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Additional breast lesions in patients eligible for breast-conserving therapy by MRI: Impact on preoperative management and potential benefit of computerised analysis

Eline E. Deurloo [a,1], Johannes L. Peterse [b], Emiel J.Th. Rutgers [c], Albert P.E. Besnard [a], Sara H. Muller [a], Kenneth G.A. Gilhuijs [a,*]

[a] *Department of Radiology, The Netherlands Cancer Institute/Antoni van Leeuwenhoek Hospital, Plesmanlaan 121, 1066 CX Amsterdam, The Netherlands*

[b] *Department of Pathology, The Netherlands Cancer Institute/Antoni van Leeuwenhoek Hospital, Plesmanlaan 121, 1066 CX Amsterdam, The Netherlands*

[c] *Department of Surgery, The Netherlands Cancer Institute/Antoni van Leeuwenhoek Hospital, Plesmanlaan 121, 1066 CX Amsterdam, The Netherlands*

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Abstract

This study was conducted to assess the incidence and impact of additional findings from magnetic resonance imaging (MRI) on the workup of patients eligible for breast-conserving therapy (BCT) and to optimise the specificity of further workup by combining radiological reading with computerised analysis. One hundred and sixteen patients eligible for BCT underwent preoperative MRI where the gold standard was histology or follow-up (median 35 months, range 23–48). The incidence of additional findings and impact on treatment (wider excision/conversion to mastectomy) were assessed. The specificity of referral to further workup was also assessed without and with computerised analysis. Additional findings from MRI occurred in 41% of patients, requiring workup in 78%. In 22% the findings were malignant, causing change in treatment. Specificity was 33% (10/30) for radiological reading alone, and 97% (29/30) combined with computer analysis.

Our findings show that additional findings preoperative MRI required workup in approximately one-third of patients and we suggest that combining radiological reading with computer analysis has the potential to accurately exclude benign lesions from further workup.
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1. Introduction

The standard treatment of early breast cancer shifted from mastectomy to breast-conserving therapy (BCT) since the 1980s when no difference in survival was shown and only a slightly larger relapse rate after BCT [1,2]. In younger patients breast relapse occurs, however, in up to 10% after 5 years [3]. Accurate assessment of tumour extent is essential to select the optimal treatment and to achieve local control with a minimum number of surgical procedures while minimising compromises to cosmetic outcome. Mammography, ultrasonography, and clinical examination are the current standard techniques to assess tumour extent. Large pathology studies have, however, shown that the spread of disease often exceeds

* Corresponding author. Tel.: +31 205122941; fax: +31 205122934.
E-mail address: kengil@nki.nl (K.G.A. Gilhuijs).
[1] Present address: Academic Medical Center, Department of Radiology, Meibergdreef 9, 1105 AZ Amsterdam, The Netherlands.

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the extent visible by conventional imaging [4]. Especially in young patients tumour extent is difficult to assess mammographically due to dense fibroglandular tissue.

Magnetic resonance imaging (MRI) is highly sensitive in detecting invasive breast cancer [5], and visualises disease extent in the breast more accurately than conventional imaging [6–9]. The specificity to discriminate between benign and malignant enhancement is, however, variable and may be as low as 37% [5]. Consequently, benign lesions may prompt larger excision volumes, which will negatively affect cosmesis. Targeted "second-look" ultrasonography of MRI-detected lesions does not always visualise these lesions to allow biopsy [10]. In any case, MRI-compatible biopsy devices are not generally available and small lesions (<1 cm) may be difficult to biopsy under MRI-guidance [11]. Follow-up imaging improves the specificity in the screening by MRI of asymptomatic women at increased lifetime risk of breast cancer [12], but the surgery of symptomatic patients cannot typically be delayed to await follow-up imaging.

Although many studies have shown that MRI has the potential to improve the preoperative staging of breast cancer [6,7,9,13–19], the consequences on the preoperative management of patients prior to BCT have not been widely discussed. In most studies only findings in one breast have been described, and only suspicious lesions have been reported which could be resolved by biopsy. Yet in other studies, change of treatment was performed for all additional findings without preoperative diagnosis of these findings [19].

Management of additional findings would be greatly facilitated if guidelines existed to identify benign lesions with high certainty prior to biopsy thus obviating the need for further workup. New techniques, such as computerised analysis of MRI images may be a way to achieve this goal [20–22].

The first aim of the current study was to assess the incidence and the impact of additional findings from MRI on the workup of patients eligible for BCT. The second aim was to evaluate if and how much the efficacy of referral for workup of additional lesions may be improved by combining radiological reading with computerised analysis.

2. Patients and methods

2.1. Patients and lesions

A prospective clinical study was performed to assess the impact of preoperative MRI on the management of patients scheduled for BCT on the basis of conventional imaging (mammography, ultrasonography) and clinical examination. Patients were included if they had pathology-proven breast cancer, and were found eligible for BCT by a multidisciplinary team of breast-cancer specialists taking the extent of the tumour and the size of the breast into account.

This study was performed after approval of the institutional review board and written informed consent of all patients. Between November 2000 and January 2003, 116 patients (mean age 54 years; range 26–86) were included with 118 cancers (2 bilateral; 103 invasive ductal carcinomas (IDC), 10 invasive lobular carcinomas (ILC), and 5 ductal carcinomas *in situ* (DCIS)). Eighty-one of the lesions were palpable (69%). The index lesion was visible by mammography in 92% (108/118), ultrasonography in 97% (113/117) and MRI in 100%. Detailed correlation of imaging with histopathology was performed.

2.2. MRI technique

MRI of both breasts was performed in prone position with a 1.5-T system (Magnetom; Siemens Medical Systems, Erlangen, Germany) using a coronal FLASH-3-D technique and a double-breast array coil. One series prior to and 4 series after power injection (2–4 ml/s; Spectris MR Injector, Medrad Inc., Indianola, PA) of contrast agent (0.1 mmol/kg; gadoteridol, Prohance, Bracco-Byk Gulden, Konstanz, Germany) were obtained at intervals of approximately 120 s. The following parameters were used: T1-weighted sequence, repetition time 8.1 ms, echo time 4.0 ms, reconstructed in-plane matrix of 256×256 pixels, isotropic in-plane resolution of $1.35 \times 1.35\ mm^2$, slice thickness 1.35 mm, no fat suppression. Subtraction was performed on a pixel-by-pixel basis to examine initial and late enhancement.

2.3. Additional findings

Additional findings were classified in two groups: (a) More extensive disease from MRI than appreciated from conventional imaging. This was defined as enhancement of the index lesion in an area significantly larger than estimated by conventional imaging, precluding oncologically safe or cosmetically acceptable BCT leading to the advise of mastectomy by the multidisciplinary team of specialists; (b) Additionally enhancing lesions from MRI, separate from the index lesion. At histology these lesions were typically not separate from the index lesion, but could be connected by areas of DCIS. Additional lesions were pathology-proven (all malignant lesions, and a fraction of benign lesions) or considered benign by follow up (no sign of malignancy after median follow up of 35 months (range 23–48)). The incidence of malignant additional findings was established for age, breast density, tumour type of the index lesion, and largest diameter of the index lesion at conventional imaging.

2.4. Workup of additional lesions

All MR images were read once in daily clinical practice by one of four senior radiologists experienced in MRI of the breast, using a dedicated viewing station [21]. Two radiologists each read approximately 300 breast MR examinations per year; the others read over 100 breast MR examinations. Additional lesions were rated based on morphological and temporal characteristics according to a standardised scoring system that is identical to the current Breast Imaging Reporting And Data System (BI-RADS) for MRI. The following scores were used: 'benign' (BI-RADS 2), 'probably benign' (BI-RADS 3), 'indeterminate/needs additional imaging' (BI-RADS 0), 'suspicious' (BI-RADS 4), and 'highly suggestive of malignancy' (BI-RADS 5) [22]. Conventional images and results of clinical examination were available during reading.

The clinical guideline employed for the workup of additional lesions was referral to targeted second-look ultrasonography for all contralateral lesions in all patients and for all ipsilateral lesions in patients $\leqslant$50 years only. In practice, lesions rated BI-RADS 2 or 3 in patients $\geqslant$50 years and lesions rated BI-RADS 2, 3, or 0 in patients $\geqslant$55 years were typically not referred.

Ultrasonographically occult lesions and non-referred lesions were excised when located within 15 mm to the index lesion or were followed up when located at larger distance. Non-referred or non-excised lesions were followed up by clinical examination and mammography or by MRI.

The incidence of additional lesions, the number of cases in which further workup was required, and the number of cases that could be characterised based on this workup, the number of benign and malignant lesions and the number of patients in which treatment was changed due to additional findings were assessed.

2.5. Combination of reading and computerized analysis

For the characterisation of additional lesions, the results from radiological reading were combined with computer analytical methods. In short, after manually selecting a point in the lesion, a computer workstation [21] automatically delineated the lesion and calculated a probability of malignancy based on 4 automatically scored features: washout, smoothness of uptake, mean margin sharpness and variation in margin sharpness [21,22]. A previously developed logistic regression model combines the conventional radiological scores with the result of computerised analysis to calculate a 'combined' probability of malignancy [22]. This results in a low probability of malignancy for lesions rated BI-RADS 2 or 3, and a high probability for lesions rated BI-RADS 5. For lesions rated BI-RADS 0 or 4 the combined model relies on the computerised analysis. In a previous study, the combined model significantly improved the performance of the radiologists [22].

The combined model was assessed independently from the radiologists and the result had no effect on patient management. The sensitivity and specificity of reading alone and that of the combined model for characterisation of additional lesions were compared.

2.6. Statistics

SPSS 10.0.5 was used. A P-value of less than 0.05 was considered to be significant. The chi-square test was used to compare incidences in subgroups.

The performance of radiological reading and that of the combined model were established using receiver-operating characteristic (ROC) analysis. ROC analysis maps the true-positive fraction to the false-positive fraction. For the ROC analysis of reading, the rates of all readers were pooled to obtain a summary performance curve for our clinic. The area under the curve (A_Z) was used as a measure of performance to distinguish between benign and malignant. $A_Z = 1.0$ indicates ability to perfectly distinguish between benign and malignant, and $A_Z = 0.5$ indicates chance performance. The A_Z values of the different curves were compared using the method described by DeLong and colleagues [23].

Benign lesions rated BI-RADS 0, 4, and 5 were defined false positives; malignant lesions in these rates were defined true positives. In addition to analysis of overall performance, performances for subgroups of ultrasonographically visible and ultrasonographically occult lesions were compared.

3. Results

3.1. Additional findings per patient

MRI showed additional findings in 48 of 116 patients (41%, Fig. 1) and in 11 of these 48 patients, more extensive disease was found (mean difference from conventional imaging 25 mm, range 6–49 mm). In 9 patients this was caused by extensive DCIS alone ($n = 2$) or with an invasive focus ($n = 7$) and in 2 patients by a unifocal invasive lesion. In 10 of 11 patients, MRI correlated better with histological extent than conventional imaging. In 1 patient, MRI and conventional imaging both correlated well with histology: conventional imaging underestimated the tumour by 3 mm and MRI overestimated it by 4 mm. Three of the patients with more extensive disease also had a contralateral (benign) lesion. Forty patients had (an) additional lesion(s) detected by MRI: ipsilateral in 24, contralateral in 14 (including three patients with more extensive disease ipsilateral) and bilateral in 2 patients. Fifty additional lesions were seen by MRI in 40 patients (Table 1, Fig. 2). Twenty lesions

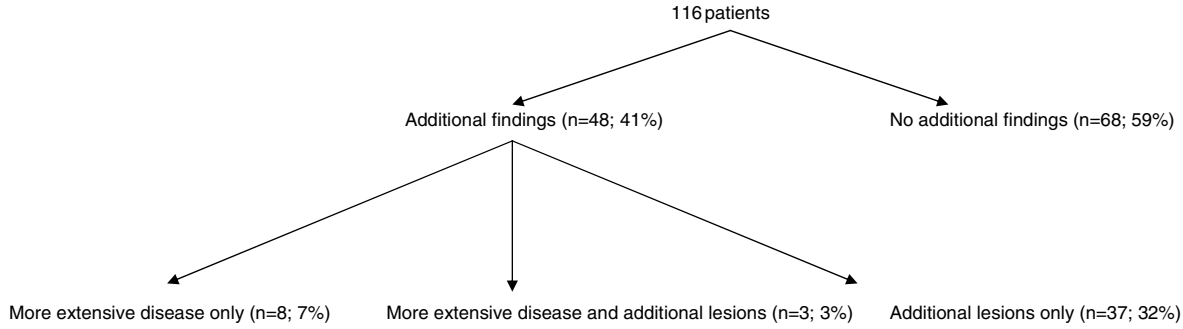

Fig. 1. The number of patients with additional findings and the type of findings for 116 patients eligible for breast-conserving therapy based on conventional imaging and clinical examination.

Table 1
Number of additional lesions per patient, localisation compared with the index lesion and diagnosis of the lesions

Additional lesions	Localisation	Number of patients (number of lesions)		
		Benign	Malignant	Total
One additional lesion	Ipsilateral	9 (9)	9 (9)	18 (18)
	Contralateral	12 (12)[a]	2 (2)	14 (14)
Two additional lesions	Ipsilateral	2 (4)	2 (4)	4 (8)
	Bilateral	1 (2)	1 (2)	2 (4)
Three additional lesions	Ipsilateral	1 (3)	1 (3)	2 (6)
Total		25 (30)	15 (20)	40 (50)

Number in parentheses is the total number of lesions.
[a] Including three patients with more extensive disease than appreciated from conventional imaging.

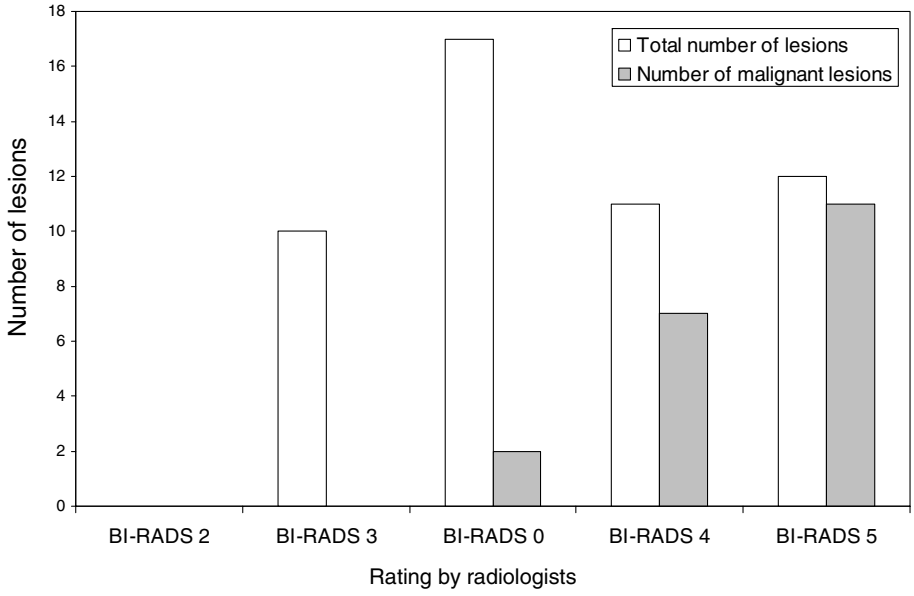

Fig. 2. Radiological rating of 50 additional lesions in patients with proven breast cancer. The white bars represent the total number of lesions in the rates. The grey bars represent the total number of malignant lesions per rate.

(20/50 = 40%) were malignant at histology. Thirty lesions (30/50 = 60%) were benign: 7 were pathology-proven (4 fibroadenomas, 1 area of fibrosis, 1 lymph node, and 1 area of hyperplasia) and 23 were followed up. Of the 50 additional lesions, 27 were <1 cm at MRI (54%; 20 benign, 7 malignant) and 23 were $\geqslant$1 cm (46%; 10 benign, 13 malignant).

Lesions located in the same quadrant as the index lesion were more often malignant than lesions in a different quadrant of the ipsilateral breast ($P = 0.02$; Table 2).

Table 2
Number of additional lesions, localisation compared to the index lesion and diagnosis

Localisation	Number of lesions		
	Benign	Malignant	Total
Ipsilateral, same quadrant	5	12	17
Ipsilateral, different quadrant	12	5	17
Contralateral	13	3	16
Total	30	20	50

Furthermore, 8 out of 12 malignant lesions in the same quadrant as the index lesion were located within 10 mm of the index lesion *versus* 0 of 5 benign lesions. Lesions in the contralateral breast had the lowest probability of malignancy (3/16 = 19%). A significantly higher incidence of additional malignant findings was found in patients with dense breasts ($P = 0.04$) and a trend towards a higher incidence of additional malignant findings for patients ⩽50 years ($P = 0.11$; Table 3).

3.2. Workup of additional lesions

Thirty-nine of 50 additional lesions were referred for further workup (78%; Table 4). Nineteen (49%) of these lesions were ultrasonographically visible and underwent biopsy (12 malignant, 7 benign). If further workup was

Table 3
Patient and tumour characteristics for patients without and with additional malignant findings

Patient/tumour characteristics		Number of patients			*P*-value
		No malignant additional finding	Malignant additional finding	Total	
Age	⩽50 years	31	14	45	0.11
	>50 years	58	13	71	
Breast density	Not dense[a]	40	6	46	0.04
	Dense[a]	49	21	70	
Size of index lesion[b]	⩽20 mm	71	19	90	0.31
	>20 mm	18	8	26	
Tumour type	IDC	79	22	101	0.32
	ILC or DCIS	10	5	15	

[a] Not dense: almost entirely fat or scattered fibroglandular tissue. Dense: heterogeneously dense or extremely dense tissue.
[b] Size of the index lesion at conventional imaging.

Table 4
Referral to and visibility at correlative ultrasonography of additional lesions per rate

Rating by radiologist	Characterisation at histology or follow up	Visible at ultrasonography	Occult at ultrasonography	Not referred to ultrasonography	Total
BI-RADS 2	Benign	0	0	0	0
	Malignant	0	0	0	0
BI-RADS 3	Benign	2	3	5	10
	Malignant	0	0	0	0
BI-RADS 0	Benign	3	9	3[a]	15
	Malignant	1	0	1[b]	2
BI-RADS 4	Benign	2	2	0	4
	Malignant	4	3[c]	0	7
BI-RADS 5	Benign	0	0	1[d]	1
	Malignant	7	3[e]	1[f]	11
Total		19	20	11	50

[a] Two patients older than 55 years of age were not referred to ultrasonography. One patient was not referred because of the small size (4 mm) of the lesion, and follow up was performed by MRI. No change of the lesion was seen in 31 months.
[b] This patient preferred mastectomy; ultrasonography was therefore not performed. The additional lesion proved to be malignant.
[c] Two patients underwent wider excision because the additional lesion was located within 10 mm of the index lesion. Both lesions proved to be malignant. One patient had an area of microcalcifications at mammography that was not suspicious, but the area correlated with the additional lesion at MRI. Stereotactic core biopsy was therefore performed and DCIS and invasive cancer were found.
[d] Ultrasonography was not performed because the additional lesion was located at a distance of 15 mm of the index lesion. A wider excision was performed to include the additional lesion in the excision volume. At histology, no additional malignant lesion was found.
[e] Two patients underwent wider excision because the additional lesion was within 10 mm of the index lesion. The lesions proved to be malignant. One patient had retrospectively at mammography also an additional lesion, highly suggestive of malignancy. Mastectomy was performed and the additional lesion proved to be malignant.
[f] Distance between index lesion and additional lesion was smaller than 10 mm, and a wider excision was done, including the additional lesion that proved to be malignant.

Table 5
Surgical management and treatment change in 116 patients considered eligible for breast-conserving therapy based on clinical examination and conventional imaging

Treatment	Reason for change in treatment	Number of patients	Mean age (years)	Percentage
No change in planned treatment		89	55.3	77
Change to mastectomy	Due to more extensive disease	11	42.6	9
	Due to additional malignant lesion (s) (proven prior to surgery)	5[a]	49.6	4
	Due to additional malignant lesion (proven after surgery)	2	46	2
Change to wider excision	Due to additional malignant lesion (proven prior to surgery)	1	48	2
	Due to additional malignant lesion (proven after surgery)	5	63	3
	Due to additional benign lesion (no malignancy found at histology)	1	69	1
Additional contralateral surgery	Due to additional malignant lesion (proven prior to surgery)	2	56.5	2
Total		116	54	100

Note that additional lesions were defined as additionally enhancing lesions separate from the index lesion at MRI. These lesions were not necessarily separate from the index lesion at histology.
[a] One patient also had contralateral surgery due to a contralateral additional malignant lesion (proven prior to surgery).

done on all lesions with BI-RADS scores 0, 4, or 5, 40 (80%) of the additional lesions would have been referred. Ultrasonographically visible lesions were more often malignant than benign ($P = 0.04$). Treatment was changed in 25 of 116 patients (22%; Table 5). Three of 116 patients underwent contralateral surgery because of an MRI-detected malignant lesion.

3.3. Combination of reading and computerized analysis

The performance of reading alone and that of the combined model were calculated for 47 of the 50 additional lesions (29 benign, 18 malignant). Three lesions were excluded, two due to severe motion artefacts near the lesion (not allowing computerised analysis) and one because it was previously used to train the computerised analysis and was therefore not new to the system.

The A_Z was 0.91 (±1 standard deviation = 0.04) for reading, and 0.98 (±0.04) for the combined model (Fig. 3). The combined model had a significantly better performance than reading alone ($P = 0.03$). Specificity was 33% for radiological reading and 97% for the combined model, at 100% sensitivity (Fig. 3). The performance for ultrasonographically visible lesions ($n = 18$; $A_Z = 0.92$ for reading and $A_Z = 1.0$ for the combined model; $P = 0.11$) was comparable to that for ultrasonographically occult lesions ($n = 19$; $A_Z = 0.97$ for reading and $A_Z = 1.0$ for the combined model; $P = 1.0$).

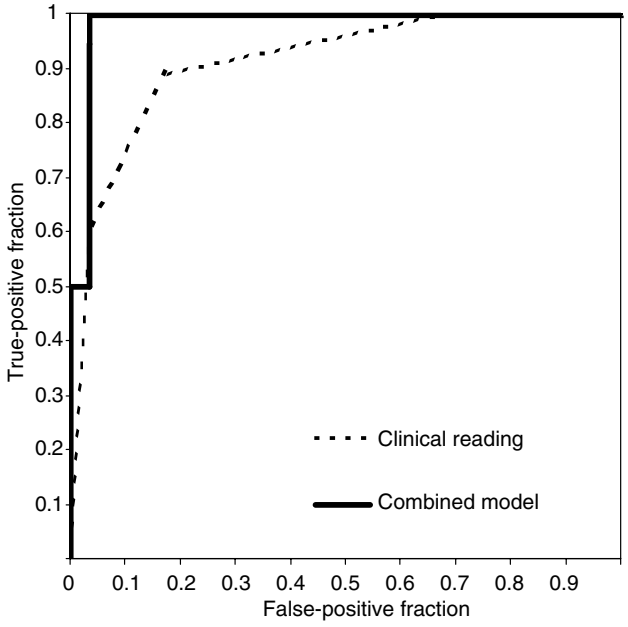

Fig. 3. ROC curves for the performance of radiological reading and that of the combination of radiological reading and computerised analysis (combined model) for the characterisation of additional lesions in patients with breast cancer. ROC = receiver operating characteristic.

4. Discussion

MRI led to additional findings in 41% of patients eligible for BCT on the basis of conventional imaging and clinical examination. The majority of these findings required workup (approximately 80%). In 22% of the patients, the additional findings turned out to be malignant, leading to a change in treatment. This confirms the value of MRI to define tumour extent prior to BCT.

However, in another 22% MRI detected additional lesions that turned out to be benign. While detection

of larger extent of the index lesion typically does not cause difficulties in patient management, additional lesions do cause problems because of their high incidence (34%) and the poor ability to distinguish between benign and malignant (specificity in the current study: 33%). The specificity in our study is lower than that reported in other studies. One explanation is that our patient population was strictly limited to women scheduled for BCT, in whom preoperative short-term follow-up by MRI is typically not an alternative option to biopsy because it would delay surgery. Secondly, scans without additional enhancement (BI-RADS 1) have not been included in the calculation of specificity (as a benign finding) because we do not consider absence of additional enhancement to be a finding at all. Obtaining histological proof of additional lesions remains difficult: in the current study additional lesions were ultrasonographically visible in only 50% of the cases. MRI-guided biopsy techniques are not widely available and are still facing technical challenges, especially in small lesions [12]. We showed that the combination of radiological reading and a computer system is able to reliably identify benign lesions and may be helpful to reduce the number of lesions that require further workup.

4.1. Additional findings and treatment change

Several studies have reported on the incidence of additional findings in patients with breast cancer (Table 6). The majority of these studies were, however, performed retrospectively in cohorts of patients not explicitly eligible for BCT, focused on one breast or described only lesions that underwent biopsy. Due to these differences, reported incidences of malignant additional findings and changes in treatment vary widely. In several studies, treatment was changed due to additional lesions detected with MRI without preoperative histological proof [9,13,17,19]. In up to 50% of patients who underwent change of treatment in these studies, the additional lesions were found to be benign after surgery. In the current study all patients, except one (who underwent a wider excision), in whom the treatment plan was changed, were ultimately proven to have a malignant additional lesion. Precautions should be taken to change the treatment for additional findings without proof of malignancy, because the majority of additional lesions will be benign and the specificity of MRI appears to be low for this population.

It should also be pointed out, however, that the clinical relevance of even additional malignant lesions is currently unproven and subject of debate, because their prevalence exceeds the current local recurrence rates after BCT [1,2]. This could suggest that additional malignant lesions are effectively removed by post-operative radiotherapy. On the other hand, insufficient evidence exists that these findings have no long-term impact. This applies especially to younger patients in whom local recurrence rates are considerably higher, up to 10% at 5 years [3]. We found a trend towards higher incidence of additional malignant findings in younger patients, suggesting that MRI may be particularly useful for this group. We also found that additional malignant lesions occur more frequently in patients with dense breasts, which appears to be a risk factor of its own [24,25].

Due to the absence of evidence from phase-III randomised trials concerning the impact of preoperative MRI on the efficacy of breast-cancer treatment, the

Table 6
Studies on the incidence of additional findings in breast cancer patients by MRI

Investigators	No. of included lesions	Inclusion criteria	No. of patients with additional findings	Ipsilateral	Contralateral	No. of patients with additional malignant lesion	Total change in management	Change in management for benign lesions
Drew [7]	178	All[a]	59 (33%)	59	Not studied	50 (28%)	20 (11%)	0
Fischer [6]	336	All[a]	69 (21%)[e]	54[e]	15[e]	69 (21%)	66 (20%)[e]	–[e]
Esserman [14]	57	All[a] + AE[b]	10 (18%)	Not specified	Not specified	9 (16%)	10 (18%)	1 (2%)
Tan [13]	83	All[a] + AE[b]	13 (16%)	Not specified	Not specified	5 (6%)	13 (16%)	8 (10%)
Bedrosian [15]	231	All[a] + OTH[c]	31 (13%)	Not specified	Not specified	19 (8%)	23 (10%)	12 (5%)
Tillman [16]	207	All[a] + AE[b]	43 (21%)	Not specified	Not specified	30 (14%)	43 (21%)	13 (6%)
Bedrosian [19]	267	All[a] + AE[b]	69 (26%)	Not specified	Not specified	49 (18%)	69 (26%)	20 (7%)
Liberman [9]	70	BCT	36 (51%)	36[d]	Not studied	19 (27%)	35 (50%)	16 (23%)
Liberman [18]	223	All[a]	72 (32%)	Not studied	72[d]	12 (5%)	61 (5%)	49 (22%)
Lee [17]	182	All[a]	15 (8%)	Not studied	15[d]	7 (4%)	15 (8%)	8 (4%)
This study	116	BCT	48 (41%)	37[f]	11	26 (22%)	25 (22%)	1 (1%)

[a] All: not only patients considered eligible for breast-conserving therapy, but also patients for mastectomy.
[b] AE: After excision: patients who underwent MRI after excision or re-excision of breast-cancer.
[c] OTH: Other indications included: axillary mass, nipple discharge.
[d] Only suspicious lesions are reported in this study, the total number of additional lesions is unknown.
[e] The number of benign lesions in the patients with breast cancer is not specified in this study; the malignant additional lesions are reported in this table.
[f] 5 Patients also had a contralateral lesion.

guidelines evaluated in this study were constructed from careful extrapolation of phase-I and phase-II studies, as well as from phase-III evidence on risk factors for local recurrence. Consequently, less than suspicious additional lesions in the ipsilateral breast of patients over 50 years of age were ignored if they could not be included in the surgical excision without compromising good cosmetic outcome (i.e., if they were more than 15 mm away from the index lesion). More aggressive follow-up of MRI findings was restricted to populations expected to be at larger risk of presenting with breast cancer after BCT (young age, (untreated) contralateral breast). It is unknown whether preoperative MRI reduces the number of reexcisions and mastectomies after BCT, which currently occur in up to one-third of all patients [26,27], while keeping the recurrence rate low. These questions need to be addressed in clinical randomised trials [28], with local control, survival and cosmetic outcome as end points.

4.2. Additional lesions and their management in clinical practice

Many additional lesions were benign (60%). Targeted second-look ultrasonography visualised only 50% of the additional lesions. Lesions that were ultrasonographically visible had higher probability of malignancy, which is in agreement with reports on a population of patients imaged for other indications [10]. A limitation of the current study is that not all benign lesions were assessed histologically and were benign by follow up (mean 35 months). The total incidence of benign additional lesions in the current study (22%) agrees well with that reported by others in the population of patients eligible for BCT (23%) [9].

4.3. Characterisation of additional lesions

Radiological reading yielded high sensitivity with relatively low specificity. If a different threshold for referral was used (e.g., BI-RADS 4 instead of BI-RADS 0), specificity would increase from 33% to 83%. Corresponding sensitivity would, however, decrease to 90%. Therefore, conventional reading alone could not reliably identify benign lesions to be excluded from further workup.

Although tested on a relatively small number of lesions, the combination of reading with computerised analysis showed significantly better performance than conventional reading alone. At 100% sensitivity the specificity increased from 33% to 97%. Although the model was tested in a prospective manner (all lesions were new to the system), validation on a larger set of additional lesions is necessary to determine whether combined analysis can effectively identify benign additional lesions that do not require further workup. To our knowledge, no other systems are currently available that allow computer-aided diagnosis of breast lesions from MRI, although several workstations are commercially available that facilitate detection of suspicious enhancing areas in the breast. It is expected that systems such as described in the current study may eventually serve as a "second opinion" to facilitate preoperative management of patients by MRI prior to BCT.

Conflict of interest statement

None declared.

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