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# Preoperative magnetic resonance imaging characteristics of oval circumscribed fast enhancing lesions in patients with newly diagnosed breast cancer

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**Abstract**

The aim of this study was to investigate the follow-up results and characteristics of oval circumscribed lesions with fast initial enhancement on preoperative magnetic resonance imaging (MRI) in patients with newly diagnosed breast cancer.

Preoperative data from consecutive patients newly diagnosed with breast cancer between 2010 and 2013 were retrospectively reviewed. Only MRI reports containing, "oval shape, circumscribed margin, and fast initial enhancement," were extracted and analyzed. Follow-up results and clinical and pathological findings were evaluated.

A total of 430 oval circumscribed lesions with fast initial enhancement were included. Forty-eight lesions were pathologically confirmed at initial workup and 382 were followed up. Among the 48 lesions, 14 were found to have additional malignancy and 34 were benign. Among the 382 followed-up lesions, only 1 was subsequently confirmed to be malignant. There were no evident changes in any of the remaining lesions during follow-up. The overall rate of malignancy was 3.5% (15/430). When lesions exhibited delayed washout enhancing kinetics ($P < .001$), were located ipsilaterally ($P = .007$), and closer to the primary tumor ($P = .012$), the possibility of malignancy was high. High T2-weighted imaging signal intensity suggested benignity ($P = .043$).

Although the probability of being diagnosed with malignancy during follow-up in this study was low (0.3%), this investigation revealed several preoperative MRI characteristics that should alert clinicians to the possibility of malignancy.

**Abbreviations:** ACR = American College of Radiology, BI-RADS = Breast Imaging and Reporting Data Systems, BPE = background parenchymal enhancement, CAD = computer-aided diagnosis, MRI = magnetic resonance imaging, ROC = receiver-operating characteristic curve, T2WI = T2-weighted imaging, US = ultrasound.

**Keywords:** breast, follow up studies, magnetic resonance imaging, neoplasm, oval circumscribed lesions

## 1. Introduction

The use of preoperative breast magnetic resonance imaging (MRI) has increased substantially because of its utility in detecting occult disease that may not have been apparent using traditional breast imaging modalities.[1–4] Preoperative MRI in patients with newly diagnosed breast cancer plays an important role in the evaluation of disease extent and in detecting multifocal and multicentric tumor growth in the ipsilateral breast, and is a powerful screening method for synchronous contralateral breast cancer.[5,6] However, breast MRI has modest specificity, which causes a considerable number of false-positive results. When lesions exhibit delayed washout enhancing kinetics, and are located ipsilateral and closer to the primary tumor, the possibility of malignancy is high, is more expensive, and requires the use of an intravenous contrast agent.[2–4,7,8] To standardize and reduce the false-positive rates, the American College of Radiology (ACR) introduced the 2003 edition of the MRI Breast Imaging and Reporting Data Systems (BI-RADS) lexicon.[9] However, there is a lack of clinical data to assess probable benign or unusual enhancing lesions requiring short-term follow-up. Moreover, few studies to date have addressed these limitations. Therefore, it is imperative to provide useful information regarding the detection of additional enhancing lesions in preoperative breast MRI. Among many false-positive lesions, we encounter oval circumscribed enhancing lesions with fast initial enhancement, which encompass morphological benign masses with suspicious enhancing kinetics and those with unique focus from surrounding background parenchymal enhancement (BPE). Oval circumscribed lesions are believed to be benign morphological features

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according to the BI-RADS lexicon in terms of having the lowest positive predictive value for cancer.[10] Considering kinetic features, it has been demonstrated that a delayed washout pattern curve is a strong indicator of malignancy, and is independent of other criteria.[11] If oval circumscribed enhancing lesions exhibit a persistent kinetic curve; they do not require further evaluation. However, we often encounter many oval circumscribed lesions that exhibit initial fast enhancement, irrespective of delayed enhancement kinetics, in clinical practice. In fact, oval circumscribed suspicious enhancing lesions are grouped with heterogeneous spectra in terms of proximity to the index tumor, size, T2-weighted imaging (T2WI) signal intensity, and degree of BPE. For several reasons, these lesions may not always be a reliable indicator of benignity on MRI. First, patients with newly diagnosed breast cancer undergoing MRI are at relatively high risk.[12] Second, the perception of margin smoothness on MRI is dependent on technical factors, including spatial resolution, and window and level settings.[13] Third, the histological correlation of the visually perceived margin in MRI is different from conventional imaging modalities such as mammography.[14,15] These lesions are too prominent to simply be considered as being normal or too small to characterize. It is difficult to assess these diagnostic concerns accurately without sufficient clinical evidence. Currently, there are no specific guidelines or consensus on how to manage these lesions, whether they should be managed conservatively or considered for more aggressive tissue sampling. Furthermore, the significance and outcomes of these lesions are unclear, especially when detected on preoperative MRI in patients with breast cancer. Accordingly, the purpose of our study was to investigate the follow-up results and characteristics of oval circumscribed lesions with fast initial enhancement on preoperative MRI in patients with newly diagnosed breast cancer.

## 2. Material and methods

### 2.1. Study population

Given the retrospective nature of this study and the use of anonymized patient data, requirements for informed consent were waived. The study protocol, however, was approved by the institutional review board. The study population included patients with newly diagnosed breast cancer who underwent preoperative MRI. From January 2010 through May 2013, a total of 502 lesions were found in 326 patients. If an examination revealed >1 lesion, each lesion was evaluated separately. If a patient underwent several MRI scans after the assessment was made, only the initial examination, in which a lesion was identified, was included in the study data. The inclusion criteria were as follows: oval circumscribed enhancing lesions (mass or focus) exhibiting fast enhancement in initial phase within 2 minutes of contrast administration, other than known malignancy; lesions that were correlated pathologically, via either biopsy or excision; and, if biopsy or excision was not performed, follow-up studies for >2 years were reviewed for the lesion's stability. Of the 502 lesions, 72 were excluded, as they were difficult to correlate pathologically because the patient had undergone mastectomy without needle localization or lacked follow-up imaging for >2 years. Therefore, after appropriate inclusion and exclusion criteria were applied, the final study population included 430 oval circumscribed lesions with fast initial enhancement detected on preoperative MRI in 273 patients with newly diagnosed breast cancer (Fig. 1).

### 2.2. MRI technique and interpretation

Bilateral breast MRI was performed using a 1.5 T or 3 T closed-magnet scanner (Achieva, Philips Healthcare, Best, The Netherlands) equipped with a dedicated bilateral breast surface coil. The standard imaging protocol included T2-weighted, fat-suppressed (SPAIR) imaging (repetition time/echo time, 6841/70 ms; flip angle 90 degree; field of view, $300 \times 300$ mm; thickness, 2.0 mm; matrix, $460 \times 430$) and dynamic contrast enhanced, fat-suppressed, gradient echo, T1-weighted axial imaging (repetition time/echo time, 3.92/1.9 ms; flip angle, 12 degree; field of view, $300 \times 300$ mm; dynamic scan duration, 60 seconds; thickness, 2.0 mm; matrix, $300 \times 300$). Patients received gadobutrol (Gadavist or Gadovist, Bayer Pharma AG, Berlin, Germany) at a single dose of 0.1 mmol/kg body weight (corresponding to 0.1 mL/kg). Precontrast and 5 repeated post-contrast images were obtained at 60-second intervals. To evaluate kinetics, a commercial computer-aided diagnostic (CAD) workstation (CADSTREAM version 4.1.3; Confirma, Inc, Kirkland, WA) was used. The CAD system was configured to compare the pixel intensity values of the pre-contrast and immediate post-contrast image series using a 50% enhancement threshold. Preoperative MR examination was performed within 2 to 3 weeks after pathologic confirmation using core needle biopsy. Two radiologists (with 2 and 10 years' experience in breast imaging) retrospectively reviewed the recorded MRI features of the 430 oval circumscribed lesions with suspicious enhancing kinetics. Pathological index, tumor size, and location were noted as ipsilateral or contralateral. If the enhancing lesion was located ipsilateral to the index tumor, distance from the tumor was recorded. The findings of all MRI examinations were evaluated and recorded using ACR BI-RADS MR lexicons. For BI-RADS assessment of category 0 lesions, additional imaging, such as targeted ultrasound (US), was performed to avoid biopsy. For BI-RADS category 3 lesions, short-term follow-up MRI was performed, as recommended by the initial interpretation. Lesions were considered as benign or negative categories, or upgraded to suspicious categories during follow-up imaging. Additionally, corresponding T2WI of oval circumscribed lesions with fast initial enhancement were evaluated and classified visually according to signal intensity. Lesions were rated as having high intensity when they exhibited fluid signal or relatively higher signal intensity than normal breast tissue, or non-high signal intensity with respect to the breast parenchyma by referring to a previous report.[16]

### 2.3. Data and statistical analysis

Medical records were reviewed to evaluate the clinical and final pathological findings. If biopsy or excision was not performed, follow-up studies for >2 years were reviewed for lesion stability. Age, menopausal status, tumor size, and histological tumor profile were recorded for statistical analysis. The independent 2-sample Student $t$ test was used to compare continuous variables between the benign and malignant groups. The $\chi^2$ test, Fisher exact test, or mean $t$ test was used to compare the categorical variables among the groups. Statistical analysis was performed using PASW version 18 (IBM Corporation). All tests were 2-sided, and $P < .05$ was considered to be statistically significant.

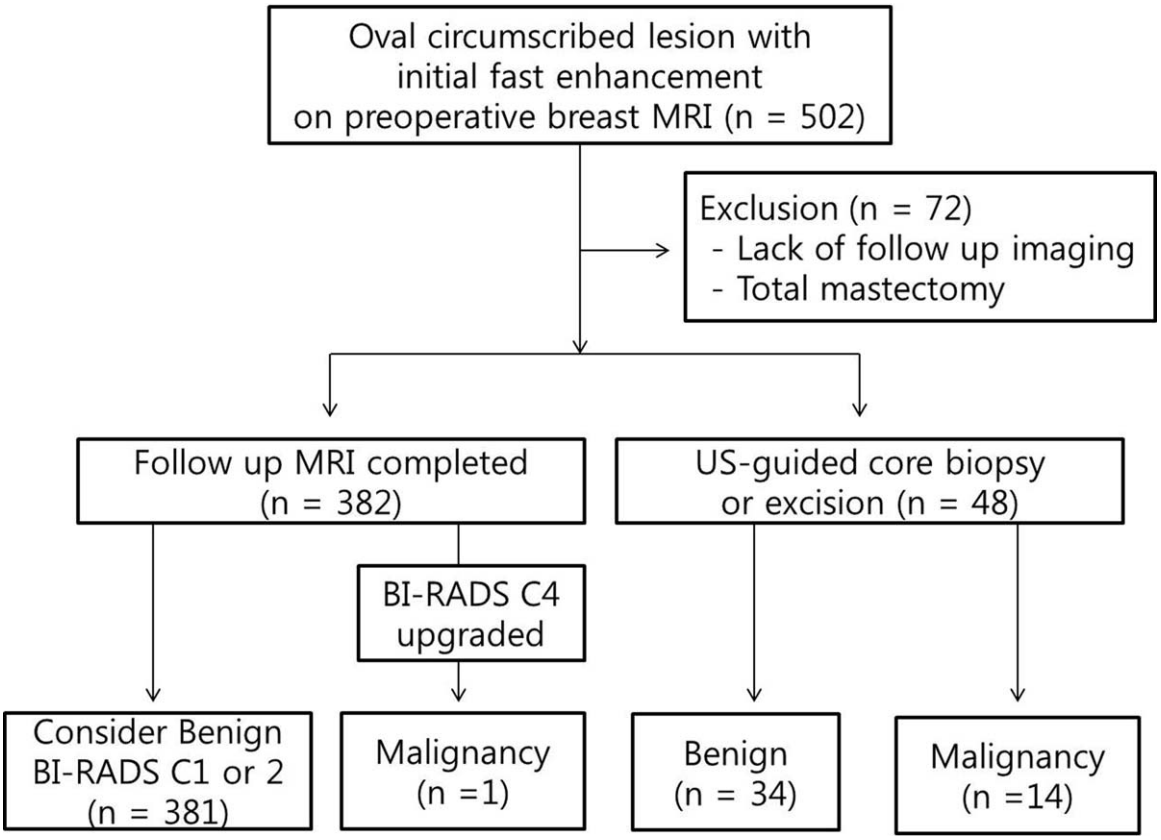


**Figure 1.** Diagrammatic flow chart of the 430 lesions and follow-up results. BI-RADS = Breast Imaging Reporting and Data System, C = category, MRI = magnetic resonance imaging, US = ultrasound.

## 3. Results

### 3.1. Lesions detected at initial primary cancer work-up

Of the 430 oval circumscribed lesions with fast initial enhancement detected on preoperative MRI in patients with newly diagnosed breast cancer, 48 were recommended for MRI-directed targeted US for further evaluation at initial work-up. Forty-eight lesions were correlated on MR-directed targeted US and underwent US-guided core biopsy and US-guided localized excision. Among the 48 lesions, 14 were found to be unsuspected additional malignancies separate from the known index tumor, and 34 were confirmed to be benign (Fig. 1). Oval circumscribed enhancing lesions with fast initial enhancement were apparent on MR-directed US, and were more likely to be confirmed as a malignancy than not (14/48 vs. 1/382; $P \leq .001$). Final pathological analysis of the 14 malignant lesions included: invasive ductal carcinoma (n = 10) (Fig. 2); ductal carcinoma in situ (n = 3); and tubular carcinoma (n = 1) (Table 1). Among the 34 benign lesions, fibroadenoma (n = 10) (Fig. 3) and intraductal papilloma (n = 9) (Fig. 4) were the most common diagnoses. Other benign lesions included atypical ductal hyperplasia, flat epithelial atypia, radial scar, fibrocystic change, sclerosing adenosis, complex sclerosing lesion, florid ductal hyperplasia, nodular adenosis, and mammary duct ectasia.

### 3.2. Lesion follow-up and outcomes

The remaining 382 of 430 lesions were followed-up with imaging only and, of these, 381 (99.7%) were stable or disappeared for at least 2 years. All but 1 was subsequently considered to be in BI-RADS assessment category 1 or 2, based on the stability or resolution of the original MRI findings. Per review of the medical record, these patients were cancer-free at US, mammography, or clinical follow-up for >2 years. One of 382 (0.3%) lesions was upgraded to BI-RADS assessment category 4 because of morphological changes, with persistent suspicious enhancement kinetics on 2-year follow-up after initial MRI. MRI-directed US was performed, and biopsy was obtained. The pathology results revealed invasive ductal carcinoma (Table 1) (Fig. 5).

### 3.3. MRI characteristics of oval circumscribed enhancing lesions

The overall frequency of malignancy in oval circumscribed lesions with fast initial enhancement on preoperative breast MRI was 3.5% (15/430). Fourteen lesions were diagnosed on initial MRI and removed at the time of surgery for definitively known primary breast cancer. The remaining lesion was found at subsequent MRI follow-up. The clinical and pathological features of the 430 oval circumscribed lesions with fast initial enhancement detected on preoperative breast MRI are summarized in Table 2. There were no statistically significant differences in age, family history of breast cancer, or initial clinical tumor staging. There were also no statistically significant differences according to histological and molecular subtypes. Table 3 summarizes the MRI findings of the 430 oval circumscribed lesions. There were no statistically significant differences in size or

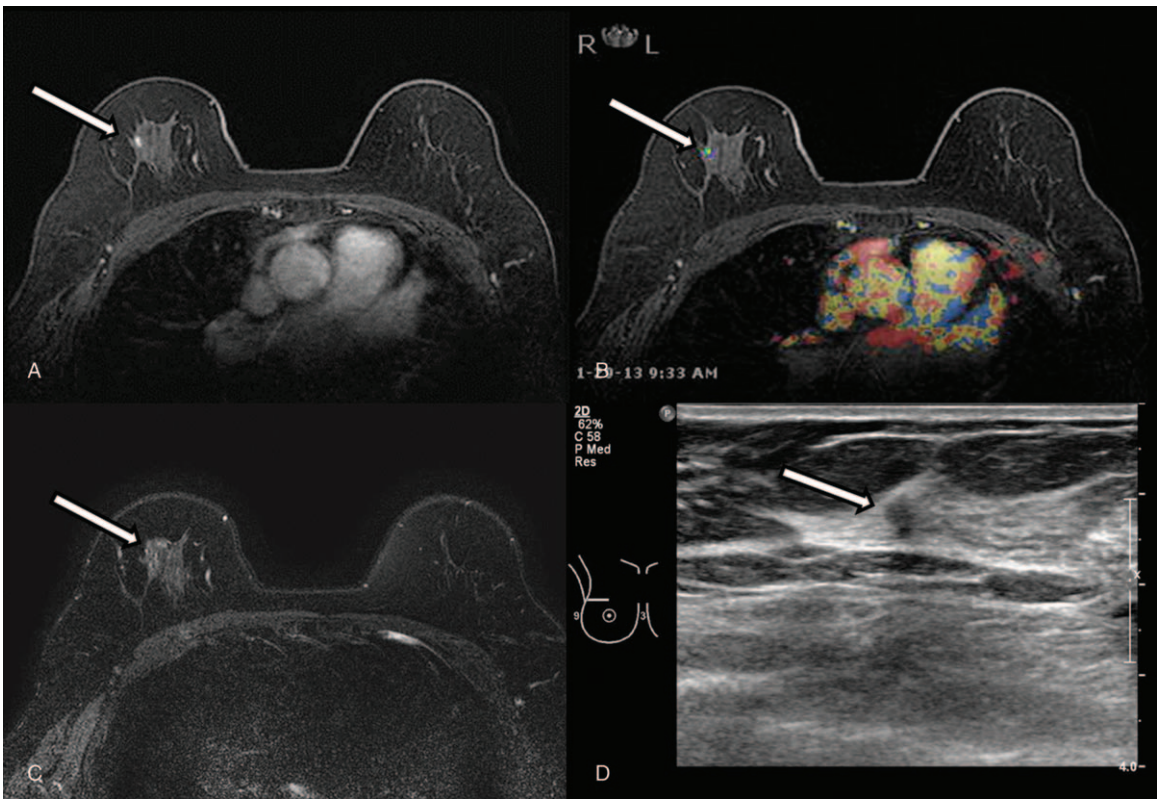


**Figure 2.** Magnetic resonance images (MRI) from a 49-year-old woman with newly diagnosed right breast cancer. (A, B) On preoperative breast MRI, the contrast-enhanced axial image demonstrates additional oval circumscribed enhancing mass revealing initial fast enhancement in the ipsilateral right upper outer breast (arrow). (C) On T2-weighted imaging, the mass exhibited non-high (intermediate) signal intensity compared with breast parenchyma (arrow). (D) MRI-directed ultrasound was performed, and a 0.6 cm oval hypoechoic mass was observed in the right 10'o clock area, correlating with the MRI-detected lesion. Core needle biopsy revealed invasive ductal carcinoma.

disease extent between the benign and malignant groups ($P = .932$). T2WI signal intensity demonstrated statistical significance ($P = .043$), there was no malignancy among lesions that exhibited high signal intensity on T2WI (Fig. 3). In terms of delayed phase enhancement pattern, washout kinetics were significantly higher in the malignant group (53.3% [8/15]) than in the benign group (2.4% [10/415]) ($P < .001$). Among 415 benign lesions, 10 (2.4%) exhibited delayed washout kinetics. Pathologically confirmed benign lesions exhibiting delayed washout kinetics on preoperative MRI were diagnosed as intraductal

**Table 1**

**Characteristics of patients with confirmed malignancy.**

| Pt | Pathology | Size, cm | Time from index examination to diagnosis, mo | Menopause | BPE | Delayed enhancement pattern | Laterality | Distance from main mass, cm |
|---|---|---|---|---|---|---|---|---|
| 1 | DCIS | 1.1 | Initial exam | No | Mild | Plateau | Contra | — |
| 2 | DCIS | 1.3 | Initial exam | Yes | Mild | Plateau | Contra | — |
| 3 | DCIS | 0.6 | Initial exam | No | Mild | Persistent | Ipsil | 1.0 |
| 4 | Tubular ca. | 0.6 | Initial exam | No | Moderate | Wash out | Contra | — |
| 5 | IDC | 0.6 | Initial exam | Yes | Minimal | Wash out | Ipsil | 3.2 |
| 6 | IDC | 0.5 | Initial exam | No | Moderate | Wash out | Ipsil | 0.6 |
| 7 | IDC | 0.7 | Initial exam | No | Moderate | Wash out | Ipsil | 0.7 |
| 8 | IDC | 0.6 | Initial exam | No | Moderate | Wash out | Ipsil | 1.2 |
| 9 | IDC | 0.7 | Initial exam | Yes | Mild | Wash out | Contra | — |
| 10 | IDC | 0.7 | Initial exam | Yes | Mild | Wash out | Ipsil | 1.2 |
| 11 | IDC | 0.7 | Initial exam | Yes | Minimal | Persistent | Contra | — |
| 12 | IDC | 0.5 | Initial exam | Yes | Minimal | Persistent | Ipsil | 2.3 |
| 13 | IDC | 0.5 | Initial exam | Y | Marked | Persistent | Ipsil | 1.8 |
| 14 | IDC | 0.7 | Initial exam | No | Mild | Plateau | Ipsil | 3.7 |
| 15 | IDC | 0.5 | 24 (upgraded at MRI) | No | Marked | Wash out | Ipsil | — |

BPE = background parenchymal enhancement, ca = carcinoma, DCIS = ductal carcinoma in situ, exam = examination, IDC = intraductal carcinoma, Ipsil = ipsilateral, MRI = magnetic resonance imaging, Pt = patient, SI = signal intensity.

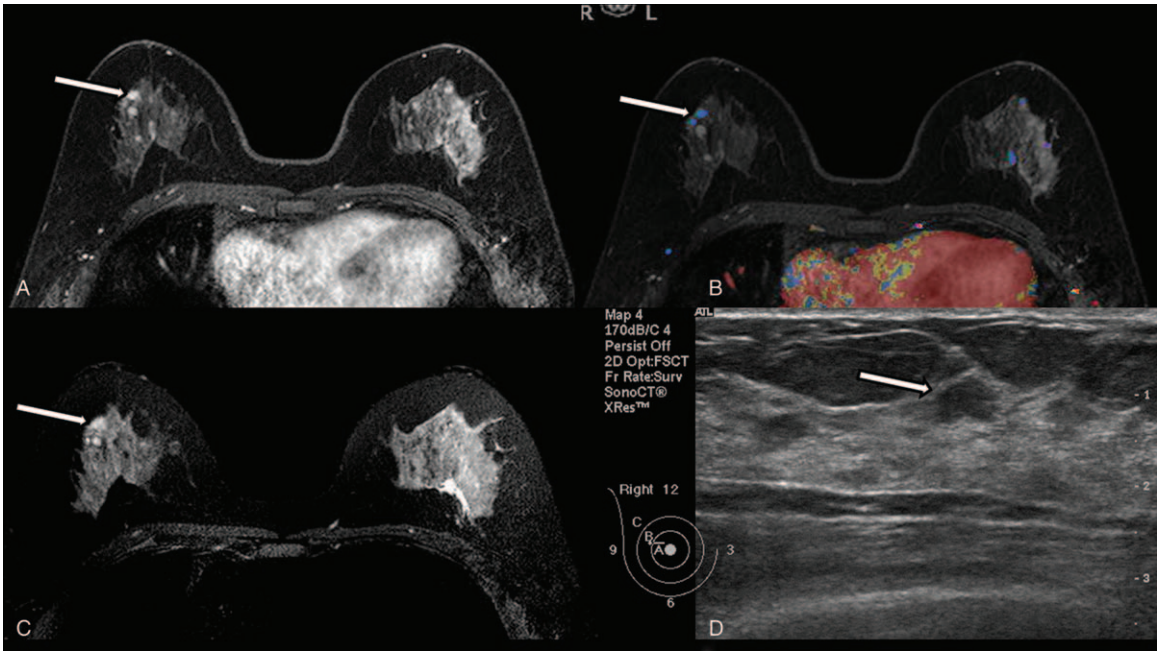


**Figure 3.** Magnetic resonance images (MRI) from a 66-year-old woman with newly diagnosed cancer in the left breast. (A, B) The preoperative breast MRI contrast-enhanced axial image demonstrates an additional oval circumscribed enhancing mass, demonstrating initial fast and delayed persistent enhancement in the contralateral right breast (arrows). (C) T2-weighted imaging signal intensity of this lesion was assessed to be high (arrow). (D) MRI-directed targeted ultrasound was performed, and a 0.6 cm oval hypoechoic mass was observed in the right 10' o clock area (arrow), correlating with the MRI-detected lesion. Core needle biopsy revealed fibroadenoma.

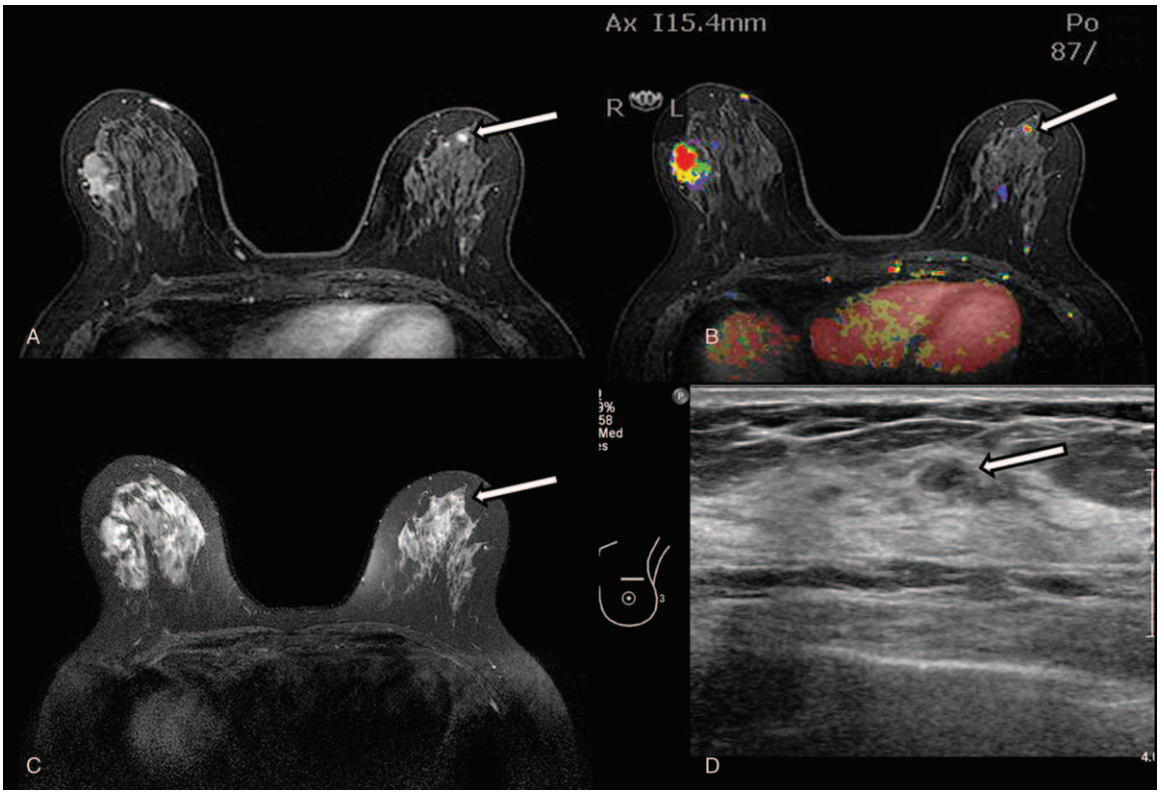


**Figure 4.** Magnetic resonance images (MRI) from a 68-year-old woman with newly diagnosed cancer in the right breast. (A, B) On preoperative breast MRI, the contrast-enhanced axial image demonstrates right breast cancer and a contralateral oval circumscribed enhancing mass exhibiting initial fast and delayed washout enhancement kinetics in the left upper breast (arrow). (C) T2-weighted image signal intensity of this lesion was assessed to be non-high (intermediate) compared with breast parenchyma. (d) MR targeted ultrasound was performed, and a 0.6 cm oval hypoechoic mass (arrow) was seen in the left 12' o clock area, correlating with the MR-detected lesion. Core needle biopsy revealed intraductal papilloma.

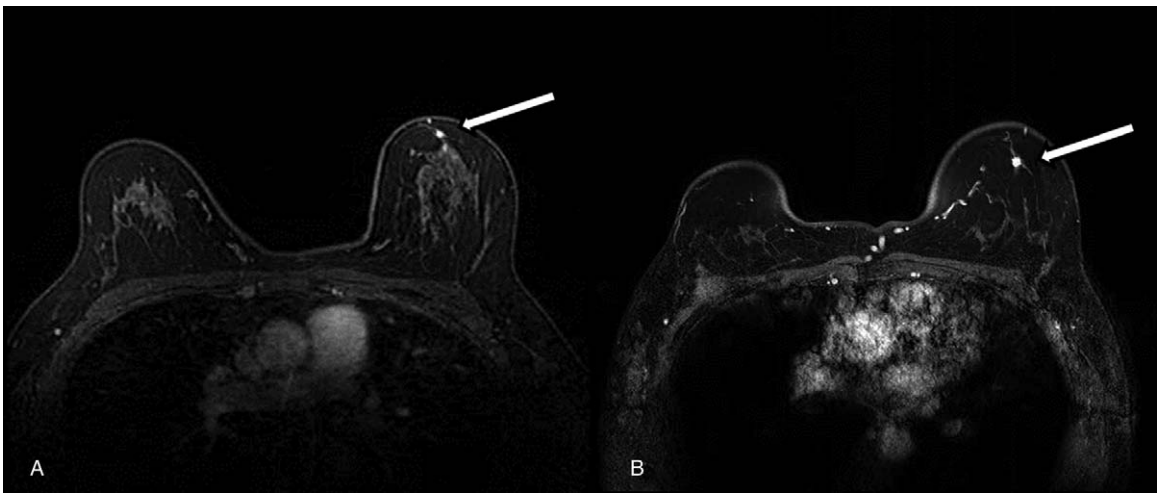


**Figure 5.** Magnetic resonance images (MRI) from 54-year-old woman with newly diagnosed right breast cancer. (A) The preoperative contrast-enhanced axial image of the breast demonstrates a contralateral left breast oval circumscribed enhancing mass (arrow). This lesion exhibited initial fast and delayed washout enhancement kinetics and non-high (intermediate) T2-weighted image signal intensity. Short-interval follow-up was recommended. (B) At 24-month follow-up, the focus appears larger with suspicious morphologic change (arrow). Core needle biopsy revealed invasive carcinoma.

papilloma (n = 5) (Fig. 4), atypical ductal hyperplasia (n = 1), and atypical papilloma (n = 1). The remaining 3 lesions were not confirmed pathologically and downgraded within 2 years of follow-up. Of the 415 benign lesions, 137 (33%) were located in the ipsilateral breast, and the remaining 278 (67%) were located in the contralateral breast. Among the 15 malignant lesions, 10 (66.7%) were located in the ipsilateral breast, and the remaining 5 (33.3%) were located in the contralateral breast ($P = .007$). In 147 oval circumscribed lesions with fast initial enhancement located on the ipsilateral side, the closer the distance from the known primary index tumor, the more likely it was to be malignant ($P = .012$). The 2-cm distance to the index tumor showed the highest area under the receiver-operating characteristic curve (ROC) (0.682). Sensitivity of 72% and specificity of 59% were obtained at the best cutoff point of 19 mm.

**Table 2**

**Comparison of clinicopathologic features between benign and malignant cases.**

| Characteristic | Benign (n = 415) | Malignancy (n = 15) | *P* |
|---|---|---|---|
| Age, y, mean ± SD | 47 ± 10.4 | 55 ± 11.9 | .162 |
| Family history | | | .331 |
| Yes | 52 (12.5) | 0 (0.0) | |
| No | 332 (80.0) | 14 (93.3) | |
| Unknown | 31 (7.5) | 1 (6.7) | |
| Menopausal status | | | .023 |
| Pre-menopause | 325 (78.3) | 8 (53.3) | |
| Post-menopause | 90 (21.7) | 7 (46.7) | |
| Tumor size* | | | .708 |
| cTis | 45 (10.8) | 1 (6.7) | |
| cT1 | 231 (55.7) | 10 (66.7) | |
| cT2 | 116 (28.0) | 4 (26.7) | |
| cT3 | 23 (5.5) | 0 (0.0) | |
| Molecular subtype | | | .685 |
| Luminal A | 199 (48.0) | 9 (60.0) | |
| Luminal B | 93 (22.3) | 2 (13.3) | |
| HER 2-enriched | 53 (12.8) | 1 (6.7) | |
| Triple negative | 70 (16.9) | 3 (20.0) | |
| Histological subtype | | | .148 |
| Intraductal carcinoma | 315 (75.9) | 11 (73.3) | |
| Invasive lobular carcinoma | 29 (7.0) | 0 (0.0) | |
| Ductal carcinoma in situ | 45 (10.8) | 1 (6.7) | |
| Other | 26 (6.3) | 3 (20.0) | |

Data are presented as n (%) unless otherwise indicated. HER2 = human epidermal growth factor receptor 2, SD = standard deviation.

* At initial clinical staging.

**Table 3**

**Comparison of magnetic resonance imaging findings between benign and malignant cases.**

| Characteristic | Benign (n = 415) | Malignancy (n = 15) | *P* |
|---|---|---|---|
| Lesion size, cm, mean ± SD | 0.71 ± 0.34 | 0.72 ± 0.26 | .932 |
| BPE | | | .663 |
| Minimal | 85 | 3 | |
| Mild | 109 | 6 | |
| Moderate | 133 | 4 | |
| Marked | 88 | 2 | |
| T2-weighted imaging signal intensity | | | .043 |
| High | 80 (19.3) | 0 (0) | |
| Non-high | 335 (80.7) | 15 (100) | |
| Delay enhancement pattern | | | <.001 |
| Wash out | 10 (2.4) | 8 (53.3) | |
| Plateau | 118 (28.4) | 3 (20.0) | |
| Persistent | 287 (69.2) | 4 (26.7) | |
| Laterality | | | .007 |
| Ipsilateral | 137 (33.0) | 10 (66.7) | |
| Contralateral | 287 (67.0) | 5 (33.3) | |
| Distance from index tumor (ipsilateral)* | 3.0 ± 1.7 (n = 137) | 1.6 ± 1.1 (n = 10) | .012 |

Data are presented as n (%) unless otherwise indicated. BPE = background parenchymal enhancement.

* Only in ipsilateral lesions (total n = 147).

## 4. Discussion

Several authors have reviewed the outcomes of short-term follow-up of probable benign MR lesions. These lesions have been reported to occur at a frequency of 7% to 24% of total MR examinations, with malignancy rate of 1% to 4%.[17–22] As evident from the wide variation, there are differences according to the indication for breast MRI. In our institution, the most common indications for breast MRI are preoperative assessment of the extent of malignant disease and identification of additional malignant lesions after the initial diagnosis of breast cancer.

In the first experience in our practice, the concept of MR BI-RADS category 3 was relatively new and introduced some challenges. The MR BI-RADS category 3 metrics are not well established, and there is a lack of standard imaging characteristics and defined criteria. Therefore, short-term MRI follow-up lesions were highly variable in our population, and BI-RADS category 0 (i.e., incomplete assessment) and BI-RADS category 3 (short-term follow-ups) were frequently and inappropriately applied. The most common findings that caused difficult decision making were morphologically benign lesions (i.e., oval circumscribed enhancing mass or unique focus) exhibiting suspicious enhancing kinetics. Suspicious kinetics included fast enhancement in the initial phase that is conspicuous from BPE when using CAD software. Therefore, we decided to assess the clinical implications of oval circumscribed enhancing masses that exhibited fast initial enhancement.

The total malignancy rate for the 430 incidentally detected oval circumscribed enhancing lesions with fast initial enhancement in this study was 3.5% (15/430). Fourteen lesions were confirmed to be malignant on initial preoperative MRI work-up, and 1 malignant lesion was found at subsequent MRI examinations at 2 years' follow-up. During MRI surveillance, 99.7% (381/382) of the lesions were subsequently downgraded to BI-RADS category 1 or 2. The vast majority of the lesions were either decreased in size or had disappeared on follow-up MRI. Our results suggest that, given the low cancer rate, oval circumscribed enhancing lesions with fast initial enhancement may be safely downgraded. Moreover, follow-up MRI for these lesions is unnecessary, especially considering the high cost of MRI. During the assessment of possible malignant lesions, when oval circumscribed enhancing lesion(s) with fast initial enhancement were confirmed on MRI-directed, targeted US, they were more likely to be malignant (14/48 vs. 1/382; $P < .001$). In our study population involving 430 lesions, we found an additional suspicious lesion on MRI-directed targeted US in 11.2% (48/430), which eventually underwent additional biopsy procedures. In fact, the indications for MRI-directed targeted US were somewhat expanded. It was often used to determine the suitability of US-guided biopsy for suspicious enhancing lesions, which are associated with a higher risk for malignancy. If the oval circumscribed fast enhancing lesion observed on MRI in the preoperative evaluation is also evident on additional targeted US, the possibility of malignancy is high. According to our data, when it is not visible on additional targeted US, the possibility of malignancy is low and, therefore, can be followed.

In contrast to some statistically significant MRI findings in relation to benignity or malignancy, oval circumscribed enhancing lesions with fast initial enhancement exhibiting high signal intensity on T2WI are usually not malignant. From a histological perspective, high signal intensity on T2WI suggests the presence of an entrapped enlarged duct or cystic component. Therefore, there is a high likelihood of papilloma and cysts. Among 80 lesions exhibiting high signal intensity on T2WI, 46.3% (37/80) disappeared. We speculate that this result was because of size reduction of the cysts. Approximately 48.8% (39/80) of lesions were stable during follow-up. We presume that this result was because of stable cysts, lymph nodes, or intraductal papilloma. Intramammary lymph nodes must be considered in the differential diagnosis of initially detected oval circumscribed lesion(s) on contrast-enhanced breast MRI. In several previous reports, core biopsy was performed for these lesions, and histopathology revealed reactive lymphoid hyperplasia.[5,23–25] Conversely, enhancement characteristics are not helpful because normal lymph nodes may avidly enhance [26,27] and can demonstrate an enhancement pattern similar to that of malignant lesions.[28] Therefore, meticulous correlation among targeted US or mammography is necessary to minimize the risks for false-positives on breast MRI. In our study, there was no lymphatic tissue in the biopsy results, and lymph nodes identified in patients who underwent an additional targeted US were considered to be benign. The 3 remaining lesions were pathologically confirmed as fibroadenoma, and 1 was a fibrocystic change. These pathological results were compatible with the high signal intensity findings on T2WI. When considering the delayed enhancement pattern(s), of the 18 lesions exhibiting delayed washout kinetics, 10 were benign and 8 were confirmed to be malignant. Delayed washout enhancing lesions have a higher possibility of malignancy. This result supports previously reported findings according to malignancy.[29] Among the 10 benign lesions exhibiting a delayed washout pattern, one was confirmed to be atypical ductal hyperplasia, and 3 disappeared during follow-up. The remaining 6 (60%) lesions were confirmed to be papillomas.

When the enhancing lesions are small, morphological characteristics generally cannot provide sufficient support for a confident diagnosis, and washout kinetics lead to more suspicious findings. In addition, several previous reports have suggested that some papillomas also exhibit fast initial enhancement and delayed washout patterns, similar to those of invasive ductal carcinoma. Of the pathologically confirmed breast lesions in our study, intraductal papilloma and fibroadenoma were the most common; therefore, when oval circumscribed lesions are detected on MRI exhibiting delayed washout kinetics, intraductal papilloma should be considered.

If oval circumscribed fast enhancing lesions exhibit high signal intensity on T2WI, the possibility of a benign lesion, such as fibroadenoma, is very high; consequently, additional tissue confirmation is not required. If oval circumscribed fast enhancing lesions exhibit a washout pattern on the delay phase, the possibility of a benign lesion, such as papilloma, is very high and no additional short-term MR follow-up is needed. Additional special MR sequences, such as diffusion weighted images, also could offer additional tissue information.[30,31] The probability of malignancy was higher in lesions located ipsilaterally to the index tumor than the contralateral lesions. In ipsilateral cases, proximity to the index tumor increased the probability of malignancy.

Our study had some limitations. First, the study was a retrospective, single-institution design, wherein images were read by multiple operators, with variations in the completeness of lexicon characterization and classification. Second, enhancing lesions adjacent to the known index tumor, which did not have pathological correlates from local biopsy or excision, were included in this study and removed together with the tumor in breast-conserving surgery. However, before surgical treatment, targeted US was performed in all cases, and the lesions were

evaluated and confirmed pathologically. The lesions that were not seen in the targeted US were highly likely to have been benign, as the data in this study suggest and, therefore, would not have had a significant impact on the actual results. Third, the assessment category of the oval circumscribed lesions with fast initial enhancement was distributed as BI-RADS categories 3, 4, and 0, inconsistently. Therefore, we could not evaluate the outcome according to the BI-RADS category. However, targeted US was performed in all cases, and the category was judged to have no effect on the actual outcome. Despite the fact that many studies investigating breast MRI have been published, there is currently little evidence to determine which MRI-detected lesions are appropriate for further characterization, including biopsy, short-interval follow-up, or the length of time required to establish imaging stability, especially when detected on preoperative MRI of patients with breast cancer. It is important to share data regarding the outcome(s) of suspicious small, benign-appearing enhancing lesions (i.e., oval circumscribed enhancing lesions with fast initial enhancement) to avoid unnecessary biopsy and follow-up.

In conclusion, the malignancy rate of oval circumscribed lesions with fast initial enhancement detected on preoperative MRI was 3.5%. However, the probability of being diagnosed with malignancy during the follow-up was as low as 0.3%. When these types of lesions exhibit delayed washout kinetics, non-high signal intensity on T2WI, and are located ipsilateral and closer to the primary tumor at the initial work-up, the possibility of malignancy should be considered.

## Author contributions

**Conceptualization:** Mijung Jang.
**Data curation:** Ja Yoon Jang.
**Formal analysis:** Hye Shin Ahn.
**Methodology:** Bo La Yun.
**Software:** Bo La Yun.
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