Contrast-enhanced MR imaging has gained recognition in the last decade as a valuable adjunct to both mammography and ultrasound for detection of breast carcinomas. Most authors agree that the sensitivity of breast MRI is excellent, ranging between 88% and 100%, although specificity is only moderate, at 37% to 95%.

Rapid enhancement and early washout are generally observed in breast carcinomas, but there are exceptions to this pattern. Certain carcinomas, particularly lobular cancer and carcinoma in situ, may enhance slowly or not at all. On the other hand, some enhancement can be seen in benign lesions such as fibroadenomas. Because of its high sensitivity, MRI reveals small lesions that may not be visible on mammography and/or ultrasound. MRI of the breast thus produces a diagnostic dilemma, as these lesions are often nonpalpable, precluding accurate and safe excision.²

If diagnostic MRI of the breast identifies a suspicious lesion, every effort should be made to reidentify the lesion on conventional modalities such as mammography or ultrasound. If the lesion can again be clearly identified, localization or biopsy should be performed using a conventional modality. MR-guided localization or biopsy should be limited to BI-RADS IV and V lesions that are visible only on MRI. Short-term follow-up is recommended for BI-RADS III lesions.⁴,⁵

Most MR-guided interventions are performed in closed magnets. As a result, only the identification of the lesion and verification of correct needle position are performed under MR guidance. All other steps of the procedure (wire placement, biopsy, and treatment) are performed outside the magnet. Some groups have reported on MR-guided interventions in open magnets,⁶ which have low magnetic field strengths (0.2T to 0.5T) and provide direct vertical or horizontal access to the patient. Open systems appear to have advantages over closed systems in that they provide direct access to the breast during the entire intervention and allow real-time monitoring of the needle insertion and placement. In addition, they allow interventions in the direction of the magnetic field, which minimizes susceptibility artifacts. But their low field strength makes open magnets unsuitable for diagnostic imaging, and they are not as prevalent as closed magnets.

MR-guided preoperative localization or biopsy procedures are usually performed with stereotactic devices that immobilize the breast and allow a more precise needle placement, resulting in high accuracy.⁷-¹⁴ Various systems have been described in the literature with the patient in the supine, prone, or prone decubitus position. Most stereotactic devices allow simultaneous localization of two or more lesions within one or both breasts (Figure 1). Interventional procedures using a freehand technique have almost completely lost their importance.¹⁵

LOCALIZATION AND BIOPSY
MR can be used for both biopsy and localization.
- Preoperative localization. Fully MR-compatible materials should be used for MR-guided preoperative localization (needle-localized open breast biopsy). Several manufacturers offer MR-compatible needles, hookwires, and coaxial needles composed of titanium or nickel-chromium alloys. Artifacts caused by these materials usually pose no problems. All preoperative localization and biopsy procedures are performed under local anesthesia in sterile conditions. The needle is placed under MR guidance, the correct needle position is verified, and the hookwire is then released (Figure 2). Because lesions referred for MR-guided localization are usually small, their accurate localization is critically important. A wire deviation of 10 mm is regarded as acceptable, however.⁴ An alternative two-step procedure has been described in which clip placement via a coaxial needle is done under MR guidance, and subsequent localization of the clip with a hookwire is accomplished under mammographic guidance.⁴
- Percutaneous biopsy. Reports on fine-needle aspiration biopsy (FNAB) under MR guidance are
limited, which may be attributable to the technique's low accuracy. Thus, FNAB under MR guidance, for which successful sampling must be guaranteed, cannot be recommended. In contrast, 14-gauge large core breast biopsy (LCBB) (various manufacturers, including Daum Medical) and 11-gauge vacuum-assisted breast biopsy (VABB) (Mammotome, Ethicon Endosurgery, Vacora, Bard Biopsy Systems) have been shown to be effective methods of diagnosing breast disorders and reliable, efficient alternatives to open surgical biopsy (Figure 3). With these techniques, the coaxial needle is placed under MR guidance. After correct placement has been verified, the biopsies are performed over the coaxial needle outside the magnet. The accompanying table summarizes the results of these various techniques and documents that both LCBB and VABB are effective. VABB has been assumed to provide larger tissue harvest at only minimal tissue shift during the intervention, compared with large-core breast biopsy. Eleven-gauge VABB from Ethicon Endosurgery has been evaluated in a European multicenter study with 538 procedures performed to date and has achieved a success rate of 96%, with no missed cancers.

PATIENT MANAGEMENT
A common concern about MR-guided interventions is that there is usually no direct proof that the correct lesion has been excised or biopsied. Specimen MRI has been shown to be less useful because contrast enhancement cannot be demonstrated in the excised specimen. Radiologists should, therefore, always correlate the imaging and histologic findings to identify any discordance immediately. If uncertainty remains, control MR studies should be performed to prevent late false negatives.

In preoperative localizations, early postsurgical MRI within a week of the excision is recommended to demonstrate the absence of contrast enhancement at the questionable localization. After biopsy, air bubbles are often seen within the biopsy cavity, but this air may drift within the tissue and is not a precise marker. Clip placement should be performed after each biopsy to mark the biopsy site so the lesion can be localized in mammographic control studies or in the event that surgical removal of the area is necessary.

MR-GUIDED THERAPY
Early detection of small breast carcinomas has increased the demand for minimally invasive methods of treatment. Because open surgical excision carries the risk of anesthesia-related complications, hemorrhage, infection, and scarring, minimally invasive or noninvasive ablative procedures offer an alternative for tumor control.

To become generally accepted, these techniques must, in the long term, achieve equivalent or better clinical outcomes than surgical excision. In the short term, they must show complete ablation of the lesion while leaving the surrounding normal tissue unaffected. Improved cosmesis and patient comfort as well as reduced hospital stays and cost savings can also justify the use of these ablative techniques.

Several methods have been developed to achieve noninvasive tumor ablation by the focused delivery of energy to the tumor tissue, causing cell death, vascular obliteration, and tissue necrosis. Different attempts have been described, including the use of ultrasonic waves (focused ultrasound, or FUS) and laser light (laser-light interstitial thermotherapy, or LITT). FUS has the potential to very precisely deliver energy through the intact skin to a given point in soft tissue, with an accuracy of 1 mm. The technique induces temperature elevations of 55 degrees to 90 degrees C at the focal spot. MR can noninvasively measure the ultrasound-induced temperature because several MR parameters are temperature-dependent.

In LITT, MR guidance is used to place thin optical fibers that emit light from their tip into the target region. These fibers are coupled to Nd:YAG or semiconductor laser sources. Initial in vivo studies in human breast cancer and fibroadenomas have shown promising results for both modalities. The reverse effect is used in MR-guided cryotherapy. Under MR guidance, cryoprobes are inserted into the tumor bed with a target temperature of approximately -150 degrees C. Similar to the other techniques, cryotherapy leads to cellular death and vascular obliteration. Morin et al reported on 25 cryotherapies performed using a 0.5T open MR scanner. The group successfully treated 13 of 25 lesions with this technique. Research teams around the world have gained substantial experience with MR-guided interventional procedures of the breast, particularly lesion localizations and biopsies. The data document that MR-guided localization and biopsy procedures can be performed successfully and accurately. Many of the MR-guided therapeutic interventions are still under investigation and in preclinical stages. Although early published reports show promising results, further studies are necessary to demonstrate the efficacy and safety of these methods in the treatment of breast cancer.

Dr. Floery is a radiologist and Dr. Helbich is a professor of radiology, both at the Medical University of
MR breast imaging guides interventional procedures
Published on Diagnostic Imaging (http://www.diagnosticimaging.com)

Vienna, Austria.

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Disclosures:

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