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Outcome Analysis of 9-Gauge Magnetic Resonance Imaging-Guided Vacuum-Assisted Core Needle Breast Biopsies

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Abstract

Purpose—To correlate 9-gauge Magnetic Resonance imaging-guided Vacuum-Assisted breast Biopsy (MRVAB) with surgical histology to determine the upgrade rate and to correlate the frequency of MRVAB cancer diagnosis with breast MRI indications and enhancement characteristics of targeted lesions.

Materials and Methods—The HIPAA compliant study was approved by the institutional review board. A database search was performed of all MRVABs performed from January 1, 2005 to September 31, 2010. The breast MRI indications, history, age, risk factors, lesion size, enhancement characteristics, pathology at MRVAB and at surgery were documented. Fisher's exact test and Analysis of Variance were used for statistical analysis.

Results—A total of 218 lesions underwent MRVAB in 197 women (mean age 52 years, range 28 - 76 years), of which 85 (39%) had surgical correlation. (R1, #3) There were 48/218 (22%) malignant, 133/218 (61%) benign, and 37/218 (17%) high-risk lesions at MRVAB. Ten (12%) of 85 lesions were upgraded to malignancy at surgery, with a final malignancy rate of 25%. The frequency of malignancy was significantly higher in patients presenting for diagnostic (50/177, 28%) versus screening (4/41, 10%, $P < 0.05$) evaluation, patients with ipsilateral cancer (22/49, 45%, $P < 0.001$), lesions with washout kinetics (34/103, 33%, $P < 0.05$); and relatively higher in lesions with non-mass-like enhancement (26/76, 34%, $P = 0.07$), which represented ductal carcinoma in situ in the majority (17/26, 65%, $P < 0.005$).

Conclusion—Patients with ipsilateral cancer who have additional suspicious lesions identified on MRI require careful evaluation and biopsy to exclude additional sites of cancer that may impact surgical management.

Introduction

Magnetic resonance imaging (MRI) is an important tool for screening high risk women and for the diagnosis of breast cancer. Studies have shown that breast MRI has high sensitivity, but relatively low specificity, for the detection of breast lesions and should be used judiciously in specific patient populations including staging of patients with known breast cancer and screening high risk patients [1-4]. Breast MRI should be interpreted in conjunction with mammographic and sonographic evaluation.

Targeted second-look sonography is performed for suspicious lesions identified on MRI. When a corresponding abnormality is found on sonography, tissue sampling is performed ideally under sonographic guidance. However, the reported success rate of second-look sonography varies from 23% to 76% [5-11] (R2, #3). MRI-guided biopsy is performed for tissue sampling of lesions visualized only on MRI [12-15]. MRI-guided vacuum-assisted core needle biopsy (MRVAB) is fast, safe, and provides large tissue samples for histopathological evaluation. The cancer detection rates using MRI-guided breast biopsy varies considerably, from 18% to 61%, in the published literature [17-21]. This variation can be explained by significant differences in study design and patient population. Underestimation of malignancy that has been reported in MRVAB impacts clinical management [22-24].

The terms “upgrade to malignancy” and “underestimation of malignancy” have been used interchangeably in the literature for lesions that were diagnosed as high risk lesions at biopsy, but with final pathology at excision changed to malignancy (in situ or invasive), as well as for in situ lesions at biopsy upstaged to invasive cancer at surgery [17-21]. The term “upgrade rate to malignancy” was used in our study to define frequency of upgrading of benign and high risk lesions at MRVAB (false negative cases) to malignancy, as well as upstaging in situ MRVAB lesions (true positive cases) to invasive cancer according to final histopathology at surgery. (R1,#1, #4)

The purpose of this study was to determine the correlation between indications for breast MRI and enhancement characteristics of targeted lesions, and to determine the frequency of cancer diagnosis by MRVAB. Histopathology at MRVAB was correlated with histopathology at surgery to determine the upgrade rate.

Materials and Methods

Subjects

The study was approved by the institutional review board at The University of Texas MD Anderson Cancer Center and was compliant with the Health Insurance Portability and Accountability Act. A retrospective database search was performed at a single institution to identify all patients who had undergone MRVAB between January 1, 2005 and September 31, 2010. A total of 197 women who had 218 breast lesions biopsied were included in the study. The age of these patients ranged from 28 to 76 years, (mean 52 years). Routine work up with diagnostic mammographic evaluation and ultrasound exam if indicated was performed in all patients before initial MRI evaluation and did not reveal suspicious

calcifications or masses. All MRVAB patients had undergone the targeted second-look sonography exam after initial MRI evaluation with no corresponding sonographic abnormality detected, and proceeded to MRVAB. The MRI suspicious lesions identified by second-look ultrasound were biopsied under sonographic guidance.

MR Imaging

All patients underwent bilateral breast MRI using a 1.5-T system (Signa, GE Healthcare, Waukesha, WI; or Sentinelle Medical, Toronto, Canada) or the 3.0-T system (Signa HDx 3.0T, GE Healthcare, Waukesha, WI) and a bilateral 8-channel phased array breast coil (GE Healthcare). Scans were performed with the patient lying in a prone position and with gentle immobilization of the breasts. Sequences performed included bilateral axial pre-contrast T1-weighted spin-echo, right and left sagittal T2-weighted fat-suppressed fast spin-echo, and bilateral sagittal dynamic contrast-enhanced imaging before and after injection of gadopentetate dimeglumine (0.1 mmol/kg, Magnevist, Bayer Schering Pharma AG, Berlin, Germany) intravenously as a bolus, followed by a saline flush, using an injector (Spectris Solaris, Medrad Inc., Warrendale, PA). The dynamic contrast-enhanced images included four contrast-enhanced images obtained with a three-dimensional (3-D) T1-weighted fat-suppressed fast spoiled gradient-echo sequence with effective slice thickness <2mm and acquisition time, <120 seconds.

MRI-Guided Biopsy

Prior to the MRI-guided biopsy, written informed consent was obtained from all patients. An 8-channel dedicated breast biopsy coil (Sentinelle Medical, Toronto, Canada) fitted with a sterile perforated plate and two reference fiducial markers to be placed in random holes in the plate were utilized. A fat-suppressed 3-D spoiled gradient echo sequence with scan parameters matching the diagnostic dynamic sequence, before and after intravenous administration of contrast (0.1 mmol/kg Magnevist, Bayer Schering Pharma AG, Berlin, Germany) were used. MRI images were obtained routinely in the sagittal and axial planes and, when deemed necessary by the performing radiologist, also in the coronal plane. The coordinates (superior to inferior, anterior to posterior, and right to left) of the enhancing lesion were calculated by measuring the distance between the nearest reference marker and the lesion. For the large lesions the area with most suspicious kinetics was targeted for biopsy. (R2,#4) Biopsies were performed using a 9-gauge vacuum-assisted core needle biopsy device (ATEC, Suros Surgical Systems, Hologic, Inc., Indianapolis, IN). Six to 12 cores were obtained circumferentially at the discretion of the performing radiologist. Post-biopsy axial sequence (T1-weighted fast relaxation fast spin echo sequence, fat suppressed, TE minimum/TR=500 ms, slice thickness 3mm, no intersection gaps, acquisition time 20 sec) was performed to document that the post-biopsy changes correlated with the targeted lesion. A titanium clip (Gel-Mark Ultra Biopsy Site Marker, SenoRx, Irvine, CA) was then placed at the biopsy site. The scan was repeated for clip identification. The post procedure two orthogonal view mammograms were obtained for verification of the clip placement. The biopsy was performed by one of 13 radiologists, including the authors, with one to ten years of experience.

Data Collection and Analysis

Patient Characteristics—A retrospective chart review was performed of the 197 patients who underwent a total of 218 MRVAB procedures to include data on age, risk factors, clinical history, and clinical indications for breast MRI. The indications for breast MRI were divided into screening and diagnostic categories. The screening group consisted of patients with high risk of breast cancer who were asymptomatic. The diagnostic group consisted of patients with known ipsilateral breast cancer, known contralateral breast cancer, a prior history of breast cancer, mammographic abnormality not detectable by sonography, axillary metastasis from an unknown primary malignancy, and other indications (skin thickening, nipple retraction, palpable finding). The MR images were reviewed by 2 dedicated breast radiologists with 5 and 7 years of breast MRI experience, respectively, according to the Breast Imaging Reporting and Data System (BI-RADS) MRI lexicon [25].

Lesion Enhancement Characteristics—Lesions were characterized by size and type (focus, mass and non-mass) per the BIRADS MRI lexicon [25]. A lesion was classified as a focus when it measured less than 0.5 cm. The lesion enhancement characteristics analyzed included: mass morphology – margin for the mass (smooth or irregular/spiculated), distribution patterns for a non-mass (regional, segmental, linear/ductal, and focal); and time-intensity kinetics – persistent, plateau or washout. In patients with more than one suspicious lesion seen in the same breast during diagnostic breast MRI evaluation, the largest lesions with the most suspicious morphological characteristics and enhancement kinetics were selected for MRVAB.

Histopathology—Histopathology at MRVAB was compared with the final histopathology at surgery to determine the upgrade rate. The cancer detection rate was calculated by ratio of malignant lesions to the number of biopsied lesions. Lesions with the following histopathology at MRVAB were included in the high risk group: atypical ductal hyperplasia (ADH), atypical lobular hyperplasia (ALH), lobular carcinoma in situ (LCIS), and radial scar. Surgical excision was performed for all malignant lesions diagnosed at MRVAB. Surgical excision of high risk lesions was determined on a case-by-case basis by consensus at a weekly multidisciplinary high-risk clinical management conference with dedicated breast radiologists, breast pathologists, breast surgical oncologists, and clinical cancer prevention physicians in attendance. Radiological and histopathological correlation of biopsied lesions was analyzed by this conference. A clinical management conference database with final histopathology, and patient outcomes provided follow-up data for high risk patients who did not undergo surgery. All patients with benign and high risk histopathology had short-term 6 month clinical and MRI follow up, annual mammography and if necessary annual ultrasound.

Statistical Analysis—For comparison of the continuous variable Analysis of Variance (ANOVA) was used. For comparing two 2-level categorical variables, Fisher's exact test was used to test the difference. P-value less than 0.05 was considered significant. All tests were carried out using SAS 9.2 by SAS Institute Inc., Cary, NC, U.S.A.

Results

Histopathology at MRVAB

Of the 218 lesions biopsied, 48 (22%) were malignant: 22 ductal carcinoma in situ (DCIS), 6 invasive ductal carcinoma (IDC), 6 IDC and DCIS, 8 invasive lobular carcinoma (ILC) and 6 IDC and ILC (Fig 1). There were 133 (61%) benign (Fig 2) and 37 (17%) were high-risk lesions (Table 1). Of the 37 high-risk lesions, 13 were atypical ductal hyperplasia (ADH), 12 were atypical lobular hyperplasia (ALH), 6 were lobular carcinoma in situ (LCIS), and 6 were radial scar (R1; #7). The majority of benign lesions were fibrocystic changes (n=35), followed by fibroadenoma (n=14), sclerosing fibrosis (n=12), columnar cell changes (n=11), sclerosing adenosis (n=11), benign breast parenchyma (n=11), papilloma, (n=9), apocrine metaplasia (n=9), pseudoangiomatous stromal hyperplasia - PASH (n=7), hemangioma (n=5), fat necrosis (n=5), inflammatory changes (n=2), tubular adenoma (n=1) and adenosis tumor (n=1).

Histopathology after Surgery

Surgery was performed in 85/218 (39%) lesions. Of the 48 patients with MRVAB-proven malignant lesions, all underwent surgery. Four biopsy proven DCIS lesions at MRVAB were upgraded to IDC at surgery. Of the 133 benign lesions, 20 (15%) underwent surgery. The reasons for surgery of benign lesions included prophylactic bilateral mastectomy (n = 11), mastectomy in cases of known ipsilateral cancer (n = 8), and radiological histopathological discordance (n = 1). Final histopathology of the discordant suspicious lesion that showed a benign finding at MRVAB showed DCIS at surgery. Of the 37 high risk-lesions, 17 (46%) were surgically resected. Five lesions were upgraded to invasive cancer or DCIS after surgery: three ADH lesions were upgraded to DCIS (Fig 3), one ADH lesion was upgraded to IDC and DCIS, and one LCIS lesion was upgraded to ILC. Of 85 surgically excised lesions, 10 (12%) were upgraded after surgery. (R1; #3)

The number of lesions that were malignant at biopsy and remained malignant at surgery was 48 – they represented true positive (TP) lesions. Four out of these 48 lesions were understaged – they were diagnosed as in situ cancers at MRVAB and were upgraded to invasive cancer at surgery. There were six lesions, one benign and five high risk lesions, which were upgraded to malignancy – false negative lesions (FN). We had no false positive (FP) lesions – all lesions diagnosed as malignant at MRVAB were confirmed at surgery. Therefore positive predictive value (PPV) for our study was 100%. (R1; #2, #5, #10)

Follow-up

Follow-up was performed for 133/218 (61%) patients with benign pathology at MRVAB, with a mean of 39 months, (range six to 69 months). Patients in this group received follow-up care with a 6 month follow up breast MRI, yearly mammographic and when indicated with yearly sonographic imaging, as well as with serial clinical visits. No malignancy was diagnosed in this group of patients at last follow-up. Six month follow up breast MRI was used to confirm successful biopsy of targeted lesions. No sampling and targeting errors were documented in the study cohort. (R2; #6). The final rate of malignancy among the MRVAB lesions in our patient population was 25% (54/218) (Table 1).

MRI Indications

The indications for MRI in the 218 patients who underwent MRVAB showed that a majority presented for diagnostic work-up (177/218, 81%) versus high-risk screening (41/218, 19%) (Table 3). The frequency of malignancy was significantly higher in the diagnostic (50/177, 29%) versus the screening group (4/41 or 10%), ($P < 0.05$). The malignancy rate in patients with known breast cancer was 29% (30/105). Within this group, a significantly higher cancer rate was found in women with ipsilateral breast cancer (22/49 lesions, 45%), than in women with contralateral breast cancer (8/56 lesions, 14%) or in women with a remote history of breast cancer (9/29 lesions, 31%) ($P < 0.001$) (Table 2).

Lesion Size and Type

Lesion size ranged from 0.3 cm to 14 cm, mean 1.7 cm. Mass size ranged from 0.5 cm to 3.6 cm, mean 1 cm. Non-mass-like lesions were larger than mass-like lesions, size ranged from 0.5 to 14 cm, mean 3.2 cm ($P < 0.001$). Two (2/25, 8%) biopsied foci yielded malignancy. The probability of malignancy was 22% for masses (26/117). The highest rate of malignancy by morphologic features was found in non-mass-like lesions (26/76, 34%). Fisher's exact test revealed statistically significant higher cancer rate in a non-mass-like lesion when compared to foci ($P < 0.01$), however it was not significantly different from that in the mass lesions ($P = 0.07$) (Table 3).

Analysis of the pathologic diagnosis showed that a significant majority of non-mass-like lesions showed DCIS (17/26, 65%, $P < 0.005$), with the rest distributed almost equally between ILC (3/26, 11%), DCIS and IDC (2/26, 8%), IDC (2/26, 8%), IDC with ILC (2/26, 8%). However, mass-like lesions did not show significant prevalence for any type of pathology with almost similar rate for IDC (7/26, 27%) and ILC (6/26, 23%), equal number of DCIS and IDC with DCIS (5/26, 19% each), and the least number of IDC with ILC (3/26, 12%).

We analyzed relationship between lesion size and rate of malignancy. We found the highest cancer rate in lesions larger than 5 cm (77%), followed by lesions between 2 and 5 cm (29%), with lowest malignancy rate in lesions smaller than 2cm (20%). There was statistically higher rate of malignancy for lesions larger than 5 cm ($P < 0.005$). For the large lesions the area with most suspicious enhancement kinetics was targeted during MRVAB. (R2; #4)

There was no significant difference in the cancer detection rate when stratified by the number of suspicious lesions documented and the number of suspicious lesions biopsied per patient. The largest and most suspicious lesion by morphology and enhancement characteristics was selected for biopsy when multiple suspicious lesions were detected by diagnostic MRI evaluation. (R2; #5) The probability of malignancy was 23% (35/150) when only one suspicious lesion was detected and biopsied, 35% (12/34) when two or more suspicious lesions were detected but only 1 was biopsied and 21% (7/34) when multiple suspicious lesions were detected and at least 2 were biopsied.

Lesion Morphology and Enhancement Kinetics

Analysis of lesion morphology showed a higher malignancy rate for masses with irregular/spiculated borders (24/90, 27%) versus for those with smooth borders (2/27, 7%) ($P < 0.05$). The probability of malignancy for non-mass-like lesions by distribution characteristics was slightly higher for lesions with segmental distribution (7/17, 41%), and was almost equal for lesions with linear/ductal and regional distribution (10/27, 37% and 9/25, 36% respectively) (Table 3). Analysis of this data by Fisher's exact test did not show statistically significant differences in the rate of malignancy by distribution characteristics. There was a significantly higher rate of malignancy in lesions demonstrating washout kinetics (34/103, 33%, $P < 0.05$). Specifically, washout kinetics was found in 69% (18/26) of malignant masses and 58% (15/26) of malignant non-mass-like lesions. Malignancy was found less often in lesions with persistent (4/36, 11%) or plateau kinetics (16/79, 20%) (Table 3).

Analysis of a combination of morphologic and kinetic characteristics demonstrated the lowest cancer rate in lesions with persistent kinetics appearing as a focus or a smooth mass; and in lesions with plateau kinetics appearing as smooth mass. The highest probability of malignancy was in lesions with washout kinetics demonstrating a non-mass-like morphology (48%, 15/31) followed by an irregular/spiculated mass-like (31%, 16/51) lesions (Table 4). However, Fisher's exact test did not reveal significant differences between any of these groups.

Discussion

MRI-guided biopsy is widely performed for tissue sampling of lesions with suspicious MRI characteristics which are not identified on second-look sonography [16, 18-20, 26-31]. The reported cancer detection rate for MRVAB ranges from 18% to 61% [19, 20], the majority of investigators reporting a probability of malignancy in the 20%–40% range [16, 17, 21, 27-29]. The malignancy rate of MRVAB in our population was 22%, with 25% final malignancy rate at surgery. Of the 85 patients who underwent surgery, 10 (12%) lesions were upgraded, which is within the range reported in the literature (7% to 25%) [16, 18, 20, 27, 29]. Four of 22 DCIS tumors were upgraded to IDC, with a histological underestimation rate for DCIS in our patient population of 18%, which falls within the reported range of 17% to 25% [20, 29, 32].

The upgrade rate in our study for all high-risk lesions, as well as ADH alone, was 29%. This is slightly lower than in the published literature for ADH (32% to 50%), and for all high-risk lesions (31% to 50%) [22-24]. The recommendation in the literature is to excise all high-risk lesions due to such a high degree of underestimation on biopsy. This is not currently a routine practice in our institution, where each high-risk patient is discussed in a multidisciplinary conference. There are published data that describe significant histological predictors of upgrade of ADH to carcinoma [33, 34]. According to these publications, ADH lesions on core biopsy demonstrating significant cytologic atypia and/or necrosis are most likely to be associated with carcinoma and should be excised. However, ADH without these features, regardless of extent of involvement, is associated with minimal risk of carcinoma and may undergo careful imaging and clinical follow up. Utilizing this information we categorize each lesion in the different risk group depending on histopathologic and imaging

results, and conservative versus surgical management is recommended on a case-by-case basis. This practice, together with use of a large gauge biopsy needle, may contribute to the relatively lower underestimation rate seen in our study.

There was a significantly higher probability of malignancy in patients who presented for diagnostic versus screening MRI (28% versus 10%, $P < 0.05$). Almost half of the suspicious lesions biopsied in patients with known ipsilateral breast cancer were malignant (45%, $P < 0.05$). Similar data were reported in previously published series [17, 27]. These findings underscore the need for biopsy of additional suspicious lesions identified in patients with ipsilateral breast cancer in order to exclude multifocal/multicentric disease, which can impact their clinical management.

The reported malignancy rate is higher for masses (34-60%) than for non-mass-like enhancements (27-41%) [19, 27, 29]. However, only 22% of malignant lesions were masses in our group of patients. We found the highest rate of malignancy in non-mass-like lesions (34%), although this prevalence was not statistically significant ($P=0.07$). This discrepancy is likely related to a different success rate of second-look sonography for detecting masses versus for non-mass lesions. Most enhanced mass lesions requiring biopsy are readily identified on sonography and biopsied under sonographic guidance, while non-mass-like lesions are more likely to undergo MRI-guided biopsy. The recently published series by Candelaria et al. [35] from our institution retrospectively reviewed 131 lesions in 83 patients, initially identified as suspicious by MRI imaging. A correlate at second look ultrasound was found in 88 (67%) lesions and 27 of 88 (31%) were malignant. There was significantly higher likelihood of detecting foci (8/12, 67%) and masses (60/82, 73%) than non-mass like lesions (20/37, 54%) on second look ultrasound according to this study. (R2; #1) In the retrospective study by Abe et al [6] ultrasound correlation was made in 57% of MRI suspicious lesions with sonographic correlate found for 65% of mass-like lesions versus 12% of non-mass-like lesions. Similarly, Meissnitzer et al [11] found a sonographic correlate for 62% of masses versus for 31% of non-mass-like lesions, while DeMartini et al [7] reported a sonographic correlate in 58% of mass-like lesions, with 30% correlate found for non-mass-like lesions. (R2; #3) This data supports our finding of a higher malignancy rate in non-mass-like lesions during MRVAB.

A significant majority (65%, $P < 0.005$) of malignant non-mass-like lesions were DCIS, with only 19% of malignant masses representing DCIS. This high prevalence of DCIS may be a reason for the low detection rate of non-mass-like lesions by sonography and high MRI-guided biopsy rate for this morphologic group. The most common distribution pattern for non-mass-like lesions in our study was segmental (41%), which is in the reported range of 30%–50% [27, 29]. In mass-like group the significant majority of malignant lesions had irregular/speculated borders (27%, $P < 0.05$).

Non-mass-like lesions were significantly larger than masses, with a mean size of 3.2 cm versus 1 cm, respectively ($P < 0.001$). This may be a contributing factor to the higher rate of malignancy observed in non-mass-like lesions. We also found significantly higher rate of malignancy for large, more than 5 cm, lesions ($P < 0.005$). (R2; #4)

Washout kinetics was significantly more often seen in malignant lesions in our series (33%, $P<0.05$). Similar results were reported by Mahoney et al. [19], who found washout kinetics in 42% of patients. Han et al. [27] reported the highest probability of malignancy in lesions with plateau and washout kinetics (31% and 29% respectively).

A limitation of our study is that not all patients with high risk lesions underwent excision. In our institution, which is a tertiary cancer center, each high risk lesion is discussed at the weekly multidisciplinary clinical management conference, which includes dedicated breast radiologists, breast pathologists, breast oncologists, breast surgical oncologists and cancer prevention specialists. We use published histological predictors for upgrade of ADH to carcinoma together with imaging findings for final management decision for this group of high-risk lesions [33, 34]. Because of the high specialization and high volume encountered in our institution, there is higher confidence in determining follow up care versus surgical excision for patients with high-risk lesions, which may not be comparable to that in practices with less volume. This also illustrates current heterogeneity and controversy in the management of high risk lesions across the nation, due to lack of consistent data and patient numbers. All high risk patients without surgical excision as well as patients with benign MRVAB pathology received follow up care with 6 month follow up MRI, annual mammographic and if indicated yearly sonographic imaging, and serial clinical visits. The mean follow up was 39 months with range from six to 69 months. Another limitation of our study is that as a large tertiary cancer center we have a high referral population, which limits compliance with follow up recommendations. However, no malignancy was found in the follow up group during the study period.

In conclusion, the final malignancy rate in our MRVAB population was 25%, with an upgrade rate of 12%. We found that indications for breast MRI and lesion enhancement characteristics impact the frequency of malignancy diagnosed by MRVAB. The malignancy rate was relatively higher in non-mass-like lesions which showed DCIS in the significant majority of cases. The prevalence of DCIS in non-mass-like lesions explains inability to find sonographic correlate for these lesions on second look ultrasound exam. The probability of malignancy was significantly higher in masses with irregular/speculated borders than in smooth masses. There was significantly higher rate of malignancy in lesions with washout kinetics. The frequency of malignancy was significantly higher in the diagnostic group with almost half of the biopsied suspicious lesions in the subgroup of patients with known ipsilateral cancer being malignant. Therefore, suspicious lesions identified in patients with known ipsilateral breast cancer, require careful radiological-histopathological correlation, to determine and direct the need for surgical evaluation.

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Fig. 1.

58-year-old woman with isolated Paget's disease in the left nipple and no mammographic or sonographic abnormality.

A. Sagittal T1 weighted fat suppressed 3D fast spoiled gradient-echo subtraction MR image with post processed parametric color map demonstrates non-mass-like enhancement (arrow).

B. Kinetic display shows washout enhancement kinetic pattern. **C.** Axial T1 weighted fat suppressed 3D fast spoiled gradient-echo image demonstrates non-mass-like regional clumped enhancement (arrow).

D. Axial T1 weighted fat suppressed fast relaxation fast spin echo image obtained during biopsy shows obturator in place (arrow). Histopathology at MRVAB and surgery was ductal carcinoma in situ, Grade 3.

Fig. 2.

66-year-old woman with right breast cancer presents for staging MRI, which reveals abnormal enhancement in the contralateral left breast.

A. Left sagittal T1 weighted fat suppressed 3D fast spoiled gradient-echo subtraction MR image with post processed parametric color map demonstrates non-mass-like enhancement (arrow).

B. Kinetic display shows plateau enhancement kinetics. **C.** Axial T1 weighted fat suppressed 3D fast spoiled gradient-echo image demonstrates non-mass-like regional clumped enhancement (arrow).

D. Axial T1 weighted fat suppressed fast relaxation fast spin echo image obtained during biopsy shows obturator in place (arrow). Histopathology at MRVAB was fibroadenoma.

A

B

C

D

Fig. 3.

69-year-old woman with palpable thickening at 12 o'clock and negative mammogram and sonography.

A. Sagittal T1 weighted fat suppressed 3D fast spoiled gradient-echo subtraction MR image with post processed parametric color map demonstrates non-mass-like regional enhancement (arrow).

B. Kinetic display shows washout enhancement kinetics.

C. Axial T1 weighted fat suppressed 3D fast spoiled gradient-echo image demonstrates non-mass-like regional enhancement (arrow).

D. Axial T1 weighted fat suppressed fast relaxation fast spin echo image obtained during biopsy shows obturator in place (arrow). Histopathology at MRVAB was atypical ductal hyperplasia. Final histopathology at surgical excision was ductal carcinoma in situ, Grade 2.

Table 1

Histopathology of 218 Lesions that had MRI-guided vacuum-assisted core needle biopsy, Surgery, and Follow up

Histopathology	MRVAB (n=218) (%)	Surgery (n=85) (%)	Follow-up (n=133) (%)
Malignant	48 (22)	48 (100)	0
Benign	133(61)	20 (15)	113 (85)
High risk	37 (17)	17 (46)	20 (54)
Total	218	85 (39)	133 (62)

MRVAB = Magnetic Resonance imaging (MR)-guided Vacuum-Assisted Biopsy; High risk group pathology: Atypical Ductal Hyperplasia (ADH), Atypical Lobular Hyperplasia (ALH), Lobular Carcinoma In Situ (LCIS), Radial scar

Table 2

Indications for MRI and Frequency of Malignancy in 218 Breast Lesions that Underwent MRVAB.

Indications for MRI	Biopsied Lesions (n=218) (%)	Malignant Lesions (n=54) (%)
Screening	41 (19)	4/41 (10)
Diagnostic	177 (81)	50/177 (28) [$P<0.05$]
Known cancer (either breast)	105 (48)	30/105 (29)
Ipsilateral breast Cancer	49 (29)	22/49 (45) [$P<0.001$]
Contralateral breast Cancer	56 (29)	8/56 (14)
History of prior breast Cancer	29 (13)	9/29 (31)
Screening mammogram abnormality	10 (5)	2/10 (20)
Axillary metastasis with unknown primary	8 (4)	4/8 (50)
Others *	25 (11)	5/25 (20)
Total	218	54

MRI = Magnetic Resonance Imaging.

* Others refers to: skin thickening, nipple retraction, palpable finding, and incidental finding during work-up of abnormality in the contralateral breast

Table 3

Lesion Type, Morphology, Kinetic Characteristics and Probability of Malignancy in 218 Lesions.

	Number of Lesions (n=218) (%)	Number of Malignant Lesions/Number of Biopsied Lesions (%)
Lesion Type		
Focus	25 (11)	2/25 (8)
Mass	117 (54)	26/117 (22)
Non-mass	76 (35)	26/76 (34)
Total	218 (100)	54/218 (25)
Mass Lesion Margins		
Smooth	27 (12)	2/27 (7)
Irregular/spiculated	90 (41)	24/90 (27) [$P<0.05$]
Non-mass distribution		
Focal	7 (3)	0/7 (0)
Linear/ductal	27 (12)	10/27 (37)
Segmental	17 (8)	7/17 (41)
Regional	25 (12)	9/25 (36)
Lesion Kinetics		
Persistent	36 (17)	4/36 (11)
Plateau	79 (36)	16/79 (20)
Washout	103 (47)	34/103 (33) [$P<0.05$]

Table 4

Probability of Malignancy by Combined Morphologic and Kinetic Characteristics in 218 Breast lesions that underwent MRVAB.

Morphology	Persistent (n=36) (%)	Plateau (n=79) (%)	Washout (n=103) (%)	Total (n=218) (%)
Focus	0/5 (0)	1/11 (9)	1/9 (11)	2/25 (8)
Smooth mass	0/2 (0)	0/13 (0)	2/12 (17)	2/27 (7)
Irregular/spiculated mass	1/11 (9)	7/28 (25)	16/51 (31)	24/90 (27)
Non-mass	3/18 (17)	8/27 (30)	15/31 (48)	26/76 (34)
Total	4/36 (11)	16/79 (20)	34/103 (33)	54/218 (25)