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Research Article

The Role of Contrast-Enhanced MRI in Differentiation Between Recurrent Breast Cancer and Benign Post-Operative Lesions

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Abstract

Background: Magnetic resonance imaging (MRI) is highly sensitive to detect clinically suspected lesions that mammography and sonography may miss. However, routine postoperative MRI surveillance is not recommended unless there is concerning clinical or radiological evidence. ***Objective:*** To evaluate the role of MRI in assessing postoperative breast lesions and distinguishing benign changes from recurrence. ***Methods***: This prospective cohort analysis was conducted at the National Center for Early Detection of Breast Cancer, Oncology Teaching Hospital, Medical City, from January 2022 to August 2022. The study enrolled breast cancer patients who had undergone breast-conserving surgery (BCS) or mastectomy within the past 24 months and were currently under radiological surveillance or presented with a new clinically detected mass. ***Results***: A total of 42 lesions from 32 patients were analyzed; 21(65.7%) were under routine follow-up, while 11(34.3%) presented with a new mass. Mammography and/or ultrasound detected 36(85.7%) lesions, while MRI identified six (14.3%) additional lesions. Histopathology confirmed malignancy in 22(68.2%) patients. Five of six MRI-discovered lesions were malignant in histology, with a mean diameter of 7.5mm ranging from 6-11mm. Irregular shape, speculated margin, heterogeneous enhancement, and diffusion restrictions were significantly associated with malignancy. Using histopathology as the gold standard, MRI demonstrated 100% sensitivity, 55% specificity, and 78.6% accuracy. ***Conclusions***: Dynamic contrast-enhanced MRI can improve the characterization of postoperative breast lesions. This method can help minimize benign lesion biopsies and detect recurring malignancies and multifocality when traditional imaging fails.

Keywords: Breast contrast-enhanced MRI, Accuracy, Benign postoperative changes, Recurrent breast cancer.

دور التصوير بالرنين المغناطيسي المعزز بالتباين في التمييز بين سرطان الثدي المتكرر والآفات الحميدة بعد الجراحة

الخلاصة

الخلفية: التصوير بالرنين المغناطيسي (MRI) حساس للغاية للكشف عن الآفات المشتبه بها سريريا والتي قد يفوتها التصوير الشعاعي للثدي والتصوير بالموجات فوق الصوتية. ومع ذلك، لا ينصح بالمراقبة الروتينية للتصوير بالرنين المغناطيسي بعد الجراحة ما لم تكن هناك أدلة سريرية أو إشعاعية مقلقة. **الهدف**: تقييم دور التصوير بالرنين المغناطيسي في تقييم آفات الثدي بعد الجراحة والتمييز بين التغيرات الحميدة والتكرار. **الطرائق**: تم إجراء هذا التحليل الجماعي المستقبلي في المركز الوطني للكشف المبكر عن سرطان الثدي، مستشفى الأورام التعليمي، المدينة الطبية، من يناير 2022 إلى أغسطس 2022. شملت الدراسة مرضى سرطان الثدي الذين خضعوا لجراحة الحفاظ على الثدي (BCS) أو استئصال الثدي خلال ال 24 شهرا الماضية وكانوا حاليا تحت المراقبة الإشعاعية أو تم اكتشافهم بكتلة جديدة تم اكتشافها سريريا. **النتائج**: تم تحليل ما مجموعه 42 نموذج من 32 مريضا؛ 21 (65.7٪) كانت تحت المتابعة الروتينية، بينما ظهرت 11 (34.3٪) مع كتلة جديدة. اكتشف التصوير الشعاعي للثدي و/أو الموجات فوق الصوتية 36 (85.7٪) آفة، بينما حدد التصوير بالرنين المغناطيسي ستة (14.3٪) آفات إضافية. أكد التحليل النسيجي وجود ورم خبيث في 22 مريضا (68.2٪). كانت خمس من ست آفات مكتشفة بالرنين المغناطيسي خبيثة نسيجيا، حيث يبلغ متوسط قطرها 7.5 مم يتراوح من 6-11 ملم. ارتبط الشكل غير المنتظم والهامش المضاربة والتعزيز غير المتجانس وقيود الانتشار بشكل كبير بالورم الخبيث. باستخدام التحليل النسيجي كمعيار موثوق، أظهر التصوير بالرنين المغناطيسي حساسية بنسبة 100٪ وخصوصية 55٪ ودقة 78.6٪. **الاستنتاجات**: يمكن أن يؤدي التصوير بالرنين المغناطيسي الديناميكي المعزز بالتباين إلى تحسين توصيف آفات الثدي بعد الجراحة. يمكن أن تساعد هذه الطريقة في تقليل خزعات الآفات الحميدة واكتشاف الأورام الخبيثة المتكررة وتعدد البؤر عند فشل التصوير التقليدي.

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INTRODUCTION

Breast cancer continued to be a major public health concern. In addition to being the most prevalent cancer among women globally, the incidence of this disease among younger women is on the rise. Underdeveloped regions accounted for over half of breast cancer diagnoses and nearly 66% of breast cancer-related deaths in 2020 [1]. It is crucial to diagnose breast cancer early and administer surgical treatment, particularly for young women who undergo breast-conserving surgery (BCS), which is also referred to as partial mastectomy or lumpectomy, and subsequent radiotherapy [2]. One of the most significant obstacles encountered by oncologists following postoperative radiotherapy is the presence

of an overt mass or increased density in mammograms that is difficult to differentiate from local recurrence [4]. Approximately 15% of women who are diagnosed with early-stage breast cancer will experience a local invasive recurrence within twenty years, which is associated with a three- to four-times increased risk of mortality [3]. Diagnostic imaging modalities have a significant impact on the sensitivity of local recurrence detection. MRI is a highly sensitive tool for the detection of clinically suspected lesions that are occult on mammography and sonography [2]. However, it is not recommended for routine follow-up after BCS, except in the event of suspicious clinical or radiological evidence [4]. Patients' prognoses and the management of clinical and surgical therapy methods are both affected by the evaluation of any residual/recurrent malignancy following treatment. Consequently, this study aimed to analyze MRI function in evaluating postoperative breast lesions and its accuracy in differentiating benign changes from recurrence.

METHODS

Study design and setting

A prospective cohort study conducted at the National Center for Early Detection of Breast Cancer, Oncology Teaching Hospital, Medical City, from January to August 2022. The study was approved by the ethical committee of the Oncology Teaching Hospital. All patients were given informed written consent.

Inclusion criteria

The study included all patients who met the inclusion criteria, which were: A patient with a history of breast cancer who underwent breast-conserving surgery or mastectomy within the last 24 months and was diagnosed with a Breast Imaging Reporting and Data System (BIRADS) 4 lesion(s) on mammography and/or ultrasound at the surgery bed [5], mastectomy bed, or other quadrant of the ipsilateral breast. The rationale for including patients within two years of primary surgery is that breast cancer recurrence most frequently occurs during the first few years post-surgery. Additionally, patients may still exhibit fat necrosis, edema, and scarring up to two years after the procedure.

Exclusion criteria

Pregnant patients, those with contraindications to MRI, or claustrophobia were excluded from the study, in addition to patients with BIRADS 4 or more on MRI and did not have cytology or histopathology confirmation.

Interventions and outcomes measurement

Mammography (5149456-5, GE, Hungary) both cranial-caudal (CC) and mediolateral (ML) views were performed for twenty-six patients with subsequent complementary ultrasound examinations. For patients with modified radical mastectomy (n=13), high-resolution conventional ultrasound (GE/Logic58, Korea,) was conducted using a linear array transducer operating at 8–12 MHz. 3.2. MRI of the breast was conducted on a superconducting 1.5 T MR imaging apparatus (Magnetom Aera, Siemens Health Care, Germany). Dedicated bilateral sixteen-channel breast coils were employed to examine all patients in the prone position. BIRADS 4 lesions were identified in several patients.

The MRI protocol

Scout view sagittal protocol localization and T1-weighted pulses were applied. Fast spin-echo (FSE) was used to acquire axial non-fat saturated TIWI with the following image parameters: TR: 426 ms, TE: 4.6 ms, slice thickness: 3 mm, FOV: 300-360 mm, matrix: 307 x 512. The following settings were used to get an axial T2-weighted turbo spin-echo: TR 5220, TE 67, 384 x 512 matrix, and 3 mm slice thickness. To obtain axial short T2 Transverse Dixon fat and water, the following parameters were used: TR 7000-9000 ms, TE 70 ms, slice thickness 3-4 mm, inter-slice gap 1 mm, FOV 300-360 mm, and matrix 307 512. Diffusion-weighted imaging (DWI) was performed before contrast intake in the axial plane at spin-echo sequence with (0,400,800 sec/mm^2) b-values, and ADC maps were reconstructed. An ADC value less than 1.0 x 10^{-3^3} was considered restricted. Dynamic contrast MRI was conducted after administering a 0.2 mmol/kg gadopentetate Di meglumine bolus via an automated injector at a rate of 3-5 ml/s through an 18–20-gauge intravenous cannula in the antecubital vein. All dynamic experiments were conducted in the axial plane using fat saturation pulses for fat suppression. The FL 3-D T1WI Spair sequence was employed, with parameters including TR 4-8 ms, TE 2 .4 ms, flip angle 20-25, slice thickness 2 mm, no inter-slice gap, FOV 300-360 mm, and 307 x 512 matrixes. The next step was a 20-ml bolus infusion of saline at 3–5 ml/s. The dynamic study includes one pre-contrast and five post-contrast series, each lasting 1.16 min with a 20-s gap between them. The post-processing workflow involved three key steps: First, time-signal intensity curves were generated for lesions showing suspicious enhancement patterns. Second, maximum intensity projection (MIP) views were created in all three orthogonal planes. Finally, reformatted sagittal, coronal, and axial projections were produced through image subtraction, where pre-contrast images were subtracted from their corresponding post-contrast series.

Image analysis

Two breast radiologists with experience ranging from 5 to 20 years evaluated the images. All cases were examined collaboratively, and the final diagnosis was mutually accepted. Initially, T2 fat sat images were analyzed to identify edema, postoperative seroma, and hematoma. Additionally, T1WI was conducted to identify adipose within the lesion [6]. Each lesion was evaluated using the MRI BI-RADS Atlas (2013)

morphology descriptors [7]. Lesions were categorized as either a mass, a non-mass-like enhancement (NMLE), or a focus. A mass was defined as a three-dimensional, space-occupying lesion, typically visible on pre-contrast T1- or T2-weighted images. Masses were characterized by their shape, margins, and internal enhancement patterns. Non-mass-like enhancement (NMLE) was defined as enhancement that did not conform to a discrete mass or focus. NMLE was further classified based on its distribution, internal enhancement pattern, and whether it exhibited symmetric or asymmetric enhancement. Any detected lesion was assessed for the size, extent, and multiplicity, as well as relation to the skin, nipple, and chest wall with kinetic assessment done. Axillary lymph nodes were also assessed for their shape, size, cortical thickness, and uniformity. MRI criteria for a suspicious ALN included a shortest diameter ≥10 mm, L/T <2, and a replaced hilum. Patients' follow-up and histopathology: Suspected lesions classified as BIRADS 4 or higher on MRI were re-evaluated using a second-look ultrasound. Then, the detected lesion was sampled using core needle biopsy (gauge 14), guided by ultrasound. Lesions exhibiting less alarming characteristics were evaluated with fine needle aspiration biopsy under an ultrasound guide to rule out malignancy.

Statistical analysis

All statistical analyses were carried out using Statistical Package for Social Sciences (IBM Corp., Armonk, N.Y., USA) software version 25. Continuous variables were expressed as mean, standard deviation ± SD, or range. Observational data were presented as frequency and percentage. To assess the proportions of nominal/ ordinal variables in different groups, statistical comparisons were performed using the Chi-square test or Fisher's exact test, as appropriate. Statistical significance was defined as a *p*-value less than 0.05. Sensitivity was measured as the proportion of malignancies that were correctly identified by the evaluated test. Specificity was measured as the proportion of benign diseases that were correctly identified as such. The positive predictive value (PPV) is measured as the proportion of positive for malignancy tests that were truly positive. Negative predictive value (NPV) was measured as the proportion of negative for malignancy tests that were true negative. The overall test accuracy was measured as the proportion of all results that were true.

RESULTS

A total of 32 patients were included with a mean age of 50.59 ± 7.6 years, ranging between 37 and 68 years; 14 (43.8%) of them were in menopause. Approximately two-thirds of the patients, 21 (65.6%), were asymptomatic on routine follow-up, while 11 (34.3%) presented with a new palpable mass. A total of 42 lesions were identified; 36 (85.7%) were present in the preceding mammography and/or US, while 6 (-14.3%) were newly discovered by MRI, mammograph and US BIRADS with other patients' characteristics are presented in Table 1.

Table 1: Patients and characteristics of the lesions

Characteristic		n(%)
Menstrual state (n=32)	Reproductive	18(56.3)
	Menopause	14(43.8)
Type of referral (n=32)	Follow up	21(65.6)
	New lump	11(34.4)
Nature of lesions (n=42)	Present on preceding US and mamo	36(85.7)
	New discovered by MRI	6(14.3)
Mammogram BIRAD (n=21)	BI-RADS 0	1(4.8)
	B-IRADS I	1(4.8)
	B-IRADS IV	19(90.5)
US BIRAD (n=36)	BI-RADS IV	36(100)

In 22 cases (52.4%), the final histopathology diagnosis confirmed cancer. Most of them were invasive carcinoma, but one case (2.4%) was ductal carcinoma in situ (DCIS) and two cases (4.8%) were metastatic axillary LN. While mammography was able to detect 14 (82.25%) malignant tumors, it miscategorized 5 (35.2%) benign lesions as suspicious lesions (BIRADS 4). MRI, on the other hand, recategorized 10 suspicious lesions (BIRADS 4) by ultrasound to benign lesions (BIRADS 2) or benign lesions needing follow-up (BIRADS 3), which were confirmed on histopathology (Table 2). Five out of six lesions that were newly discovered on the MRI were suspicious lesions (BIRADS 4) and confirmed malignant on histopathology with a mean larger diameter of 7.5 mm ranging between 6 and 11 mm. All these lesions were IDC in the ipsilateral breast; 2 (40%) were at the site of the operation, 2 (40%) were away from the site of the operation, and one (20%) was a suspicious axillary LN (Table 3). The comparison of MRI morphology, diffusion, and dynamic characteristics of malignant and benign lesions are illustrated in Table 3. Irregular speculated morphology features are significantly associated with final malignant diagnosis, p= 0.021 and 0.001, respectively. Among the types of enhancement, heterogenous enhancement was seen in 12 (54.5%) malignant lesions, which was marginally significant compared with benign lesions, where it was observed in only 4 (21.1%), p= 0.055. Also, restrictive diffusion (ADC value below 1x10-3) was significantly linked to 14 (63.6%) of the tumors that were cancerous, but almost none of them were seen in the benign lesion (p< 0.001). 12 (80%) of the benign lesions were associated with the type I curve, and 60% of malignant lesions were equally distributed between curve types II and III (p= 0.019).

Table 2: Final diagnosis of lesions discovered during MRI or on preceding mammograph and/or US with corresponding site and BIRADS

Characteristic		Present on pre-exiting US and/or mamo (n=36)		Newly discovered by MRI (n=6)	
		Benign n=19	Malignant n=17	Benign n=1	Malignant n=5
Ste of lesion	At site of operation	12(40.9)	11(41.1)	1(100)	2(40)
	Away from operation site	6(14.4)	5(12.2)	0	2(40)
	Axillary LN	1(0.6)	1(0.6)	0	1(20)
Mammo BIRAD	BI-RADS 0	1(1.6)	0	-	-
	BI-RADS 1	1(1.6)	0	-	-
	BI-RADS 4	5 (35.2)	14(100)	-	-
US BIRADS	BI-RADS 4	19(100)	17(100)	-	-
	BI-RADS 2	7(36.8)	0	1(100)	0
MRI BIRADS	BI-RADS 3	3 (15.8)	0	0	0
	BI-RADS 4	9 (47.4)	17(100)	0	5(100)

Values were expressed as frequency and percentage.

Table 3: Comparison in MRI morphology, diffusion, and dynamic characteristics of malignant and benign lesions

MRI features		Histopathology diagnosis		*p*-value
		Benign (n=20)	Malignant (n=22)	
Type of lesions in MRI	Normal*	1(5)	0	0.127
	Mass	6(30)	14(63.6)	
	Non-mass	8(40)	6(27.3)	
	Fluid collection	2(10)	0	
	LND	3(15)	2(9.1)	
Mass shape (n=20)	Oval	3 (50)	0	0.023
	Round	2 (33.3)	6 (42.9)	
	Irregular	1(16.7)	8 (57.1)	
Mass margins (n=20)	Circumscribed	4 (66.7)	0	0.001
	Irregular	2(33.3)	7 (50)	
	Speculated	0	7 (50)	
Type of enhancement	Homogenous	7(36.8)	5(22.7)	0.055
	Heterogenous	4(21.1)	12(54.5)	
	Clumped	0	2(9.1)	
	Cluster ring	0	1(4.5)	
	Peripheral enhancing	4 (21.1)	1(4.5)	
	Faint	1(5.3)	0	
	Non-enhancing	3(15.8)	1(4.5)	
Distribution of non-mass enhancement (n=14)	Focal	7 (87.5)	2 (33.3)	0.119
	Linear	0	1 (16.7)	
	Regional	1(12.5)	2 (33.3)	
	Segmental	0	1 (16.7)	
Type of diffusion	No restriction	19(100)	8(36.4)	<0.001
	Restriction	0(0.0)	14(63.6)	
Type of curve	1	12(80)	8(40)	0.019
	2	3(20)	6(30)	
	3	0	6(30)	
MRI BIRADS	BI-RADS 2	8 (40)	0	<0.001
	BI-RADS 3	3 (15)	0	
	BI-RADS 4	9 (45)	22 (100)	

*The anticipated lesion on the US which appeared normal on MRI was not included in the results of dynamic study.

The MRI features of malignant tumors according to the final histopathology diagnosis are illustrated in Table 4 and Figure 1. Histopathologically, we diagnosed 19 out of 34 MRI BIRADS 4 as invasive ductal carcinoma, 1 as DCIS, and 2 as infiltrated axillary IN. The in situ lesion appeared as a restricted enhancing mass with a progressive curve. On the other hand, invasive carcinomas showed up as a mass in 13 cases (68.4%) and as a non-mass lesion in 6 cases (31.6%). The enhancement was spread out in different ways, and more than half of the cases were heterogeneous. Although 6 (31.6%) exhibited a washout-type curve, there were 7 (36.8%) with progressive and 6 (31.6%) plateau curves. Table 5 illustrates the MRI features of benign/nonneoplastic postoperative changes according to the final histopathology diagnosis. Out of 20 benign lesions, fat necrosis was the most frequently encountered lesion, accounting for 6 (26.1%). Post-operative fibrosis changes were the second most frequent, accounting for 5 (21.7%). Half of fat necrosis appeared as mass lesions, 2 (33.3%) exhibited nonrestricted heterogenous enhancement, and the rest showed peripheral enhancement with fat content on T1 FSE, and none had washout curves. Postoperative fibrosis appeared as a mass in 2 (40%) and a focal non-mass in 3 (60%) of the cases. The majority depicted homogenous enhancement 3 (60%), however, heterogenous and faint enhancement was also seen. All were associated with a progressive type of curve (type I). The validity of the MRI test was assessed (Table 6). Using histopathology as the gold standard and classifying BIRADS 3, 4, and 2 as suspicious or benign, MRI demonstrated high sensitivity yet low specificity (64.7%) and an overall accuracy of 78.6%.

DISCUSSION

The distortion of normal breast architecture following surgery may persist for many years, and it may be difficult to distinguish between benign postoperative

alterations and local recurrence on mammography [8]. The combination of enhancement kinetics following injection of gadolinium contrast material with morphology enhances the effectiveness of MRI in detecting recurring cancers [9].

Table 4: The MRI features of malignant tumors according to final histopathology diagnosis

MRI feature		Histopathological result			
		Total	In situ (n=1)	Invasive (n=19)	Infiltrated ALN (n=2)
Type of lesions in MRI	Mass	14	1(100)	13(68.4)	0
	Non-mass	6	0	6(31.6)	0
	LND	2	0	0	2(100)
Mass shape	Round	6	1 (100)	5 (38.5)	0
	Irregular	8	0	8 (61.5)	0
Mass margins	Irregular	7	1 (100)	6 (46.2)	0
	Speculated	7	0	7 (53.8)	0
Distribution of non-mass enhancement	Focal	2	0	2(10.5)	0
	Linear	2	0	2(10.5)	0
	Regional	1	0	1(5.3)	0
	Segmental	1	0	1(5.3)	0
Type of enhancement	Homogenous	5	0	4(21.1)	1(50)
	Heterogenous	12	1(100)	11(57.9)	1(50)
	Clumped	2	0	2(10.5)	0
	Cluster ring	1	0	1(5.3)	0
	Peripheral enhancing	1	0	1(5.3)	0
	Non-enhancing	0	0	0	0
Type of restriction	No restriction	8	0	8(42.1)	0
	Restriction	14	1(100)	11(57.9)	2(100)
Type of curve	1	8	1(100)	7(36.8)	0
	2	6	0	6(31.6)	0
	3	6	0	6(31.6)	0

Values were expressed as frequency and percentage. ALN: Axillary lymph node.

In the present study, re categorized 10 (27.8%) BIRADS 4 lesions detected by ultrasound to BIRADS 2 and BIRADS 3, which were confirmed benign on histopathology. Ertekin *et al*. have recently evaluated the role of MRI in category 4 solid mass lesions detected by mammography and ultrasonography [10]. They reported that MRI reclassified 74 out of 121 (61.2%) BI-RADS 4 lesions to lower categories (BI-RADS 2 or 3) [10]. Lesions at the scar bed, adjacent to the margin, which are the common site of recurrence, may be overlooked in mammography or breast ultrasonography as a result of architectural distortion, increased density at the lumpectomy site, and posttreatment edema [4]. Moreover, MRI detected six additional lesions that were not identified in a preceding mammography and ultrasound, five (83.3%) of which were malignant. In a previous study, Park and colleagues analyzed the malignancy rate among the 119 MRI-identified lesions and determined a malignancy rate of 68.1%. Lesions classified as BI-RADS 4C-5 had a substantially greater incidence than lesions classified as 4A-4B, while ipsilateral same-quadrant lesions had a significantly higher incidence than contralateral lesions [11]. It is well known that MRI is the best way to find multicentric diseases that might not be visible or detectable with regular breast lesion screening imaging [12]. Nevertheless, such lesions in the setting of primary lesions are often DCIS or invasive cancer smaller than 1 cm, which are argued to result in overtreatment of patients and more aggressive surgical procedures [13]. In the setting of cancer patients, we found that all these newly diagnosed tumors on MRI were invasive lesions with a mean largest diameter of 7.5 mm, 40% were away from the site of the previous operation, and virtually all were away from the index tumor.

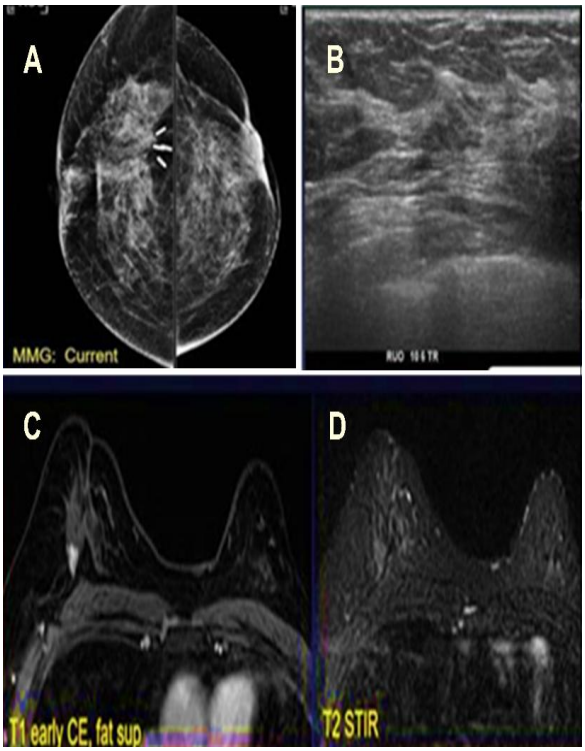

Figure 1: 33 years female with a history of right breast cancer one year ago, was treated with breast-conserving surgery; On the annual follow up mammogram. **A**) CC view showed heterogeneous dense breast ACR C, with clips at the site of operation, no suspicious microcalcification, normal skin thickening, both nipples retracted with skin fold; **B**) US depicted a small ill-defined heterogenous hypoechoic area at the site of the previous operation. On MRI **C**)T1 contrast early, and **D**) T2 STIR showed enhancing mildly restricted non-mass area at the corresponding site. Core needle biopsy under US guide revealed a local recurrence.

Table 5: MRI features of benign/nonneoplastic post-operative changes according to final histopathology diagnosis

MRI Features		Total	Normal N=1	Post-op fibrosis N=5	Fat necrosis N=6	FC N=1	Seroma N=2	Granuloma N=2	LN N=3
Type of lesions in MRI	Normal	1	1(100)	-	-	-	-	-	-
	Mass	6	-	2(40)	3(50)	-	-	1(50)	-
	Non-mass	8	-	3(60)	3(50)	1(20)	-	1(50)	-
	Fluid collection	2	-	-	-	-	2(100)	--	-
	LND	3	-	-	-	-	-	-	3(100)
Mass shape	Oval	5	-	1 (50)	2 (66.7)	-	-	-	-
	Round	2	-	-	1 (33.3)	-	-	1(100)	-
	Irregular	1	-	1(50)	-	-	-	-	-
Mass margins	Circumscribed	6	-	-	3 (100)	-	-	1(100)	-
	Irregular	2	-	2 (100)	-	-	-	-	-
	Speculated	0	-	-	-	-	-	-	-
distribution of non-mass enhancement	Focal	4	-	3(100)	3 (100)	1(100)	-	-	-
	Regional	1	-	-	-	-	-	1(100)	-
type of enhancement	Homogenous	7	-	3(60)	-	1(100)	-	-	3(100)
	Heterogenous	4	-	1 (20)	2(33.3)	-	-	1(50)	-
	Peripheral enhancing	4	-	-	4(66.7)	-	-	-	-
	Faint	1	-	1(20)	-	-	-	-	-
Type of Diffusion	Non-enhancing	3	-	-	-	-	2(100)	1(50)	-
	No restriction	19	-	5(100)	6(100)	1(100)	2(100)	2(100)	3(100)
	Restriction	0	-	-	-	-	-	-	-
Type of curve	1	12	-	5(100)	5(83.3)	-	-	1(50)	1(100)
	2	3	-	-	1(16.7)	1(100)	-	1(50)	-
	3	0	-	-	-	-	-	-	-
MRI BIRADS	BI-RADS 2	8	1(100)	1(20)	3(50)	-	2(100)	1(50)	-
	BI-RADS 3	3	-	2(40)	-	-	-	-	1 (33.3)
	BI-RADS 4	9	-	2(40)	3(50)	1(100)	-	1(50)	2(66.7)

Table 6: Validity of MRI in diagnosing malignant breast lesions post operatively

Test	No.	Sensitivity	Specificity	PPV	NPV	Accuracy
MRI	49	100	55.6	64.7	100	75.5

Given that these patients had completed their chemotherapy, these tumor foci might be resistant clones and require further consideration; hence, the precise extent of the lesion is an important prerequisite for informed management decisions. The overall accuracy of MRI in the current study was 78.6%, with 100% sensitivity. Although this seems lower than MRI accuracy reported by other studies, which reaches up to 95.6% [6]. The sensitivity of breast MRI for the assessment of recurrence has been reported to be 90% [14]. In comparison to conventional MRI, studies have shown that diffusion-weighted MRI demonstrates enhanced specificity and positive predictive value [4]. The low specificity seen in the current study can be attributed to the inclusion criteria, which allowed for individuals with worrisome BIRADS 4 findings on mammography and/or ultrasound. This resulted in only a few truly negative cases, leading to a decrease in specificity. The MRI features that were significantly different in malignant lesions were the heterogeneous type of enhancement and restriction of diffusion and washout curve. Compelling data reported the association between restricted diffusion and malignant behavior of the tumor [15-17] and has been identified as an independent predicting feature [16]. None of the benign lesions in the current study exhibited restricted diffusion, but 63.6% of the malignant tumors did. Nevertheless, out of the invasive malignant tumors, 8 (42.1%) did not exhibit diffusion restriction, half of which were non-mass-enhancing lesions. A different pattern has been reported by Ahmadinejad *et al*. who had 4.4% benign and 89% non-mass enhanced lesions with restricted diffusion [17]. Less than half of the benign lesions (45%) in the current study appeared suspicious (BIRADS 4) in the MRI study; two were homogenously enhanced LNs, one was fibrocystic changes that appeared as homogenously enhanced mass lesions with a type III curve and unrestricted diffusion, three were fat necrosis, and one was granulomatous inflammation. Fat necrosis is a common postoperative finding and a frequent pitfall that can be misdiagnosed as suspicious by imaging [18]. Half of the fat necrosis lesions were categorized as BIRADS2 in the current study, however, there was a lesion with heterogenous enhancement and another with a type II curve. Although fat was detected in these lesions as a high signal on T1WI [19] and fat necrosis was in differential diagnosis, a biopsy was recommended.

Study limitations

This study has certain constraints. As prospective study and despite decent recruitment, a significant number of patients were excluded due to their loss during follow-up, resulting in a small sample size. The type of biopsy was determined by the level of suspicion, with seroma and low-suspicion lesions being selected for FNA biopsy owing to limited resources.

Conclusion

In the setting of breast cancer patients' follow-up, MRI can reduce the category of BIRADS 4 and identify

additional lesions with high malignancy suspicion. Therefore, incorporating dynamic contrast-enhanced magnetic resonance imaging for assessment of postoperative breasts can provide a valuable characterization of the lesion with a high negative predictive value, particularly in ultrasound/mammography BIRADS 4 lesions. This approach can also reduce the need for unnecessary biopsies for benign lesions and determine the extent of recurrent malignancy and multifocality in cases where conventional imaging has been inefficient.

Conflict of interests

The authors declared no conflict of interest.

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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