

# Screening Breast MR Imaging in Women with a History of Lobular Carcinoma in Situ<sup>1</sup>

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## Purpose:

To assess the utility of screening magnetic resonance (MR) imaging in the detection of otherwise occult breast cancers in women with a history of lobular carcinoma in situ (LCIS).

## Materials and Methods:

This HIPAA-compliant study received institutional review board approval. The need for informed consent was waived. Retrospective review of the database yielded 670 screening breast MR studies obtained between January 2003 and September 2008 in 220 women with a history of LCIS. MR and mammographic findings were reviewed. Number of cancers diagnosed, method of detection, and tumor characteristics were examined. The cumulative incidence of developing breast cancer as detected with MR imaging and mammography was calculated. Breast density was examined as a prognostic factor in the cumulative incidence analysis.

## Results:

Biopsy was recommended in 63 lesions seen in 58 (9%) of 670 screening MR studies. Eight additional lesions were identified at short-term follow-up MR imaging for a total of 71 lesions in 59 patients. Twelve cancers (20%) were identified in 60 lesions sampled. Biopsy was recommended in 26 additional lesions identified at mammography; biopsy was performed in 25 of these lesions and revealed malignancy in five (20%). Overall, 17 cancers were detected in 14 patients during the study period. Of these, 12 were detected with MR imaging alone, and five were detected with mammography alone. Of the 12 cancers detected at MR imaging, there were nine invasive cancers and three cases of ductal carcinoma in situ (DCIS). Of the five cancers detected at mammography, two were invasive and three were DCIS.

## Conclusion:

MR imaging is a useful adjunct modality with which to screen women with a history of LCIS at high-risk of developing breast cancer, resulting in a 4.5% incremental cancer detection rate. Sensitivity in the detection of breast cancer with a combination of MR imaging and mammography was higher than sensitivity of either modality alone.

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**A**lthough a woman's average lifetime risk of developing breast cancer is one in eight, several factors increase her risk of developing breast cancer; these include genetic predisposition to develop breast cancer, family and/or personal history of breast cancer, and history of mantle radiation (1–3). A biopsy-proved diagnosis of lobular carcinoma in situ (LCIS) is also associated with an increased risk of breast cancer, resulting in a seven- to 12-fold increased relative risk estimate (4,5). The true incidence of LCIS is unknown, as LCIS is rarely mammographically visible and is usually an incidental finding at biopsy performed for other reasons. LCIS is commonly considered an indicator for risk of developing subsequent breast cancer as opposed to a precursor of invasive carcinoma (4,6). The interval between initial diagnosis of LCIS to development of subsequent cancer may be long; in fact, it has been reported to be more than 15 years in over 50% of cases (5,7).

The optimal strategy for screening all women at increased risk of developing breast cancer has yet to be established. Several groups recommend supplemental screening with magnetic resonance (MR) imaging in certain subgroups of women at high risk for breast cancer. The sensitivity of breast MR imaging in the

detection of breast cancer is high, ranging from 94% to 100%; however, specificity is lower, ranging from 37% to 97% and resulting in additional biopsies that yield normal findings, increased patient anxiety, and increased health care costs (1,8–10). These reasons underscore the importance of selecting appropriate patients for supplemental breast MR screening. On the basis of expert consensus opinion, the American Cancer Society, American College of Radiology, and Society of Breast Imaging recommend annual screening MR imaging as an adjunct to annual mammography in women with a lifetime risk of developing breast cancer of 20% or more (11,12). This recommendation is primarily based on experience in women who have a high risk of developing breast cancer because of a strong family history of disease or because of a gene mutation. To our knowledge, only one published study has been performed to evaluate the utility of screening breast MR imaging in women with a history of LCIS and atypical hyperplasia (13). Thus, the American Cancer Society states that there is insufficient evidence to recommend for or against MR screening in this population (12). The purpose of this study was to assess the utility of screening MR imaging in the detection of otherwise occult breast cancers in women with a history of LCIS.

cases of LCIS diagnosed at percutaneous biopsy at our institution. Of these 840 breast MR examinations, 670 were performed as routine screening studies and 170 were performed as short-term follow-up studies.

Breast MR imaging was performed with the patient in the prone position. Examinations were performed with a 1.5- or 3.0-T commercially available system (Sigma; GE Medical Systems, Milwaukee, Wis) and use of a dedicated surface breast coil. Imaging sequences included a localizing sequence, a sagittal fat-suppressed T2-weighted sequence, and a T1-weighted three-dimensional, fat-suppressed fast spoiled gradient-echo sequence before and three times after rapid bolus injection of 0.1 mmol/L gadopentetate dimeglumine (Magnevist; Berlex, Wayne, NJ) per kilogram of body weight. Table 1 outlines our standard imaging protocol.

All breast MR images were interpreted by dedicated breast imaging radiologists in conjunction with review of the clinical history and other available breast images. For each case, a final assessment was assigned by using American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) categories 1 to 5 (14). Classification primarily was based on lesion morphology, which was characterized as masslike or non-masslike enhancement. Kinetic features were visually assessed on the three contrast

### Advances in Knowledge

- Screening breast MR imaging performed in women with a history of lobular carcinoma in situ (LCIS) resulted in a 4.5% incremental cancer detection rate.
- In patients with LCIS who had no additional risk factors for breast cancer, screening breast MR imaging revealed malignancy in 5% of patients who underwent screening.
- The 12 mammographically occult cancers detected at screening MR imaging included three cases of DCIS and nine cases of early T1 invasive cancers.
- Five cancers detected during the study period were detected only with mammography.

### Materials and Methods

Our institutional review board approved this Health Insurance Portability and Accountability Act–compliant study, and the need for patient informed consent was waived. Retrospective review of the radiology department database revealed 840 breast MR examinations performed at our institution between January 2003 and September 2008 in 220 women with a history of LCIS diagnosis before 2006 at percutaneous or surgical biopsy. Surgical excision is recommended for all

### Implication for Patient Care

- Annual screening MR imaging may be useful as an adjunct to annual mammography in women with a history of LCIS.

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### Abbreviations:

BI-RADS = Breast Imaging Reporting and Data Systems  
DCIS = ductal carcinoma in situ  
LCIS = lobular carcinoma in situ

### Author contributions:

Guarantor of integrity of entire study, J.S.S.; study concepts/study design or data acquisition or data analysis/interpretation, all authors; manuscript drafting or manuscript revision for important intellectual content, all authors; manuscript final version approval, all authors; literature research, J.S.S.; clinical studies, J.S.S., R.A., D.D.D., E.A.M.; statistical analysis, S.F.M.; and manuscript editing, J.S.S., S.F.M., D.D.D., E.A.M.

Potential conflicts of interest are listed at the end of this article.

Table 1

## Standard MR Imaging Protocols

Sequence	Repetition Time (msec)/ Echo Time (msec)	Flip Angle (degrees)	Field of View (cm)	Section Thickness (mm)	Matrix	No. of Signals Acquired
Scout	150/Minimal	70	48	10	256 x 128	1
Sagittal T2 fat saturated	4000/102	90	18–22	3	192 x 256	2
Sagittal T1 nonfat saturated	4000/2.2	10	18–22	3	256 x 192	1
Sagittal T1 fat saturated precontrast	4000/2.2	10	18–22	3	256 x 192	1
Sagittal T1 fat saturated postcontrast x3	4000/2.2	10	18–22	3	256 x 192	1
Axial T1 fat saturated postcontrast	4000/2.2	10	28–36	1 at 1.5 T, 0.8 at 3.0 T	320 x 320 at 1.5 T, 384 x 384 at 3.0 T	1

material-enhanced images. Quantitative kinetic curves were generated in specific cases at the request of the interpreting radiologist.

For lesions detected with MR imaging that warranted biopsy, targeted breast ultrasonography (US) was recommended at the discretion of the radiologist interpreting the MR images if it was thought that the lesion might be evident at US, thereby enabling US-guided biopsy. If the lesion was not seen at US, MR-guided core biopsy or needle localization prior to surgical excision was performed.

Medical records of the 220 women were reviewed to determine the age at LCIS diagnosis, the interval between the LCIS diagnosis and MR examination, and the presence of additional risk factors, including family history of breast cancer, which was defined as breast cancer in a first-degree relative. Patients with a personal history of breast cancer were excluded.

We reviewed the most recent digital or screen-film mammographic reports for each MR imaging study to determine whether an abnormality identified at either MR imaging or mammography was detected with the other modality. Mammographic findings were reported according to the American College of Radiology BI-RADS lexicon.

Pathologic records were reviewed for the results of biopsies performed with mammographic, US, or MR guidance. Biopsy results were used to categorize lesions as benign, malignant, or high risk. The number of cancers diagnosed, the method of detection, and the characteristics of cancers were examined.

Sensitivity and specificity were determined on a per-patient basis. The exact 95% binomial proportion confidence intervals were calculated by using methods described by Clopper and Pearson (15). The McNemar test was used to evaluate paired data (16). Associations between categorical variables were assessed by using the Pearson  $\chi^2$  test for large sample sizes and the Fisher exact test for small sample sizes (whenever a cell contained fewer than five observations). Findings were considered significant at  $P < .05$ . To evaluate the accuracy of MR imaging and mammography in the detection of breast cancer, patient-level analysis was conducted. Diagnostic test accuracy was evaluated by using receiver operating characteristics curve analysis and estimating the area under the receiver operating characteristics curve (17). Cumulative incidence of developing breast cancer as detected with MR imaging and mammography were plotted by using the methods of Fine and Gray (18). The Gray test was performed to assess the significance of breast density as a prognostic factor in the cumulative incidence analysis (19). All statistical analyses were performed with commercially available software (PASW Statistics, version 18.0; SPSS, Chicago, Ill).

## Results

### MR Findings

A total of 840 breast MR imaging examinations were performed in 220 women with a history of LCIS. Of these, 670 were routine screening studies. A median

of three MR examinations per patient were performed (range, one to eight examinations per patient), and a median of 3 years of follow-up screening data were obtained (range, 0–5.5 years of data). The median age at LCIS diagnosis was 47 years (range, 25–76 years). The median age at first MR screening was 51 years (range, 27–78 years). The median interval between LCIS diagnosis and the first screening MR examination was 2 years (range, 0.5–19.0 years). A total of 64 patients (29%) had a family history of breast cancer. In the 220 patients, breasts were extremely dense in 55, moderately dense in 113, and mildly dense in 52.

A total of 504 (75%) MR studies were assigned to BI-RADS category 1 or 2. Short interval follow-up was recommended in 108 studies (16%), mainly for diffuse stippled enhancement. Follow-up images were obtained in all but four cases. For the other 104 studies assigned to BI-RADS category 3, the abnormalities were either resolved or unchanged, and none of the studies resulted in a diagnosis of cancer. In the remaining 58 studies (9%), 63 lesions (five bilateral lesions) were assigned to BI-RADS category 4. Biopsy was also recommended in eight additional lesions identified at follow-up imaging. Thus, biopsy was recommended for 71 lesions in 59 (27%) of 220 patients at some time during the study period. Of these 71 lesions, 47 (66%) had masslike enhancement and 24 (34%) had non-masslike enhancement, including 20 with clumped enhancement and four with linear enhancement.

Of the 71 BI-RADS category 4 lesions, mammography was performed

within 1 month after MR imaging in 37 (52%) of the 71 lesions, between 1 month and 6 months after MR imaging in 25 (35%) lesions, and between 7 and 12 months after MR imaging in eight (11%) lesions. One patient did not undergo mammography within 1 year after MR imaging. A mammographic correlate was identified in two (3%) of 71 lesions. Targeted US was performed at the discretion of the radiologist in 47 (66%) of 71 lesions that were deemed suspicious at MR imaging. A US correlate was identified in 19 (40%) of 47 lesions. The US correlates were masses in 18 cases and distortion in one case.

Biopsy was performed in 60 of the 71 lesions. We used MR imaging guidance in 44 (73%) lesions, US guidance in 14 (23%), and mammographic guidance in two (3%). Eleven lesions were not sampled. In three cases, MR-guided biopsy was cancelled because the lesion was not seen when the biopsy was to be performed. Seven lesions underwent short-term interval follow-up once no correlate or a benign-appearing correlate was seen on targeted US images. The initial abnormality either resolved or was stable at follow-up examinations, which were performed 6 months to 5 years after the initial examination. One patient was lost to follow-up.

In the 60 lesions biopsied on the basis of MR findings, pathologic analysis yielded benign results in 27 (45%), high-risk lesions in 21 (35%), and malignancy in 12 (20%), including one case of a high-risk lesion that was malignant (ductal carcinoma in situ [DCIS]) at subsequent excision. Of the 12 cancers, seven were invasive ductal carcinoma, two were invasive lobular carcinoma, and three were DCIS. Ten of 12 cancers identified at MR imaging manifested as masslike lesions, and two manifested as clumped non-masslike enhancement. The high-risk lesions included 13 cases of LCIS, five papillary lesions, two cases of atypia, and one radial scar. At least 2 years of follow-up data were available for 39 of the 48 lesions classified as benign or high risk at biopsy, which enabled us to confirm that they were stable. For the remaining nine lesions, between 1 and 2 years of follow-up data

were obtained in five lesions, less than 1 year of follow-up data were obtained in two lesions, and no follow-up data were available in two lesions.

### Mammographic Findings

In an additional 25 patients, mammograms showed suspicious calcifications, whereas MR images did not. In one patient, bilateral suspicious calcifications were present; therefore, a total of 26 suspicious lesions were seen on mammograms. In 20 of these cases, MR imaging was performed within 6 months of mammography, and both examinations were performed within 12 months of each other in all cases (median interval between examinations, 1 month; range, <1 day to 12 months). Stereotactic biopsy was performed in 25 lesions and revealed invasive carcinoma in two and DCIS in three.

During the study period, we diagnosed 17 breast cancers in 14 patients (Table 2). Breast cancer developed in the same breast as LCIS in five patients and in the contralateral breast in eight patients. In one patient, bilateral DCIS was initially diagnosed when lesions were detected in the left breast at MR imaging and in the right breast at mammography; this patient underwent treatment and invasive left breast cancer was subsequently diagnosed at MR imaging performed at 8-month follow-up. Of the 17 cancers detected, 12 (71%) were detected with MR imaging alone and five (29%) were detected with mammography alone. Four of the cancers detected with MR imaging were identified at the first screening MR examination; these represented incidental cancers. The interval between the MR examination in which the cancer was detected and the prior MR examination was 6 months for three cancers, 8 months for one cancer, 12 months for two cancers, 18 months for one cancer, and 4 years for one cancer. Of the 12 cancers detected with MR imaging alone, negative mammographic findings had been obtained within 1 month of MR imaging in seven cases and between 1 and 6 months of MR imaging in five cases. The 12 mammographically occult cancers were classified as either DCIS or T1 invasive

cancers. Three patients had axillary nodal involvement. Eight of nine invasive cancers manifested as masslike enhancement, and one cancer manifested as non-masslike enhancement. Two cases of DCIS manifested as masslike enhancement, and one manifested as non-masslike enhancement. Of the 10 patients with mammographically occult breast cancer, three had extremely dense breast tissue and seven had heterogeneously dense breasts. Screening MR imaging revealed mammographically occult cancers in 10 (4.5%; 95% confidence interval: 2%, 8%) of the 220 patients. MR imaging revealed mammographically occult cancers in eight (5%; 95% confidence interval: 2%, 10%) of 156 patients with a history of LCIS and no additional risk factors.

In addition to the 12 cancers detected at MR imaging, five additional cancers were detected at mammography alone. MR images had been obtained within 6 months of the abnormal mammogram. These five cancers appeared as calcifications on mammograms. Breasts were heterogeneously dense in four patients and extremely dense in one patient. Biopsy of calcifications was performed in 20 additional patients in whom no abnormality was identified on MR images.

The biopsy recommendation rate per patient was higher for MR imaging than for mammography (27% [59 of 220 patients] vs 12% [25 of 214 patients],  $P < .0001$ ). Although more cancers were detected with MR imaging, the cumulative incidence was not significantly different between varying breast densities, as shown by competing risk analysis (MR imaging,  $P = .62$ ; mammography,  $P = .86$ ) (Figure). Overall, MR imaging resulted in higher sensitivity, lower specificity, and higher accuracy when compared with mammography (Table 3).

### Discussion

Early detection of breast cancer with mammographic screening has resulted in increased survival (20). Supplemental screening with annual breast MR imaging has been shown to enable detection

Table 2

## Clinical and Imaging Features of Patients with Breast Cancer

Patient No.	Age at LCIS Diagnosis (y)	Age at Breast Cancer Diagnosis (y)	Side of LCIS	Side of Breast Cancer	Additional Risk Factor	Detection Method	Imaging Finding	Pathologic Finding*	Nodal Status
1	49	59	R	R	Family history	MR imaging	Masslike enhancement	Invasive ductal carcinoma (NA <sup>†</sup> )	Negative
2	40	52	L	L	None	MR imaging	Masslike enhancement	Invasive ductal carcinoma (NA <sup>†</sup> )	NA <sup>‡</sup>
3	55	56	R	L	None	MR imaging	Masslike enhancement	Invasive ductal carcinoma (0.5)	Negative
4	44	48	L	L	None	MR imaging	Masslike enhancement	DCIS	None
		48	L	R	None	Mammography	Calcifications	DCIS	None
		48	L	L	None	MR imaging	Masslike enhancement	Invasive ductal carcinoma	Negative
5	49	53	L	L	None	MR imaging	Masslike enhancement	DCIS	None
		57	L	L	None	MR imaging	Masslike enhancement	Invasive ductal carcinoma (1.2)	Positive
6	61	61	L	R	None	MR imaging	Calcifications	Invasive lobular carcinoma (1.3)	Negative
7	46	59	L	R	Family history	MR imaging	Masslike enhancement	Invasive lobular carcinoma (0.5)	Positive
8	38	39	L	R	None	MR imaging	Calcifications	DCIS	None
9	43	43	R	L	None	MR imaging	Masslike enhancement	Invasive ductal carcinoma (0.9)	Negative
10	39	40	R	R	None	MR imaging	Masslike enhancement	Invasive ductal carcinoma (0.8)	Positive
11	42	47	R	R	Family history	Mammography	Calcifications	Invasive ductal carcinoma (0.4)	Negative
12	38	45	L	R	None	Mammography	Calcifications	DCIS	None
13	51	52	L	R	Family history	Mammography	Calcifications	DCIS	None
14	51	54	R	L	Family history	Mammography	Calcifications	Invasive lobular carcinoma (NA*)	Positive

Note.—Data in parentheses are diameters. L = left, NA = not applicable, R = right

\* Data in parentheses are diameter (in centimeters).

<sup>†</sup> No residual carcinoma identified at time of surgical excision.

<sup>‡</sup> Lumpectomy was not performed at our institution. No additional information available in medical records.

of otherwise occult breast cancers in women who are at high risk of developing breast cancer because of a strong family history of the disease or because of a genetic mutation (1,21–24). To date, however, there is little evidence to support use of screening MR imaging specifically in this subset of women at high risk of developing breast cancer because of a history of LCIS. To our knowledge, there has been only one published study in which researchers evaluated the utility of screening breast MR imaging in women with LCIS; the study included 135 patients with LCIS who were enrolled in a screening

program for women who had a high risk of developing breast cancer (13). In that study, MR imaging depicted mammographically occult cancers in 4% of patients who underwent screening. In our study, MR imaging and mammography resulted in an incremental cancer detection rate of 4.5% (10 cancers detected in 220 patients; 95% confidence interval: 2%, 8%), which is within the 2%–7% range of cancers detected only at MR imaging in other high-risk populations (1,23,24).

The interval between diagnosis of LCIS and development of carcinoma is unclear. In one study, researchers found

that the risk of breast cancer is greatest in the first 15 years after LCIS diagnosis; in another study, researchers found that more than 50% of subsequent cancers develop more than 15 years after LCIS diagnosis (4,7,25). In our study, the median interval between diagnosis of LCIS and the first invasive cancer was 4 years; the interval was less than 15 years in all patients. Subsequent breast cancer developed in the ipsilateral breast in five patients and in the contralateral breast in eight patients. One patient developed bilateral breast cancer. Although the risk of subsequent breast cancer in patients with LCIS is

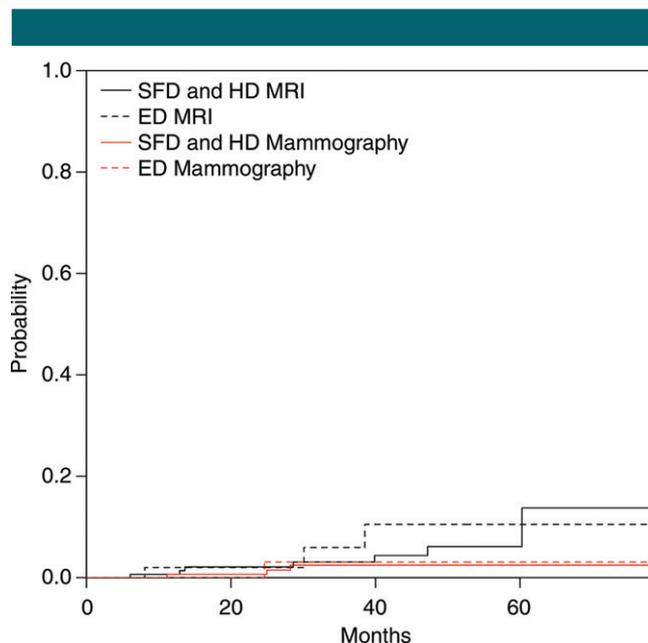
Table 3

## MR and Mammographic Performance in Detection of Breast Cancer

Diagnostic Test and Result	Result of Pathologic Examination*		Test Performance†			
	Breast Cancer	No Breast Cancer	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
MR imaging (n = 220)			71 (42, 91)	76 (70, 82)	17 (8, 29)	98 (94, 99)
Positive findings	10 (5)	49 (22)	...	...	...	...
Negative findings	4 (2)	157 (71)	...	...	...	...
Mammography (n = 214)			36 (13, 65)	90 (85, 94)	20 (7, 41)	95 (91, 98)
Positive findings	5 (2)	20 (9)	...	...	...	...
Negative findings	9 (4)	180 (84)	...	...	...	...

\* Data are numbers of patients with the given finding. Data in parentheses are percentages.

† Data in parentheses are 95% confidence interval.



Graph shows estimated cumulative incidence curves for detection with MR imaging and detection with mammography as competing events for each type of breast density. *ED* = extremely dense, *HD* = heterogeneously dense, *SFD* = scattered fibroglandular density.

known to be bilateral, some authors have reported that cancer is three times more likely to develop in the ipsilateral breast (4,5).

All 12 mammographically occult cancers detected only at MR imaging were either DCIS or T1 invasive cancers. Axillary lymph nodes were involved in three patients. These results support existing evidence that MR imaging is more sensitive than mammography in the detection of early invasive breast cancers in women who are at high risk

of developing breast cancer because of a genetic mutation or a strong family history of the disease (22,26). This may be because patients with early invasive breast cancers have subtle mammographic findings that are obscured by the underlying breast density. In our study, the five cancers that were detected mammographically and were not evident at MR imaging all manifested as microcalcifications. Calcifications are more common in patients with in situ carcinomas and are less likely to be

obscured by dense breast tissue than are masses or architectural distortions. Our data are consistent with those of prior reports in which the authors concluded that screening in patients with a hereditary risk of breast cancer by using a combination of MR imaging and mammography is more effective than screening with either modality alone (27).

The biopsy recommendation rate was higher for MR imaging than for mammography. Biopsy was recommended on the basis of MR findings in 59 (27%) of 220 women (positive predictive value, 17%). Our biopsy recommendation rate was higher than the range (2.9%–15.8%) reported when MR imaging was used to screen other women at high risk for developing cancer; in those studies, the positive predictive value varied widely, ranging from 17% to 89% (1,21,22,26). As in prior studies, the improved cancer detection yield with MR imaging was associated with additional false-positive outcomes, resulting in benign biopsy findings. Thus, physicians should discuss with patients the possibility that they may have to undergo a biopsy that yields benign findings or a series of short-term follow-up examinations in addition to annual MR screening.

Our study had several limitations. This was a retrospective study, and our sample size was small. The number of MR examinations performed per patient and the timing of mammography and MR imaging relative to one another varied. At our institution, screening breast MR imaging is not routinely recommended in any patient with LCIS.

The decision to perform screening MR examinations is at the discretion of the referring physician and the patient and may have contributed to a selection bias. Although the majority of mammograms were obtained with the digital technique, screen-film mammograms were also obtained; this might have affected cancer detection, particularly in younger patients. The potential harms associated with breast cancer surveillance should be considered. The cost-effectiveness of screening with a combination of mammography and MR imaging has been demonstrated in women with a hereditary risk of breast cancer (28). False-positive MR imaging results lead to additional biopsies and increased patient anxiety. Also, while supplemental MR screening may increase detection of early breast cancers, it is unclear whether this translates to reduced morbidity and mortality within this population.

In conclusion, MR imaging is a useful adjunct modality with which to perform screening in women with a history of LCIS who are at high risk for breast cancer, resulting in a 4.5% (95% confidence interval: 2%, 8%) incremental cancer detection rate. In patients with LCIS and no additional risk factors for breast cancer, MR imaging revealed malignancy in 5% (95% confidence interval: 2%, 10%) of patients screened. However, MR imaging should be used in addition to and not in place of mammography in this population, as sensitivity in the detection of breast cancers with a combination of MR imaging and mammography was higher than that of either modality alone.

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## References

- Morris EA, Liberman L, Ballon DJ, et al. MRI of occult breast carcinoma in a high-risk population. *AJR Am J Roentgenol* 2003; 181(3):619–626.
- Armstrong K, Eisen A, Weber B. Assessing the risk of breast cancer. *N Engl J Med* 2000;342(8):564–571.
- Dershaw DD. Mammographic screening of the high-risk woman. *Am J Surg* 2000;180(4): 288–289.
- Simpson PT, Gale T, Fulford LG, Reis-Filho JS, Lakhani SR. The diagnosis and management of pre-invasive breast disease: pathology of atypical lobular hyperplasia and lobular carcinoma in situ. *Breast Cancer Res* 2003; 5(5):258–262.
- Arpino G, Laucirica R, Elledge RM. Premalignant and in situ breast disease: biology and clinical implications. *Ann Intern Med* 2005;143(6):446–457.
- Li CI, Malone KE, Saltzman BS, Daling JR. Risk of invasive breast carcinoma among women diagnosed with ductal carcinoma in situ and lobular carcinoma in situ, 1988–2001. *Cancer* 2006;106(10):2104–2112.
- Rosen PP, Kosloff C, Lieberman PH, Adair F, Braun DW Jr. Lobular carcinoma in situ of the breast: detailed analysis of 99 patients with average follow-up of 24 years. *Am J Surg Pathol* 1978;2(3):225–251.
- Bluemke DA, Gatsonis CA, Chen MH, et al. Magnetic resonance imaging of the breast prior to biopsy. *JAMA* 2004;292(22): 2735–2742.
- Kuhl CK, Schrading S, Leutner CC, et al. Mammography, breast ultrasound, and magnetic resonance imaging for surveillance of women at high familial risk for breast cancer. *J Clin Oncol* 2005;23(33):8469–8476.
- Orel SG, Schnall MD. MR imaging of the breast for the detection, diagnosis, and staging of breast cancer. *Radiology* 2001;220(1): 13–30.
- Lee CH, Dershaw DD, Kopans D, et al. Breast cancer screening with imaging: recommendations from the Society of Breast Imaging and the ACR on the use of mammography, breast MRI, breast ultrasound, and other technologies for the detection of clinically occult breast cancer. *J Am Coll Radiol* 2010;7(1):18–27.
- Saslow D, Boetes C, Burke W, et al. American Cancer Society guidelines for breast screening with MRI as an adjunct to mammography. *CA Cancer J Clin* 2007;57(2): 75–89.
- Port ER, Park A, Borgen PI, Morris E, Montgomery LL. Results of MRI screening for breast cancer in high-risk patients with LCIS and atypical hyperplasia. *Ann Surg Oncol* 2007;14(3):1051–1057.
- D'Orsi CJ, Bassett LW, Berg WA, et al. Breast Imaging Reporting and Data System: ACR BI-RADS-Mammography. 4th ed. Reston, Va: American College of Radiology, 2003.
- Clopper C, Pearson ES. The use of confidence or fiducial limits illustrated in the case of the binomial. *Biometrika* 1934;26(4): 404–413.
- McNemar Q. Note on the sampling error of the difference between correlated proportions or percentages. *Psychometrika* 1947; 12(2):153–157.
- Obuchowski NA. Nonparametric analysis of clustered ROC curve data. *Biometrics* 1997;53(2):567–578.
- Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. *J Am Stat Assoc* 1999;94(446): 496–509.
- Gray RJ. A class of K-sample tests for comparing the cumulative incidence of a competing risk. *Ann Stat* 1988;16(3):1141–1154.
- Hellquist BN, Duffy SW, Abdsaleh S, et al. Effectiveness of population-based service screening with mammography for women ages 40 to 49 years: evaluation of the Swedish Mammography Screening in Young Women (SCRY) cohort. *Cancer* 2011;117(4):714–722.
- Lehman CD. Role of MRI in screening women at high risk for breast cancer. *J Magn Reson Imaging* 2006;24(5):964–970.
- Kriege M, Brekelmans CT, Boetes C, et al. Efficacy of MRI and mammography for breast-cancer screening in women with a familial or genetic predisposition. *N Engl J Med* 2004;351(5):427–437.
- Kuhl CK, Schmutzler RK, Leutner CC, et al. Breast MR imaging screening in 192 women proved or suspected to be carriers of a breast cancer susceptibility gene: preliminary results. *Radiology* 2000;215(1):267–279.
- Warner E, Plewes DB, Shumak RS, et al. Comparison of breast magnetic resonance imaging, mammography, and ultrasound for surveillance of women at high risk for hereditary breast cancer. *J Clin Oncol* 2001;19(15): 3524–3531.
- Page DL, Kidd TE Jr, Dupont WD, Simpson JF, Rogers LW. Lobular neoplasia of the breast: higher risk for subsequent invasive cancer predicted by more extensive disease. *Hum Pathol* 1991;22(12):1232–1239.
- Warner E, Plewes DB, Hill KA, et al. Surveillance of BRCA1 and BRCA2 mutation carriers with magnetic resonance imaging, ultrasound, mammography, and clinical breast examination. *JAMA* 2004;292(11):1317–1325.
- Warner E, Messersmith H, Causer P, Eisen A, Shumak R, Plewes D. Systematic review: using magnetic resonance imaging to screen women at high risk for breast cancer. *Ann Intern Med* 2008;148(9):671–679.
- Plevritis SK, Kurian AW, Sigal BM, et al. Cost-effectiveness of screening BRCA1/2 mutation carriers with breast magnetic resonance imaging. *JAMA* 2006;295(20):2374–2384.