase-encoding direction (at the cost of increased imaging time).
Susceptibility Artifact
Bright spots, signal dropout, and tissue distortion are the imaging characteristics of susceptibility artifact (Fig 6).

In the presence of the main magnetic field, tissues and other objects are magnetized to varying degrees. The subsequent effect on the image is most noticeable around metallic objects due to the larger induced field. The metallic object does not have mobile protons and therefore does not emit an MR signal. However, the induced fixed heterogeneities of the magnetic field cause additional artifact around the metallic object. In the presence of metal, there are larger changes in the local magnetic field, which cause rapid dephasing of spins with resultant signal loss in the region (3). In addition, since spatial position in the image is created by the intentional addition of magnetic field gradients, the unexpected alterations of the local field will change the expected precessional frequencies, thereby artificially displacing voxels in the image.

These artifacts appear more prominent on gradient-echo images due to the absence of the 180° refocusing pulse. In contrast, owing to the multiple 180° pulses in fast (turbo) SE imaging, the artifact is minimized when this sequence is used. Similar but less prominent effects are seen due to the varying magnetic susceptibility of different tissues, such as bone and soft tissue. The size of the susceptibility artifact is dependent on the size and composition of the metallic object (clip), with pure titanium producing the smallest artifact (14).

Artifacts Due to Body Habitus
Many different types of artifacts can be caused by a patient’s body habitus. Until recently, breast coils were manufactured in only one size. In obese patients, artifacts occurred from breast tissue outside the coil and from the breast touching the coil. Figure 7 demonstrates artifacts that occur when a very large breast is placed in a coil. There are weight limits for MR imaging tables, which vary by manufacturer. In addition, the width of the patient can be a limiting factor. The bore of the magnet may not accommodate patients with broad shoulders or hips. Placement of the patient’s arms down to her side or above her head can help fit some larger women into the magnet bore.
Inhomogeneous Fat Saturation

The breast is composed of variable amounts of fat. Fat is hyperintense on T1-weighted images, as is gadolinium. By suppressing the signal from fat, gadolinium enhancement is easier to detect. Several techniques are available for fat saturation, including frequency-selective (chemical) fat saturation. This requires a field strength greater than 1 T.

Frequency-selective fat suppression exploits the precessional frequency difference between the protons in fat molecules and those in water molecules, which is 220 Hz at 1.5 T. To effectively suppress the protons in the fat molecules, the correct range of frequencies must be selected. Since the frequency of precession is dependent on the magnetic field experienced by the proton, variations in the magnetic field will alter the actual precessional frequency from the expected. Therefore, in the presence of an unexpected variation in the magnetic field, there will be protons in fat that are precessing out of the range of frequencies included in the suppression pulse. These protons will not be suppressed, and the fat containing these protons will maintain its brighter signal. This results in inhomogeneous suppression of the fat signal within the breast.

Many factors can alter the magnetic field, including metallic objects. Human tissue, which is diamagnetic, also causes alterations in the magnetic field and can cause frequency-selective fat suppression to be problematic when variable tissue types are being imaged together. In breast imaging, this is particularly true due to the large amount of air in the thoracic cavity and to the air gap that can exist between the breasts.

Inhomogeneous fat saturation is easily identified as areas of hyperintense fat on fat-suppressed images (Fig 8). This process can involve portions of one breast or the entire imaged field of view. Enhancing lesions could be obscured by poor fat saturation and easily missed. Although some causes of inhomogeneous fat suppression cannot be corrected for, tuning the shim (optimizing field homogeneity) in the imaging unit can correct some of the artifact.

Pitfalls

Insufficient History

The availability of a thorough clinical history facilitates breast MR image interpretation. Pertinent information includes the indication for the study, prior surgical history, family history, and menstrual cycle and hormone use history. At our institution, this information is obtained from the referring health care provider at the time the breast MR imaging study is scheduled. At the time of imaging, the patient completes two questionnaires, an MR imaging safety form and a focused medical history form.

Errors in interpretation can occur if the appropriate clinical and surgical history is not taken into consideration. For example, Figure 9 demonstrates MR imaging changes after TRAM flap...
reconstruction with a focal area of fat necrosis. Without the history, the postsurgical findings would be perplexing and possibly misinterpreted. MR is an effective imaging modality in assessment of breast reconstruction with TRAM flaps and allows accurate differentiation of benign and malignant conditions (15). Benign findings in the reconstructed breast include skin thickening, fibrosis, fat necrosis (as shown in our example), and seroma. Chest wall and axillary recurrences can be identified with MR imaging even when clinically and mammographically occult. Knowledge of the patient’s last menstrual period in premenopausal women or hormone use in postmenopausal women is also highly relevant to proper image interpretation. Hormone-induced

Figure 9. Importance of the surgical history in a 66-year-old patient with a history of ductal carcinoma in situ, mastectomy, and TRAM flap reconstruction. Axial T1-weighted gradient-echo (400/4.19) (a) and sagittal postcontrast T1-weighted MIP (89/1.89) (b) images show asymmetry in size and shape between the right and left breasts. The area of architectural distortion and enhancement (arrow) was known to represent fat necrosis. If these images were to be interpreted without the surgical history, it could be easy to misinterpret the area of fat necrosis as a suspicious mass.

Figure 10. MR imaging performed at two different times in the menstrual cycle of a 42-year-old woman with recently diagnosed invasive ductal carcinoma. (a) Sagittal postcontrast T1-weighted MIP image (8.9/1.89) shows the invasive ductal carcinoma (arrow). Ductal extension toward the nipple was suspected; however, this finding is obscured by extensive proliferative changes. (b) Sagittal postcontrast T1-weighted MIP image (8.9/1.89) obtained 12 days later clearly shows linear extension toward the nipple (arrows). The optimal time for performing the examination is between days 3 and 21 of the menstrual cycle. A mass or more subtle finding could be obscured by the presence of innumerable proliferative foci of enhancement.
proliferative changes can mimic or obscure true lesions (Fig 10). Although some investigators have reported that the optimal time to perform breast MR imaging is between days 3 and 14 of the menstrual cycle (16), we have found that imaging up to day 21 yields accurate results.

**Lack of Contrast Enhancement**

Absence of contrast enhancement can be difficult to detect, particularly with inherent breast tissue contrast present. Figure 11a–11c provides an
example of complete lack of contrast enhancement. Even the best trained technologists occasionally overlook a missed contrast material bolus. It is up to the interpreting radiologist to assess each study for contrast enhancement quality. A completely negative study, including negative subtraction and MIP images, is a warning sign to further evaluate the study for adequate contrast enhancement. Lack of contrast enhancement in the heart, absence of normal nipple enhancement, and absence of enhanced vessels within the breast (easily appreciated on MIP images) are excellent markers for evaluating the contrast material bolus.

In addition, inadequate contrast material administration may result from poor intravenous access, failure of power injectors, and intravenous tubing malfunction, as well as the patient’s hemodynamic status. A poor contrast material bolus may be more difficult to perceive than complete lack of enhancement. Figure 11d and 11e depicts a case in which the initial MR imaging examination demonstrated poor contrast enhancement. At follow-up examination, performed with a better contrast material bolus, an area of ductal carcinoma in situ became apparent.

Complete lack of enhancement results in a nondiagnostic examination and needs to be repeated. In cases where the contrast material bolus is of questionable quality, either a repeat examination or a short-interval follow-up can be considered, taking into account the pretest probability of malignancy in each individual case.

**Nipple Enhancement**

The nipple enhances normally to varying intensities at breast MR imaging (Fig 12a) (17). This enhancement is due to the rich blood supply of the nipple-areolar complex. Abnormal nipple enhancement includes skin thickening and enhancement extending into the areola and periareolar breast tissue (Fig 12b). The differential diagnosis of abnormal nipple enhancement and thickening includes Paget disease, lymphatic obstruction, inflammatory breast carcinoma, infection, and inflammation. Clinical evaluation of the area and punch biopsy readily provide a diagnosis. MR

**Figure 12.** Nipple enhancement. (a) Sagittal MIP image shows normal nipple enhancement. The patient was a 19-year-old woman with nipple and periareolar skin thickening and inflammation at clinical examination. MR imaging was performed to rule out Paget disease and an underlying mass. The final diagnosis from skin punch biopsy was eczema. (b) MR image (8.9/1.89) shows a nipple that was pushed into the breast parenchyma (arrow) owing to the large size of the breast. This finding could be misinterpreted as a subareolar enhancing mass lesion.
imaging in these instances is indicated when there is suspicion of underlying occult malignancy.

An additional potential pitfall involving nipple enhancement is the possibility of misinterpreting a normal nipple for a mass when the nipple is flattened against the anterior surface of the coil owing to the large size of the breast (Fig 12c). Our practice has received requests to biopsy “lesions” that were nothing more than a normal nipple pushed into the breast parenchyma. In these cases, we find it helpful to view the MIP images and three-dimensional reformatted images to determine whether the enhancing lesion is indeed the nipple.

**Rim Enhancement**
Rim enhancement can be seen with malignancy, fat necrosis, or cysts, particularly complicated cysts (18). Use of T2-weighted sequences, non–fat-suppressed sequences, and second-look ultrasonography (US) can help in evaluation (Fig 13). Postoperative seromas can also show peripheral enhancement due to inflammation (Fig 14a–14c). A thin rim of enhancement is likely benign when correlation with pathology results indicates negative margins at resection. In contrast (Fig 14d, 14e), necrotic invasive cancers can have a thick irregular enhancing rim as well as bright T2 signal. However, in contrast to the T2 signal of cysts or seromas, the T2 signal of necrotic tumor is usually heterogeneous; manipulation of window level settings is necessary to demonstrate this finding, since high brightness can obscure the underlying heterogeneity.
Morphologic versus Kinetic Assessment
A combined model that uses both morphologic characteristics and kinetic assessment has been shown to improve diagnostic accuracy (19). The accepted algorithm in breast MR image interpretation is to assess the morphologic features of an MR imaging–detected abnormality to determine if a biopsy is warranted. If there is an indeterminate lesion, then kinetic assessment is applied to increase specificity. A postoperative scar should not enhance (Fig 15).

Lesions Outside the Breast
As with all other imaging modalities, a systematic evaluation of other organ systems included in the study is necessary. Other organs typically included in the field of view for breast MR imaging include portions of the lung, heart, liver, gallbladder, and stomach. Particular attention should be paid to the axilla and other lymph node drainage basins during interpretation of breast MR images. Findings in these areas may be clinically relevant.

Gastrointestinal Tract.—Common findings in the liver include hemangiomas and cysts (Fig 16). Cysts are encountered in 2.5% of the population and are more common in women (20). Cysts are characterized by low signal intensity on T1-weighted images and high signal intensity on T2-weighted images. Postcontrast images demonstrate a lack of enhancement. Hemangioma is
another hyperintense T2 lesion in the liver that is commonly encountered. This benign lesion demonstrates characteristic peripheral nodular enhancement on postcontrast images. Metastases to the liver are common in the setting of breast cancer and appear as heterogeneous lesions with enhancement.

The stomach and portions of the gastrointestinal tract are not well evaluated because of physiologic motion. In the gallbladder, cholelithiasis can be detected as filling defects within the fluid-filled gallbladder (Fig 17). This is well appreciated on T2-weighted images, paralleling the technique of MR cholangiopancreatography.

Thorax.—In the thorax, pleural fluid is a common finding. Pleural effusions can range from trace amounts of physiologic fluid (see Fig 2c) to pleural effusions of varying sizes. Lung masses may represent metastases (Fig 18).
Lymph Node Evaluation.—Abnormal lymph node findings (Fig 19) are of vital clinical significance. Knowledge of lymphatic drainage is a requisites for breast imaging. The majority of the lymph drainage is to the axilla, with a fraction draining into the internal mammary chain. The breast MR imaging search pattern must include a thorough evaluation of axillary, interpectoral (Rotter node) (Fig 20a), and internal mammary chain (Fig 20b) nodes (21). When coronal imaging is performed, the supraclavicular lymph node basins may also be visualized and need to be included in the search pattern.

As with other imaging modalities, MR imaging evaluation of lymph nodes is based on size and morphology. Micrometastases cannot be detected with MR imaging. Enhancement characteristics are not helpful since normal lymph nodes avidly enhance and abnormal lymph nodes may demonstrate lack of enhancement. Recognition of normal lymph nodes, particularly intramammary lymph nodes, is important so that they are not misinterpreted as masses (Fig 21). As with other imaging modalities, at MR imaging normal lymph nodes contain a fatty hilum, are adjacent to a vessel, and have a reniform shape. Internal mammary lymph nodes can be difficult to visualize. The average size of an internal mammary lymph node involved with metastasis is 6 mm, but it can be as small as 4 mm (22). For this reason, we considered any lymph node visualized in the internal mammary chain to be abnormal. Comparison with previous MR imaging studies, mammograms, and follow-up US can be helpful when a visualized breast mass is suspected to be a lymph node.
Breast MR imaging can be compromised by breast tissue located outside the coil. Breast tissue excluded from the coil may become folded and compressed, resulting in loss of symmetry. Maintenance of proper symmetry is ensured by proper positioning. We have found it helpful to train a group of female MR imaging technologists to position the breasts evenly within the coil, just as the mammographic technologists manipulate and position the breast within the compression paddles. It is not prudent to allow the patient to position herself in the coil. Finally, poor visualization of axillary tissue and the retroglandular tissue can result from inadequate positioning of the breast in the coil. Figure 22 shows an example of a poorly positioned breast within the coil. Blood flow can potentially be obstructed or delayed by pinching or compression caused by improperly positioned breast tissue.

Figure 20. Other lymph node basins to be evaluated with breast MR imaging. (a) Sagittal postcontrast T1-weighted image (550/8) shows an interpectoral (Rotter) lymph node (arrow). (b) Sagittal T1-weighted MIP image (6.2/3.0) shows an internal mammary lymph node (arrow). Note the internal mammary artery adjacent to the abnormal lymph node.

Figure 21. Normal intramammary lymph node. Axial T1-weighted (100/4.196) (a), close-up axial reformatted T2-weighted (6800/3.04) (b), and sagittal postcontrast T1-weighted spoiled gradient-echo (8.9/1.89) (c) images show an intramammary lymph node (arrow) that mimics a mass. The well-defined margins, high signal intensity on the T2-weighted image, fatty hilum, and proximity to a vessel are all characteristics of a benign lymph node.
Tumor Heterogeneity and Kinetic Assessment

Heterogeneous enhancement is identified by variable signal intensity within a mass. This is a sign of malignancy, likely reflecting a polymorphous cell population and tumor necrosis. When evaluating the enhancement of lesions and assessing kinetic characteristics, the worst-appearing curve should be considered in the final assessment (Fig 23). Choosing the most benign-appearing curve and ignoring the worst curve can lead to misdiagnosis.

Interpretation of Kinetic Curves

Kuhl and colleagues (23) have described three time–signal intensity curves that are important in differentiating benign from malignant lesions. The type I curve (Fig 23b) is a slow steady enhancement curve. The type II curve demonstrates plateau signal intensity (Fig 23c). The type III curve is associated with washout of signal intensity (Fig 23d) and is a strong indicator of malig-
The use of time–signal intensity curves has a sensitivity of 91% and specificity of 83% (23).

Artifactual curves are evident as multiple peaks and valleys, an appearance not consistent with contrast material perfusion through vessels (Fig 24). Kinetic time–signal intensity curves are graphic representations of physiologic processes and should follow expected vascular flow patterns.

**Figure 24.** Interpretation of a kinetic curve. Sagittal post-contrast T1-weighted image (8.9/1.89) (a) and computer-generated kinetic curve (b) show an area of artifactual enhancement (arrow in a). The curve is easily identified as abnormal because of its multiple peaks and valleys. The artifactual enhancement was likely produced by subtle misregistration. We caution against interpreting color overlay imaging findings in isolation from morphologic findings.

**Mammographic and US Findings**

Interpretation of breast MR images requires simultaneous evaluation with mammography and other available imaging studies. Evaluation of breast density and benign lesions is straightforward if the appropriate correlative studies are performed (Fig 25). At our institution, we...
recommend that a mammographic study performed within 6 months be available at the time of MR image interpretation. In addition, targeted second-look US is recommended in cases where nonspecific lesions are encountered. The use of US allows more definitive interpretation and can guide biopsy if indicated. It cannot be overemphasized that breast MR imaging does not replace mammography and that mammographically suspicious findings are to be primarily addressed regardless of MR imaging findings.

Conclusions
Breast MR imaging has evolved into an accepted and widely used adjunctive tool in evaluation of the breast. Numerous indications have emerged for breast MR imaging, and its use continues to grow. However, mammography remains the primary imaging modality for evaluation of the breast. Recognizing the potential artifacts and pitfalls associated with breast MR imaging is necessary for appropriate and accurate interpretation of the results of this important imaging tool.

References
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