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Breast Magnetic Resonance Imaging-Guided Biopsy
유방 자기공명유도 조직검사

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Despite the high sensitivity of breast magnetic resonance imaging (MRI), pathologic confirmation by biopsy is essential because of limited specificity. MRI-guided biopsy is required in patients with lesions only seen on MRI. We review preprocedural considerations and the technique of MRI-guided biopsy, challenging situations and troubleshooting, and correlation of radiologic and pathologic findings.

Index terms
Breast Cancer
Biopsy, Needle
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INTRODUCTION

The use of breast magnetic resonance imaging (MRI) is increasing for screening and diagnosis of breast cancer. MRI has greater sensitivity than other imaging modalities for the screening of women at higher risk of breast cancer, with more than half of lesions only detected on MRI (1, 2). MRI can identify primary cancer in suspected occult breast cancer patients (3). In addition, breast MRI most accurately depicts the extent of breast cancer (4-6). Although the clinical relevance of additional lesions is still controversial, preoperative MRI identifies more synchronous, ipsilateral or contralateral breast cancers than mammography and ultrasound (7-9).

However, breast MRI has limited specificity (10). If a suspicious lesion is detected, biopsy is mandatory to avoid unnecessary surgery. In addition, biopsy under MRI guidance is required for suspected occult lesions on mammography or ultrasound. The American College of Radiology requires performance of MRI-guided intervention or contact with available referral site when performing breast MRI (11). The MRI guideline of the European Society of Breast Imaging also emphasizes the necessity of offering MRI-guided intervention at a site performing breast MRI (12). The number of medical centers providing breast MRI is growing in Korea, and more MRI-guided breast biopsies are required. However, few reports describe MRI-guided breast biopsy in Korea (13, 14). In this article, we describe preprocedural considerations and technique, and correlation of radiologic and pathologic findings in MRI-guided breast biopsy.

PREPROCEDURAL CONSIDERATIONS FOR MRI-GUIDED BREAST BIOPSY

Second-Look Studies

Second-look studies should be considered for all women with suspicious lesions on MRI. If the lesion is delineated with mammography or ultrasound, biopsy under imaging guidance using

these modalities is preferred. MRI-guided biopsy is more expensive and difficult for the patient. However, the reported correlation rate of second-look ultrasound ranges from 23–57%; MRI-only lesions require an MRI-guided biopsy (15-18).

Patient Preparation

Informed consent should be obtained before the biopsy. Patients with a known contraindication for MRI or gadolinium administration should not have an MRI-guided biopsy. Patients with allergy to gadolinium or local anesthetics are also not suitable. Bleeding risk due to use of aspirin or anticoagulants or an underlying coagulation disorder is a relative contraindication for biopsy, requiring careful consideration of the risks and benefits. The patient should be able to remain prone during the biopsy for a minimum of 60 minutes. The possibility of a nonvisualized target lesion should be discussed with the patient. Even with successful visualization, the cancellation of a biopsy is sometimes necessary because of unforeseen safety issues. Complications such as hematoma, infection, and skin injury should also be discussed with the patient. For patients with breast implants, rupture is a possible complication of the biopsy.

MRI-GUIDED BREAST BIOPSY PROCEDURE

Table 1 summarizes the biopsy procedure.

Positioning

The patient lies in a prone position, and a dedicated interventional breast coil is used. Either a grid or a pillar and post system is generally used. We focus on the grid system, which is most widely used (Fig. 1). The breast within the coil is compressed by the grid. Compression pressure is adjusted for stable immobilization while preserving blood flow. The approach to a posterior mass is often difficult, requiring that sufficient breast tissue be contained in the grid to maintain distance from the chest wall.

Table 1. Summary of Breast Biopsy MRI Procedure

Procedure	Check Point
Patient positioning	Attach fiducial marker
Precontrast T1-weighted fat-saturation images (axial and sagittal)	Check location of target and grid
Postcontrast T1-weighted fat-saturation images (axial and sagittal)	Calculate distance from grid and fiducial marker using worksheet
Skin preparation, local anesthesia, and insertion of introducer with obturator	
Postcontrast T1-weighted fat-saturation images (axial and sagittal)	Repeat until adequate location achieved
Change obturator to VAB device and perform biopsy	
Post-biopsy images	Repeat biopsy if inadequate sample retrieval
Marker clip insertion	Post-marker-insertion image with MRI or mammography

VAB = vacuum assisted biopsy

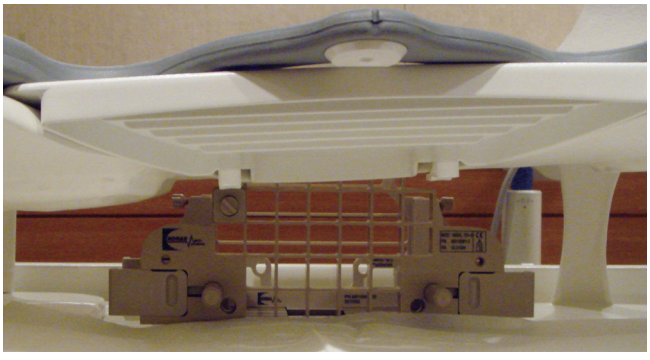

Fig. 1. MRI-guided biopsy grid system.

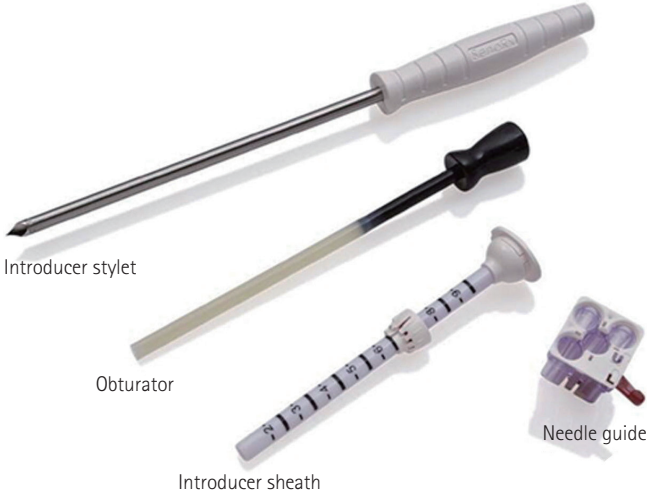

Fig. 2. MRI-guided biopsy kit contains introducer stylet, obturator, introducer sheath, and needle guide.

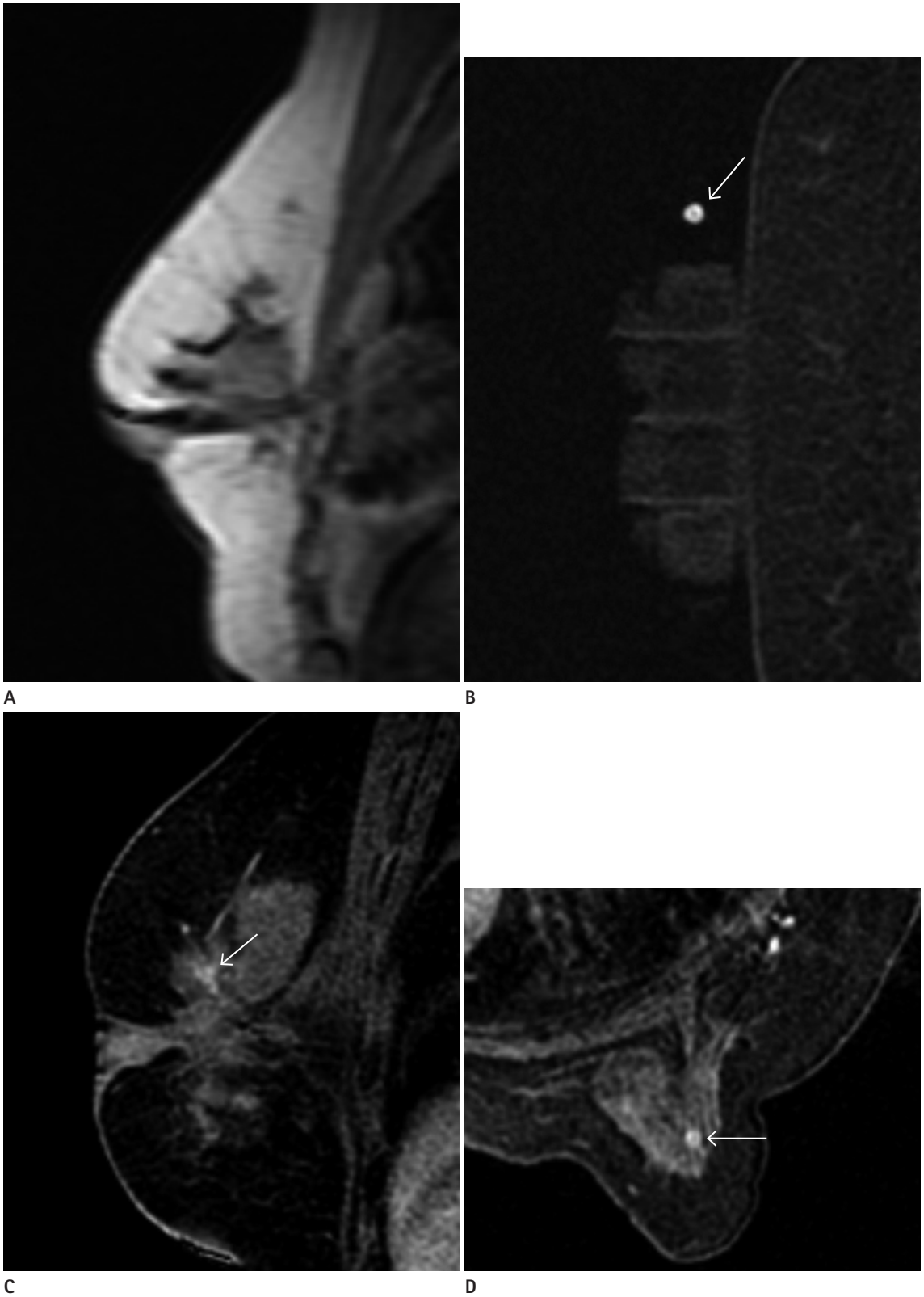

Fig. 3. MRI-guided VAB procedure.
After localizing image **(A)**, precontrast images with fiducial marker (arrow) **(B)** are obtained. Sagittal and axial postcontrast images **(C, D)** are obtained to identify target location (arrow).
VAB = vacuum assisted biopsy

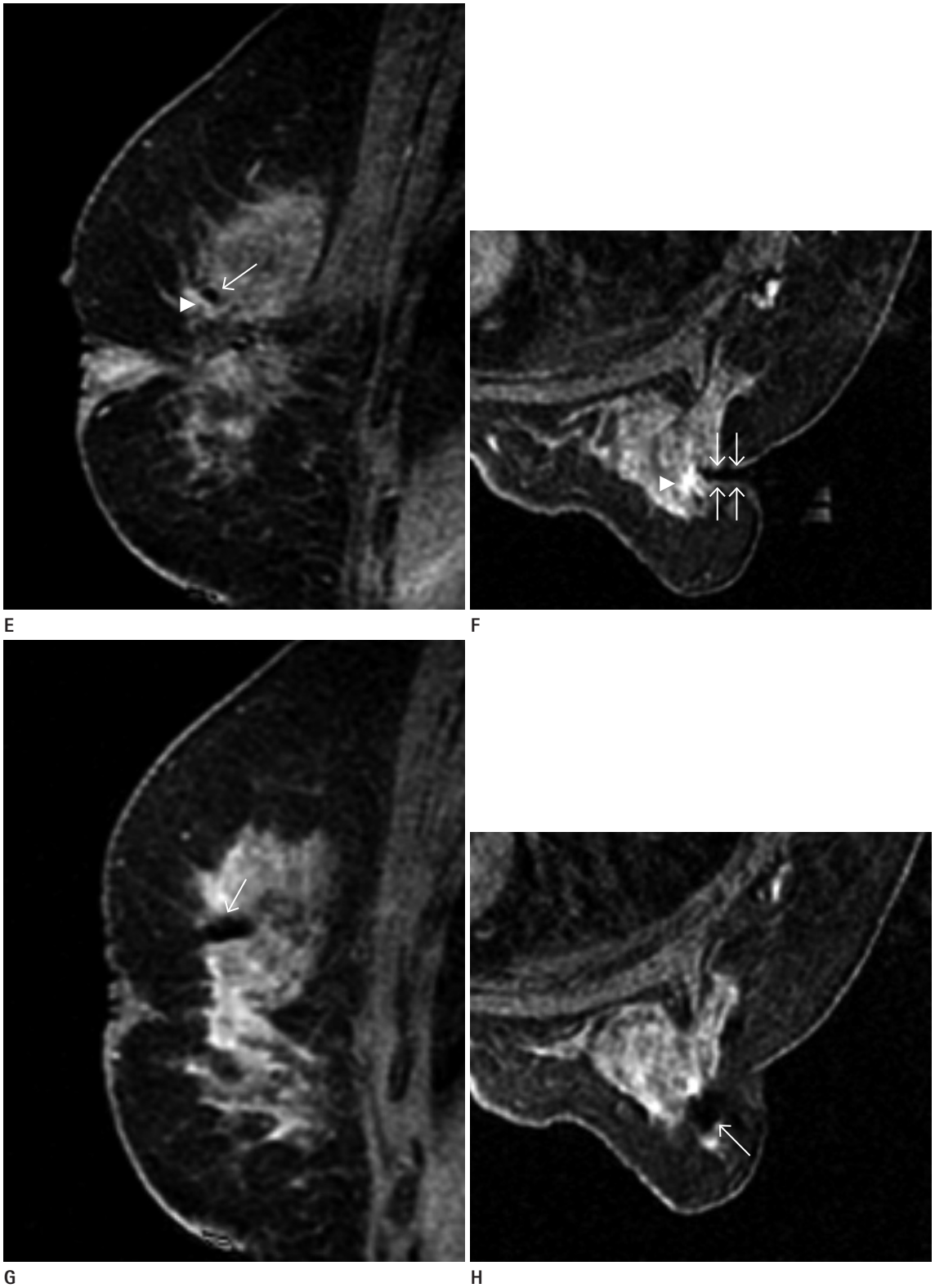

Fig. 3. MRI-guided VAB procedure.
After location of introducer sheath and obturator, sagittal and axial images **(E, F)** are obtained to confirm the position before lesion sampling. The target lesion (arrowhead) and obturator (arrow) are well demonstrated in these images. After tissue sampling, additional sagittal and axial images **(G, H)** are obtained to confirm adequate biopsy location and marker (arrow) placement. The target lesion was confirmed as ductal carcinoma *in situ*.
VAB = vacuum assisted biopsy

Fixing a fiducial marker to the grid enhances target localization.

Equipment

MRI-guided vacuum assisted biopsy (VAB) has advantages over standard core biopsy. The larger core size results in decreased sampling error and compensates for tissue shifting during needle placement (19). The European consensus group recommend a minimum 11-gauge probe size (20). The MRI-guided biopsy kit consists of an introducer stylet, obturator, introducer sheath, and needle guide. The needle guide, a cube-shaped plastic block with multiple holes for the biopsy device (Fig. 2), maintains the VAB device perpendicular to the grid.

Image Acquisition and Lesion Localization

Fig. 3 shows the MRI-guided biopsy sequence. A precontrast T1-weighted fat-saturation sequence is obtained to determine whether the target lesion is within the grid. If the target lesion is too small for detection on the precontrast image, anatomic landmarks are helpful for identification. If the precontrast image indicates that the lesion is inaccessible, the patient's position should be adjusted. After planning the proper approach route, postcontrast T1-weighted fat-saturation images are obtained. The thickness and in-plane resolution, which are similar to that of diagnostic imaging for accurate needle positioning, make localization easier. Sagittal and axial plane images are obtained. Alternatively, axial or sagittal plane images with perpendicular reconstruction can be used for lesion localization depending on the physician's preference. The entry site on the grid and depth from the skin to the lesion are measured using the fiducial marker as a reference. A worksheet provided by the manufacturer is helpful in manual localization (Fig. 4). The thickness of the needle guide should be included in the calculation. A computer-assisted diagnostic system that improves accuracy and speed of the procedure is also commercially available. About 8–13% of MRI-guided biopsy target lesions are not visible at the time of biopsy (21-23). If the target is not visible on the first postcontrast image, it is sometimes identified on a delayed image. Overpressure by the grid may interfere with breast perfusion and should be checked. A subtraction image also aids in lesion identification (Fig. 5). If the target lesion is still not visible, short-term follow-up is recommended at about 6 months.

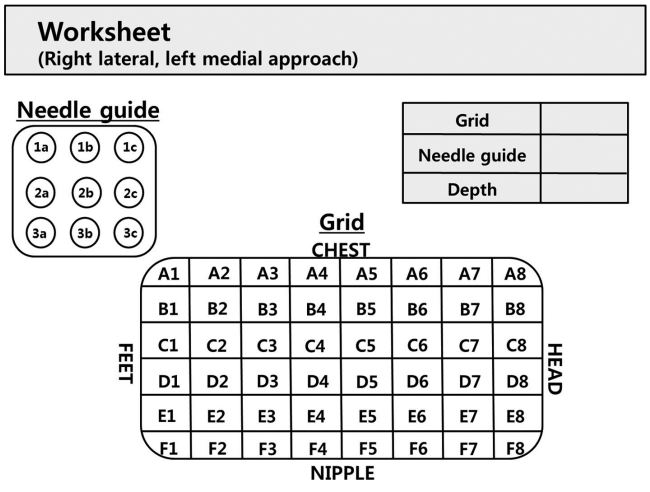

Fig. 4. Example of worksheet.

Biopsy Procedure

After standard skin preparation, local anesthesia is administered. A small nick in the skin facilitates smooth entry by the VAB device. The introducer stylet within its sheath is inserted through the needle guide to the measured depth. A twisting motion is helpful to avoid skin tenting and tissue displacement. The stylet is removed and replaced by the obturator. T1-weighted fat-saturation images are then obtained to confirm the depth and position of the introducer (24, 25). In the case of insufficient depth, the introducer sheath can be advanced after reinsertion of the stylet; if advanced past the target lesion, the introducer is gradually withdrawn. In general, the optimal position is in the center of the target. Directional sampling can be performed with a peripheral location of the needle. When the introducer position is verified as correct, the obturator is exchanged with a VAB device. The European consensus group recommends no less than 24 samples for an 11-gauge or equivalent volume if a larger probe is used (20). Liberman (26) reported that an 11-gauge VAB device collects 100 mg, and a 9-gauge VAB device collects 200 mg. T1-weighted fat-saturation images are obtained immediately after the biopsy to evaluate adequacy. Image assessment can be difficult due to contrast washout, background enhancement, hemorrhage, and air, but careful review using anatomic landmarks improves the evaluation accuracy. An additional biopsy can be performed if the target sample is insufficient. Once the target sampling is acceptable, marker clip should be placed through the introducer sheath. A post-clip-insertion image may be obtained with MRI or mammography. The importance of marker clip insertion should never be underestimated. The mark-

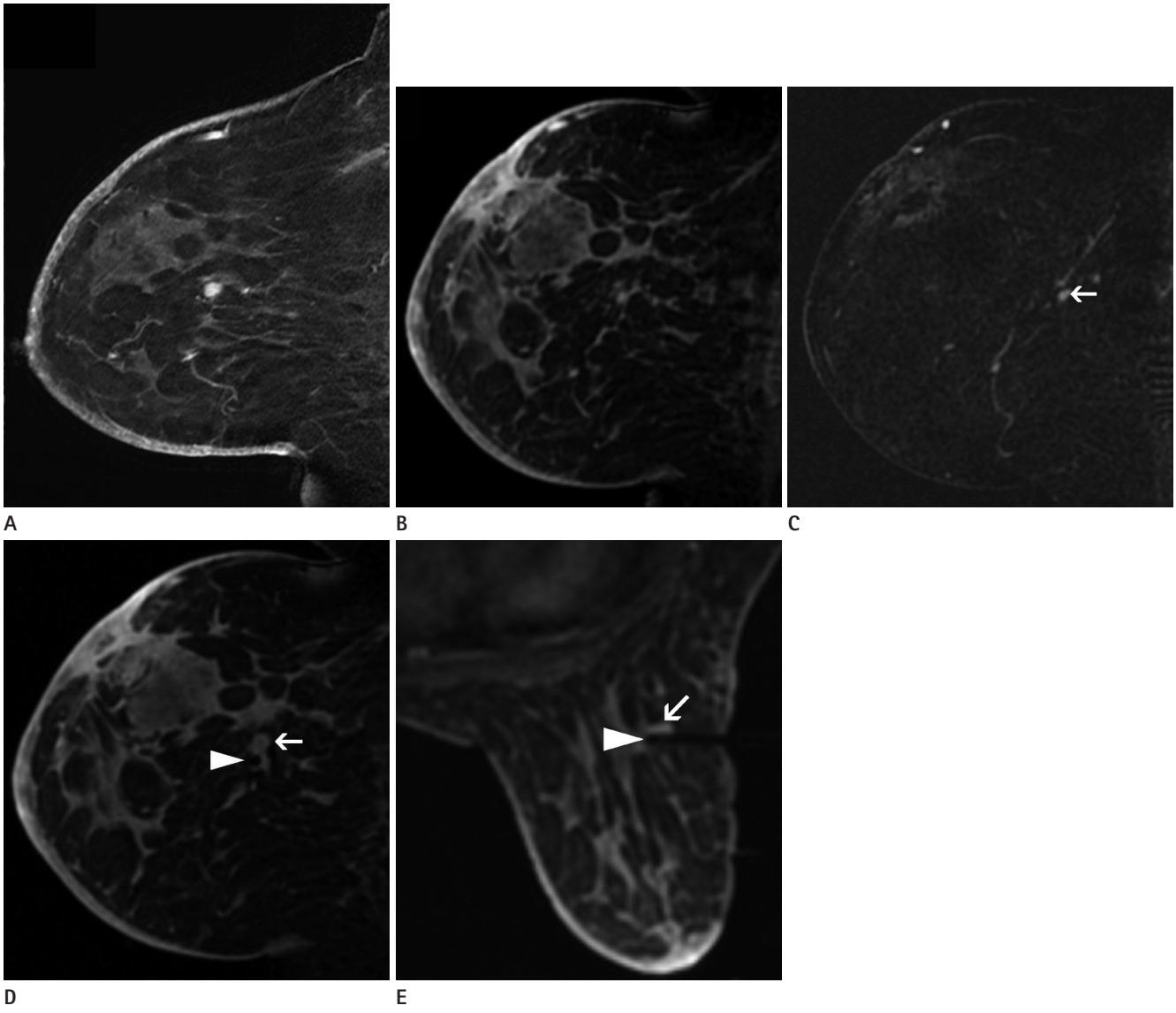

Fig. 5. A 35-year-old woman with ipsilateral breast cancer surgery 9 months previously.
Postoperative MRI shows a new, round, fast and washout-enhancing mass **(A)**. The patient underwent MRI-guided biopsy. The target lesion is not identified on the postcontrast sagittal image **(B)**. On the subtraction image **(C)**, a subtle enhancing mass is well-delineated (arrow). Repeat MRI **(D, E)** shows introducer sheath with obturator (arrowhead) in correct position, with the tip at the target lesion (arrow). The enhancing mass was pathologically confirmed as reactive hyperplasia in intramammary lymph node.

er clip facilitates mammographic or ultrasound-guided localization in place of MRI-guided localization for subsequent excisional biopsy. Moreover, if the entire target lesion is removed by VAB, the marker clip is the only way to identify the biopsy site. The breast is compressed for at least 15 minutes after the biopsy.

Complications and Management

Major complications requiring surgical intervention seldom occur with MRI-guided biopsy. Complication rates are less than 5%. Bleeding and hematoma formation are most common, and can be controlled by compression. Other rare complications are skin laceration, vasovagal syncope, and infection. Termination of the procedure due to a complication is rare (19, 27-36).

CHALLENGING SITUATIONS AND TROUBLESHOOTING

Targeting deep-seated lesions is prone to chest wall injury. To avoid this, traction on the breast tissue as much as possible, coil padding removal, and biopsy toward the anterior side are some

solutions (33). A posteromedial target location is the most difficult to access. If the patient is small, a lateral approach from the contralateral opening of the breast coil can make a deep posterior location more accessible (Fig. 6). A thin breast is another challenge for MRI-guided biopsy. A generous amount of anesthetic agent helps to increase breast thickness, and a reverse compression paddle is also useful (24, 37). VAB devices with smaller apertures or blunt tips can be used for targets in thin breasts and also those near the skin (Table 2).

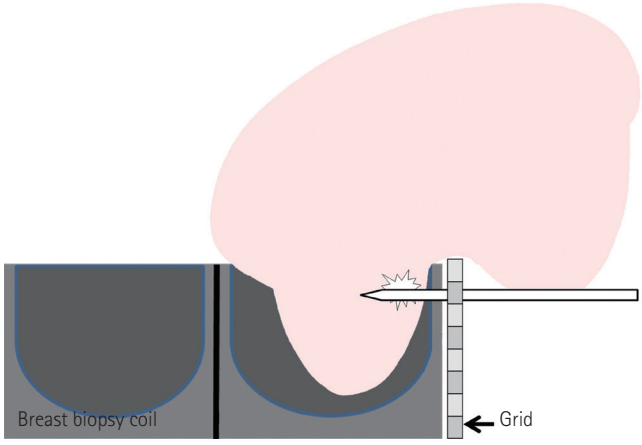

Fig. 6. Lateral approach for posteromedial located target.

Table 2. Challenging Situations and Troubleshooting

Problem	Solution
Nonvisible target	Decrease compression pressure
	Obtain delayed image
Subtle enhancement target	Subtraction image
Deep-seated target	Traction on breast as much as possible
	Remove biopsy coil padding
Posteromedial located target	Lateral approach from contralateral side of breast
Thin breast	Generous amount of anesthetic agent
	Reverse compression paddle
	Use small aperture or blunt tip device

RADIOLOGIC–PATHOLOGIC CORRELATION

As with all other image-guided biopsy techniques, MRI-guided biopsy results should be evaluated for radiologic-pathologic concordance. MRI-guided biopsy has no corresponding evaluation method such as specimen imaging in stereotactic biopsy or real-time monitoring in ultrasound-guided biopsy; therefore, radiologic-pathologic concordance requires caution. The positive predictive value of a lesion detected by MRI with subsequent MRI-guided biopsy is 16–61%; a radiologist should be aware that for radiologic-pathologic correlation, the positive predictive value is affected by the prevalence of breast cancer in a patient population (19, 30, 33, 36, 38-40). A six-month follow-up is recommended for a benign concordant biopsy result (41). The rate of radiology-pathology discordance is not high (0% to 10.7%); but the mean proportion of malignancies in discordant cases is 37.5%, and surgical excision is recommended for discordant lesions (Table 3) (19, 29, 30, 34, 36, 38, 39).

The atypical ductal hyperplasia (ADH) upgrade rate at surgery is reportedly 25–38% (19, 30, 38, 40, 42, 43). In ductal carcinoma *in situ* (DCIS), the upgrade rate ranges from 5–24% (19, 30, 38, 44). The underestimation rates for ADH and DCIS on MRI-guided biopsy are slightly higher than those for stereotactic biopsy (21% and 11%, respectively) (45, 46) or ultrasound-guided biopsy (23.3% and 13.8%, respectively) (47). Atypical lobular hyperplasia and lobular carcinoma *in situ* also have a high upgrade rate (27%) (40). Despite a limited number of studies in the underestimation rate for other high-risk lesions such as radial scars and papillomas, surgical excision for all such lesions using MRI-guided biopsy is recommended (30, 38, 40).

Table 3. Radiology-Pathology Discordance and Malignancy Rate in Discordant Cases

Author	Biopsy Device	Number of Lesions (No. of Patients)	Benign Biopsy Result	Discordance	Discordance Rate of Total Biopsy (%)	Malignancy Rate of Discordant Cases (%)
Perlet et al.[19]	11 G VAB	517 (N/A)	362	0	0	N/A
Gebauer et al.[29]	10 G VAB	42 (32)	28	1	2.4	100 (1/1)
Han et al.[30]	9 or 10 G VAB	150 (134)	90	1	0.7	0 (0/1)
Malhaire et al.[34]	10 G VAB	72 (72)	29	3	10.3	66.7 (2/3)
Noroozian et al.[36]	9 G VAB	75 (75)	56	8	10.7	0 (0/8)
Orel et al.[38]	9 G VAB	85 (75)	15	2	2.4	100 (2/2)
Rauch et al.[39]	9 G VAB	218 (197)	133	1	0.5	100 (1/1)

N/A = not available, VAB = vacuum assisted biopsy

CONCLUSION

Breast MRI is an important screening and diagnostic tool, but the limited specificity requires biopsy confirmation. MRI-only lesions that are occult on mammography and ultrasound require routine evaluation by MRI-guided biopsy. Radiologists who perform the procedure understand best the indications, preprocedural considerations, imaging protocols, biopsy techniques, and possible complications of MRI-guided VAB. Patients should be informed about the demanding nature of the procedure due to prolonged immobilization, the possibility of cancellation of the procedure, and the need for imaging follow-up despite a benign biopsy result. Appropriate patient management based on radiologic-pathologic correlation is emphasized.

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유방 자기공명유도 조직검사

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유방 자기공명영상은 높은 예민도를 갖지만, 낮은 특이도로 인해 조직검사를 통한 병리 확진이 필수적이다. 다른 유방 영상검사에서는 발견되지 않고 오직 자기공명영상에서만 보이는 병변을 진단하려면 자기공명영상 유도하 조직생검술을 시행해야 한다. 유방 자기공명유도 조직검사의 사전 고려사항과 시술방법, 어려운 상황에 대처하는 방법과 마지막으로 영상-병리 소견 연관의 시행에 대해 고찰하고자 한다.

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