Magnetic Resonance-Guided Interventional Procedures of the Breast: Initial Experience

Ruth Eliahou MD[1], Tamar Sella MD[1], Tanir Allweis MD[2], Yaacov Samet MD[2], Eugene Libson MD[1] and Miri Sklair-Levy MD[1]

Departments of [1]Radiology and [2]Surgery, Hadassah-Hebrew University Medical Center, Jerusalem, Israel

ABSTRACT: **Background:** Magnetic resonance imaging of the breast has emerged as a valuable imaging tool in addition to conventional imaging modalities. It has high sensitivity for malignant lesions and can detect mammographically, sonographically and clinically occult cancers. "MR only" lesions are best biopsied under MR guidance; however, this may be a challenging task.

Objectives: To evaluate our initial clinical experience with MR-guided core needle breast biopsy and MR-guided needle localization.

Methods: We retrospectively evaluated 81 women with 97 lesions, who were scheduled for guided core needle biopsy or MR-guided needle localization followed by surgery. Lesions were categorized as malignant, high risk, or benign according to the BI-RADS MR classification system. MR findings were compared with final histopathology or with follow-up imaging findings.

Results: Fifteen (16%) lesions were malignant (9 invasive ductal carcinoma, 2 invasive lobular carcinoma, 4 ductal carcinoma *in situ*); 7 (7%) lesions were high risk (4 atypical ductal hyperplasia, 3 radial scars); 75 (77%) lesions were benign, mainly fibrocystic changes. Other benign findings were sclerosing adenosis, pseudoangiomatous stromal hyperplasia, fat necrosis, intraductal papilloma, fibroadenoma, capillary hemangioma, and florid ductal hyperplasia. No major complications were encountered.

Conclusions: MR-guided interventional procedures of the breast are accurate, safe and feasible methods for sampling breast lesions detected only by MR and have become a significant tool in the management of certain patients.

IMAJ 2009;11:275–279

KEY WORDS: breast carcinoma, magnetic resonance imaging, MR-guided core needle breast biopsy, needle localization

In the last decade, magnetic resonance imaging has played a growing role in the management of breast cancer patients, becoming an integral tool that is used in combination with conventional breast imaging modalities – mammography and ultrasound. Of these imaging modalities, breast MR is considered to have the highest sensitivity for invasive breast cancer detection, between 94% and 100% [1-3].

MR can detect clinically suspected lesions that are not seen with mammography or ultrasound. It is especially valuable in women with dense breasts and in women with postoperative scarring or breast augmentation, when other modalities such as mammography become less sensitive. MR has been shown to detect malignancies in 2–8% of high risk women with a normal mammography [3]. In women with a known breast cancer, MR has been shown to detect synchronous lesions in the ipsilateral breast in 6–34% and in the contralateral breast in 2–24% of cases [4].

In our institution, breast MR is performed as a screening examination for high risk women with dense breasts as part of the preoperative assessment of disease extent, for post-operative detection of residual tumor, and for patients with proven metastases but an occult primary tumor. MR is also used to evaluate recurrence after previous lumpectomy and as a problem-solving tool when mammography, ultrasound and physical examination findings are equivocal [5].

While MR sensitivity for malignant lesions is high, its specificity is lower and variable, between 37 and 97% [1-3], hence histopathology is often needed for definitive diagnosis of lesions detected only with MR. Between 40 and 60% of enhancing lesions are later found to be benign [3,6]. Further work-up is warranted whenever such a lesion is detected. We usually begin with second-look ultrasound in patients with MR-enhancing lesions. When the lesion is seen with repeat ultrasound, the patient undergoes ultrasound-guided biopsy. For all other lesions, MR-guided biopsy is performed.

Two MR-guided interventional procedures of the breast are performed in our institution: percutaneous core needle biopsy and MR-guided wire localization prior to surgical excision. This study was performed to evaluate our initial clinical experience at Hadassah-Hebrew University Medical Center with MR-guided breast interventional procedures: core needle breast biopsy, and needle localization for surgical biopsy.

PATIENTS AND METHODS

We retrospectively evaluated findings and patient outcome in a series of MR-guided breast interventional procedures performed between January 2004 and August 2007 in 93 consecutive female patients with suspicious enhancing breast lesions detected on MR. All lesions were non-palpable and occult on mammogra-

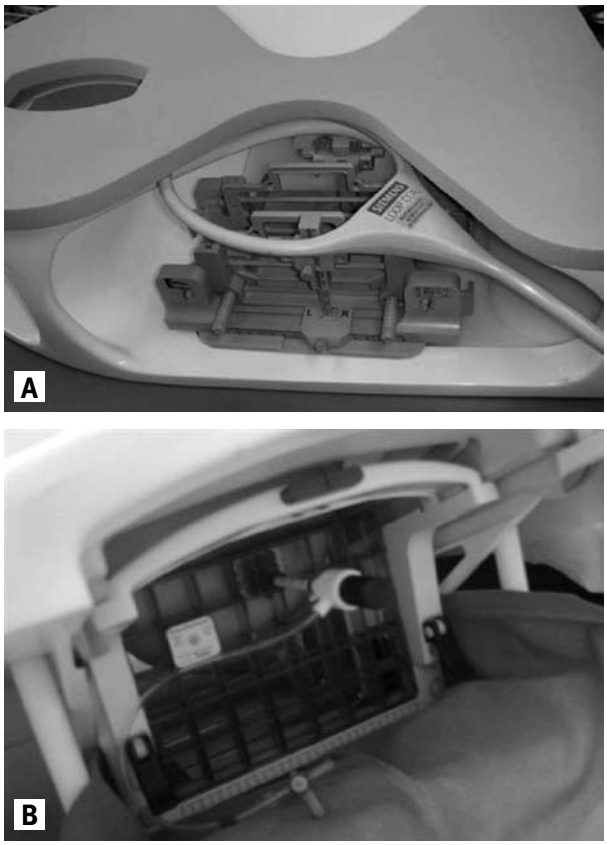

Figure 1. The MR grid. **[A]** Dedicated MR biopsy compression device and a grid localizing system. **[B]** The patient lies in a prone position with breasts in the compression device. When a lesion is detected and biopsy is attempted, localizing fiducials are placed on the grid as a reference point and the biopsy gun can be easily targeted.

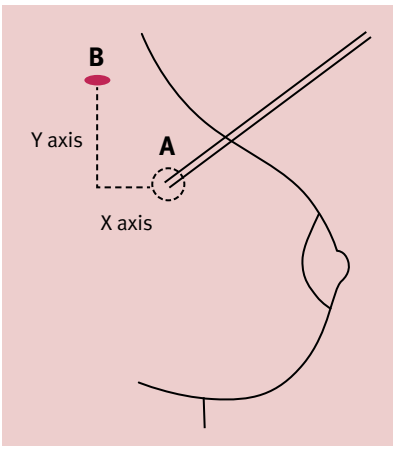

Figure 2. Lesion localization method: **[A]** Mass in the upper breast after contrast enhancement. **[B]** The location of the mass is calculated in the horizontal (X axis) and the vertical (Y axis) planes in reference to the localizing fiducial. The depth (Z axis) is then calculated by the number of slices from the lesion to the skin surface.

phy and ultrasound. Twelve women who were operated elsewhere were excluded from the study because we did not have access to surgical histopathological findings, leaving 81 study participants. Interventional procedures included MR-guided core needle biopsy or MR-guided needle localization. Informed consent was obtained for all interventional procedures.

BREAST MR TECHNIQUE AND INTERPRETATION

Breast MR was performed with the patient placed in prone position, using a 1.5 T MR system (Signa, General Electric Medical Systems, Milwaukee, WI, USA) and a dedicated breast coil (USA Instruments Inc, Aurora, OH). The imaging protocol included an initial transverse T1-weighted localizing sequence followed by a sagittal fat-suppressed T2-weighted sequence and sagittal T1-weighted 3D fat-suppressed gradient echo sequence before and three times after a rapid bolus IV injection of gadopentetate dimeglumine (Magnevist, Princeton, NJ), 0.01 mmol/L/kg of body weight. Unenhanced images were later subtracted from enhanced images and time-enhancement curves were obtained.

Two breast imaging radiologists with 12 years and 8 years experience, respectively, interpreted MR images with consideration of other imaging findings, as well as the patients' histories and clinical presentation.

BREAST MR BIOPSY TECHNIQUE

All invasive procedures were performed using a dedicated biopsy compression device and a grid localizing system [Figure 1A and B]. Patients were placed in the prone position with the breast in the immobilization device. Localizing fiducials were placed on the grid as a reference point over the expected lesion site. Contrast was administered, and localizing T1-weighted sagittal images were obtained. The patient was then drawn from the magnet. The location of the enhancing lesion was calculated in reference to the fiducials, in the vertical (y coordinate) and horizontal (x coordinate) planes. Depth (z coordinate) was calculated as the number of slices from the lesion to the skin surface translated to mm [Figure 2]. A mark was made on the skin overlaying the lesion. The skin was cleansed with alcohol and anesthetized with injection of 1% lidocaine hydrochloride (up to 8 ml).

Core needle biopsy was performed using 14, 16 and 18 gauge MR-compatible coaxial core needle biopsy systems (Daum, Schwerin, Germany). Localization was performed with 20G localizing hook wires (Cook, Inc. Bloomington, IN). For core needle biopsy, the coaxial needle was placed through the grid hole above the lesion. A sagittal T1-weighted scan was then performed to confirm the location of the needle in relation to the mass.

After confirmation, biopsy was performed with 5–12 passes; tissue samples were placed in 4% formaldehyde and sent for histopathology. A localizing titanium clip, visible on MR, mammography and ultrasound, was inserted at the end of core needle biopsy to mark the lesion in case there was a

need for additional needle biopsy and/or excision following the pathology report. A two-view mammogram was obtained to confirm clip mark placement

Needle localization was performed using the same steps as for the core needle biopsy. Localization was performed always from the lateral-to-medial direction, due to limitation in the accessibility of the MR immobilization biopsy device. Total procedure time was 40 to 60 minutes in all patients.

Clinical presentation, indications for MR, and imaging findings from other studies were recorded for each patient. Histological results of the core needle biopsy were correlated with findings at surgery for patients in whom lesions were excised. The clinical example in Figure 3 demonstrates the MR image after core needle biopsy of a benign breast lesion.

RESULTS

A total of 97 lesions were found by MR in 81 women whose median age was 51 years (range 26–71). Forty lesions (41.2%) were located in the right breast, 57 (58.8%) in the left.

Indications for breast MR included assessment of disease extent in patients with a known cancer (24 women, 29.6%), screening examination in high risk women with positive family history and known *BRCA* mutation (18 women, 22.2%), and follow-up study for patients with a personal history of breast cancer (8 women, 9.9%). In 10 women (12.3%), MR scan was performed to assess mammographically occult primary tumor in the presence of disease in the axillary lymph nodes. Highly suspicious signs and symptoms such as nipple discharge or retraction, or pain and persistent mastitis with normal or equivocal findings in other modalities were the reason for MR scan in 7 women (8.6%). MR was used as a screening technique in 8 women (9.9%) with dense breasts without specific high risk. An enhancing breast lesion was an incidental finding in one woman who underwent MR scan for another reason. The indication for MR was not stated in 5 women (6.2%) referred from outside institutions.

MR-guided biopsy was performed for 56 lesions. MR-guided needle localization followed by surgery was performed in 41 lesions. Biopsy or needle localization was performed for one lesion in 68 women, 2 lesions in 13 women, and 3 lesions in one woman.

The average diameter of biopsied lesions was 1.14 cm (range 0.4–3.2 cm); average diameter of lesions managed with needle localization was 8 mm (range 4–20 mm).

Of 97 lesions that were sampled at core needle biopsy or surgery following needle localization, 15 (15.5%) were malignant, with histopathology of invasive ductal cancer in 9 lesions, invasive lobular cancer in 2, and ductal carcinoma *in situ* in 4. Of these, two lesions had a mixed composition of both types. The average size of these lesions was 9 mm (range 5–18 mm).

Seven lesions (7.2%) were classed as high risk, with findings of atypical ductal hyperplasia in four women and radial scarring in three. The average diameter of these lesions was 8.7 mm (range 5–20 mm). Of the four ADH lesions, three were found in core needle biopsy, while one was found in excisional biopsy.

Seventy-five lesions (77.3%) were benign, with histopathology of fibrocystic changes (52 lesions, 53.6%), sclerosing adenosis (6 lesions, 6.1%), capillary hemangioma (4 lesions, 4.1%), florid ductal hyperplasia (4 lesions, 4.1%), fibroadenoma (3 lesions, 3%), intraductal papilloma (2 lesions, 2%), PASH (pseudoangiomatous stromal hyperplasia) (2 lesions, 2%), or fat necrosis (2 lesions, 2%). Benign lesions had an average diameter of 0.98 cm (range 0.4–3.2 cm) [Table 1].

ADH = atypical ductal hyperplasia

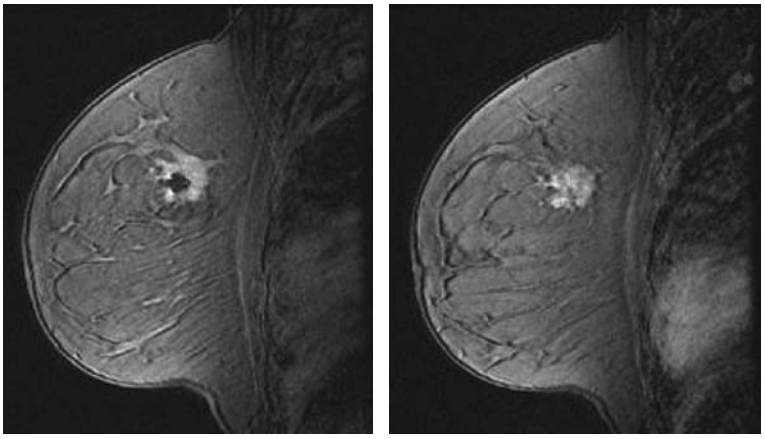

Figure 3. Gadolinium-enhanced MR image of a 32 year old high risk woman *BRCA* carrier with positive family history and dense breasts, undergoing a routine screening MR. **[A]** Suspicious 2 cm enhancing lesion was found in the upper outer quadrant. **[B]** The same lesion after core needle biopsy showing the artifact caused by the clip. Histology from core needle biopsy showed benign changes. Due to the discordance between the view on MR and the biopsy results, the patient underwent excisional biopsy that confirmed that the lesion was benign. Six month follow-up follow up MR was also normal.

Table 1. Histopathology findings

Histopathology	MR-guided procedure
Invasive ductal Ca	9
DCIS	4
Invasive lobular Ca	2
High risk*	7
Benign*	75
Total lesions	97

*Benign: Intraductal papilloma (n=2), fibroadenoma (n=3), pseudoangiomatous stromal hyperplasia (n=2), fat necrosis (n=2), sclerosing adenosis (n=6), capillary hemangioma (n=4), florid ductal hyperplasia (n=4), and fibrocystic changes (n=52).

* High risk: ADH (n=4), radial scar (n=3).

Histopathology at excisional biopsy differed from findings at biopsy in five patients. In one, findings of low grade DCIS at biopsy were upgraded to invasive ductal carcinoma and high grade DCIS during lumpectomy. One lesion found to be benign fibrocystic changes at biopsy was upgraded to well-differentiated infiltrating keratinizing squamous cell carcinoma based on a subsequent skin biopsy. Another lesion found to be benign fibrocystic changes at biopsy was diagnosed as fibroadenoma in the excisional biopsy. In the last two lesions, findings of sclerosing adenosis and capillary hemangioma at core needle biopsy and excisional biopsy were concordant. The indication for an excisional biopsy after benign findings on core needle biopsy was discordant with the MR appearance, which occurred in four patients. For the other benign lesions, further surgical procedure was not performed.

Follow-up studies, including at least one ultrasound or MR examination, were performed for 20 patients harboring 22 of 75 benign lesions detected in the initial MR series. All lesions were stable at a mean follow-up period of 24 months (range 4–44). Ten of these patients undergo annual MR due to high risk for breast carcinoma. We lack follow-up studies for the remaining 44 women with 53 benign lesions in the initial series, and we have no information regarding examinations in other centers for these women. In general, our recommendation is for a 6 month follow-up study after a benign finding on biopsy. There were no significant complications in the 81 patients, although 64 women developed small hematomas, which resolved spontaneously.

DISCUSSION

Breast MR was introduced to Hadassah in the year 2000, and we performed the first MR-guided interventional procedures in January 2004. We currently perform an average of 400–500 breast exams and 24 interventional breast procedures a year. We describe here our experience based on a retrospective study of MR-guided biopsy for 97 interventional procedures in 81 women. Fifteen lesions were malignant, 7 were high risk lesions, and 65 were benign. The only complication was transient hematoma, which resolved without further intervention in 64 women.

MR-guided procedures can be challenging. MR-compatible equipment is required; even so, needles, wires and clips can create artifacts. The patient must be removed from the magnet while the procedure is underway, and there is limited access to the medial and posterior breast due to its placement in the compression device [7]. Lesion enhancement often depends on the presence of contrast material, which washes out 5–10 minutes after injection, causing target lesions to "vanish"; thus there is a limited window for biopsy or wire placement. Another challenge is that, unlike mammography, it is impossible to confirm lesion retrieval once a tissue sample is obtained. However, despite these obstacles, an increasing number of breast biopsies are performed at our institution and all over the world, for lesions detected solely on MR.

For years, the mainstay of MR-guided breast intervention was wire localization followed by excisional biopsy. Several studies confirm the advantages of this method. Cancer was detected in 31–73%, and high risk lesions such as ADH and lobular carcinoma *in situ* in up to 29% of women undergoing these procedures [3,6].

Percutaneous MR-compatible core needle biopsy systems are now used widely and several reports have shown they facilitate safe, accurate, and effective core needle biopsy [1-3]. In the last three years 9-G vacuum-assisted biopsy systems have become available and have also shown excellent results [4,8,9]. Such a system (ATEC Breast biopsy and excision system, Suros Surgical Systems) was recently purchased by our department and introduced to our routine clinical work. This technology completely replaced the previous 14G core needle biopsies; they are time efficient, have less needle artifacts and overall give better results. However, this study summarizes our results with the previously used 14-16 G MR-compatible core needle biopsy guns. The new data concerning the vacuum biopsies will be analyzed in the future.

In our study, 75 (77%) of the lesions that were diagnosed using MR-guided procedures were benign. This high proportion of benign findings further accentuates the advantage of the MR interventional system in preventing unnecessary surgeries. This high percentage of benign findings that were enhanced on MR were shown in other studies as well [5,6]. Liberman et al. [5] found 70% of the lesions to be benign. Morris and colleagues [6] found 60.4%. The high proportion of benign lesions encountered emphasizes the potential benefit of MR-guided biopsies, which may spare most women with MRI-detected lesions from surgical excision.

Of the lesions that were diagnosed, 22 (23%) were malignant and high risk lesions and necessitated further surgery. These data emphasize the strength of MR in the diagnosis of lesions that are occult clinically, sonographically and in mammography. We found that although MR-guided interventional procedures are more complicated, take more time and are costly, they still offer the benefits of MR (high sensitivity and detection rate for suspected lesions) while minimizing false positive findings and improving specificity by tissue sampling. In addition, it is important to emphasize the small diameter of the lesions that were biopsied (1.4 cm). This ability promotes early diagnosis of small carcinomas.

Being a tertiary referral center, we lack follow-up studies for most patients (n=61) in our database, and this is a potential limitation of this study. However, our general recommendation is for a 6 month follow-up study after a benign finding on biopsy.

DCIS = ductal carcinoma *in situ*

In conclusion, our initial clinical experience suggests that MR-guided core needle biopsy and MR-guided needle localization are safe, feasible and accurate procedures. Procedures with the guidance of MR play an invaluable role in the management of lesions detected by MR only and have become an essential tool for breast imaging.

Correspondence:
Dr. R. Eliahou
Dept. of Radiology, Hadassah University Hospital, P.O. Box 12000, Jerusalem 91120, Israel
Phone: (972-2) 677-6901
Fax: (972-2) 643-7531
email: ruthe@hadassah.org.il

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