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Evaluation of malignant breast masses with abbreviated breast magnetic resonance imaging

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ABSTRACT

Objectives: Our study aimed to investigate the sensitivity of the abbreviated magnetic resonance imaging (MRI) in the detection of tumors in breast cancer patients.

Methods: Patients who underwent breast MRI between March 2018 and October 2021 were reviewed retrospectively. Patients with a histologic diagnosis of breast malignancy were included in the study. Patients who underwent a biopsy or an interventional procedure before the MRI examination and who received neoadjuvant chemotherapy were excluded from the study. Abbreviated MR protocol included a pre-contrast T1-weighted, 1st minute contrast-enhanced T1-weighted, and 1st minute subtracted series. Additionally, 2nd minute post-contrast series were evaluated.

Results: A total of 83 lesions with a histologic diagnosis of breast cancer were evaluated in 81 patients. The mean age of the patients included in the study was 51.08 years (range: 27-79 years). Seventy-four of the 83 breast lesions showed contrast enhancement in the 1st-minute contrast-enhanced images and subtraction images (sensitivity 89.1%). When missed cases were re-evaluated all of them were visible in the second-minute contrast-enhanced series.

Conclusions: In this study, malignant lesions could be detected with high-sensitivity abbreviated MRI protocol and the addition of second-minute contrast-enhanced series to the protocol significantly improve lesion detection. We believe that MRI with the abbreviated MRI protocol can be used for screening purposes in high-risk women with dense breasts.

Keywords: Breast cancer, magnetic resonance imaging, abbreviated MRI, mammography, breast cancer screening

Magnetic resonance imaging (MRI) of the breast is the method with the highest sensitivity in the diagnosis of breast cancer. Cases in the high-risk group (with BRCA gene mutation, lifetime breast cancer risk over 20-25% with statistical models based on family history, radiotherapy history at the age of 10-30, Li Fraumeni syndrome, Cowden, Bannayan-Riley -Those with Ruvalcaba syndrome or their first-degree relatives) annual breast MRI scan is performed. In recent years, annual screening indications for breast MRI have been increasing [1].

Mammography is the basic imaging method in breast cancer screening, although the risk of breast cancer in dense breasts is 4-6 times higher than in fatty breasts, the sensitivity of mammography decreases below 50% [2, 3]. In addition, mammography sensi-

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tivity is low (40%-30%) in fast-growing tumors that do not cause spiculation and distortion (often triple-negative and human epidermal growth factor receptor 2 positive type tumors) [4, 5]. In many studies conducted in recent years, the rate of interval cancer has significantly decreased in patients with dense breasts with the addition of MRI [1, 6-8]. In line with these data, in the declaration published by EUSOBI (European Breast Imaging Society) in 2022, it is recommended that a breast MRI be performed every 2-4 years for women aged 50-70 years with extremely dense breasts [9].

Breast MRI as been increasingly used to study breast cancer for screening. However, a method to be used for screening should be simple, short-term, and easy to evaluate, as in mammography. Breast MRI is not a cost-effective imaging method with a long acquisition and evaluation time. Abreviated breast MRI, or an abbreviated protocol for breast MRI, was first proposed by Cristiane Kuhl *et al*. [10] in 2014. It was designed to be used for breast cancer screening and only needed the acquisition of two sequences: T1-weighted images taken before and right after the injection of gadolinium. The abbreviated MRI protocol includes differences in various studies [10-12].

In this study, we aimed to evaluate the cases with malignant masses in the breast with the abbreviated MRI protocol retrospectively and to determine the detection rate of the lesions.

METHODS

Our study is a single-center retrospective study. Between March 2018 and October 2021, patients with a histologic diagnosis of breast cancer diagnosed by biopsy and MRI of the breast were included in the study. Patients who underwent a biopsy procedure recently performed before MRI, and who received neoadjuvant chemotherapy were excluded from the study.

Ethics committee approval (2023-09/303) and informed patient consent was waived. Our study was conducted in accordance with the Declaration of Helsinki.

MRI Technique

All MRI scans were performed on a 1.5 Tesla (T) MRI device with an 18-channel superficial breast coil in the prone position (Aera; Siemens Healthcare, Erlangen, Germany). If the patient is premenopausal, the study is performed between the 5th and 15th days of the menstrual cycle.

Multiparametric MR sequences (fat-suppressed T2-weighted sequence, diffusion-weighted sequence (DWI), pre-contrast non-fat-suppressed T1-weighted sequence, and post-contrast T1-weighted sequences with dynamic contrast in 5 series) were obtained in all patients. For series with dynamic contrast, 0.1 mmol of contrast agent per kilogram (Gadovist; Bayer Healthcare Pharmaceutical, Berlin, Germany) was injected, and approximately 20 cc of saline was administered after the infusion of the contrast agent to ensure homogeneous distribution of the contrast agent. Post-contrast enhanced images were obtained from 30 s after contrast injection and the acquisition time for one scanning was about 60 s. Subtraction images were created automatically by the device.

Table 1. Comparison of routine Breast MRI protocol and abbreviated MRI protocols

MRI Protocol		Dynamic Series				
		1st min	2nd min	3rd min	4th min	5th min
		80. s	143. s	206. s	269. s	332. s
Conventional Routine Scanning Protocol	Fat saturated T2WI, DWI, T1WI	✓	✓	✓	✓	✓
Abbreviated MRI Scanning Protocol	T1WI	✓				

MRI = magnetic resonance imaging, DWI = diffusion-weighted imaging, T_1WI = T_1-weighted imaging, T_2WI =T_2-weighted imaging

Evaluation of Images

Images were retrieved from the archive system (PACS). Pre-contrast T1-weighted images, 1st-minute post-contrast T1-weighted images, and 1st-minute subtraction images were included in this protocol (Table 1). A breast radiologist (EY) with approximately 10 years of experience in breast imaging evaluated the images with the abbreviated MRI protocol. The cases had been reported by a different breast radiologist. The radiologist (EY) was informed that all patients are diagnosed with a malignant mass, but she was not informed about the localization of the masses, previous examinations of the patient, or the patient's history. The radiologist reviewed the images and noted any pathologic contrast enhancement. The findings were recorded as present or absent in the Excel file. Results were checked later whether the contrast enhancement matched the original tumor.

Statistical Analysis

Descriptive statistics were used to describe continuous variables (mean, standard deviation, minimum, median, maximum).

RESULTS

The mean age of the patients included in the study was 51.08 years (27-79 years). A total of 83 histologically proven malignant breast lesions were evaluated in 81 patients. Of these lesions, 91.5% were invasive breast carcinoma (73 invasive ductal carcinomas, 2 invasive lobular carcinomas, and 1 metaplastic carcinoma), and 8.4% were ductal carcinoma in situ (7 patients). The mean diameter of the lesions was 27.8 mm (range: 3-100 mm).

Seventy-four of the 83 malignant breast lesions showed contrast enhancement in the 1st minute contrast-enhanced series and were visible in subtracted images (sensitivity 89.1%) (Fig. 1). Nine lesions were not detected (Fig. 2). The contrast-enhanced T1-weighted and subtracted series (Fig. 2) acquired in the second minute showed all nine of the lesions that the abbreviated protocol had failed to detect. The mean and median diameter of these nine missed cancers were 20.7 and 16.2 mm respectively. The size and histologic type of the missed cancers are given in Table 2.

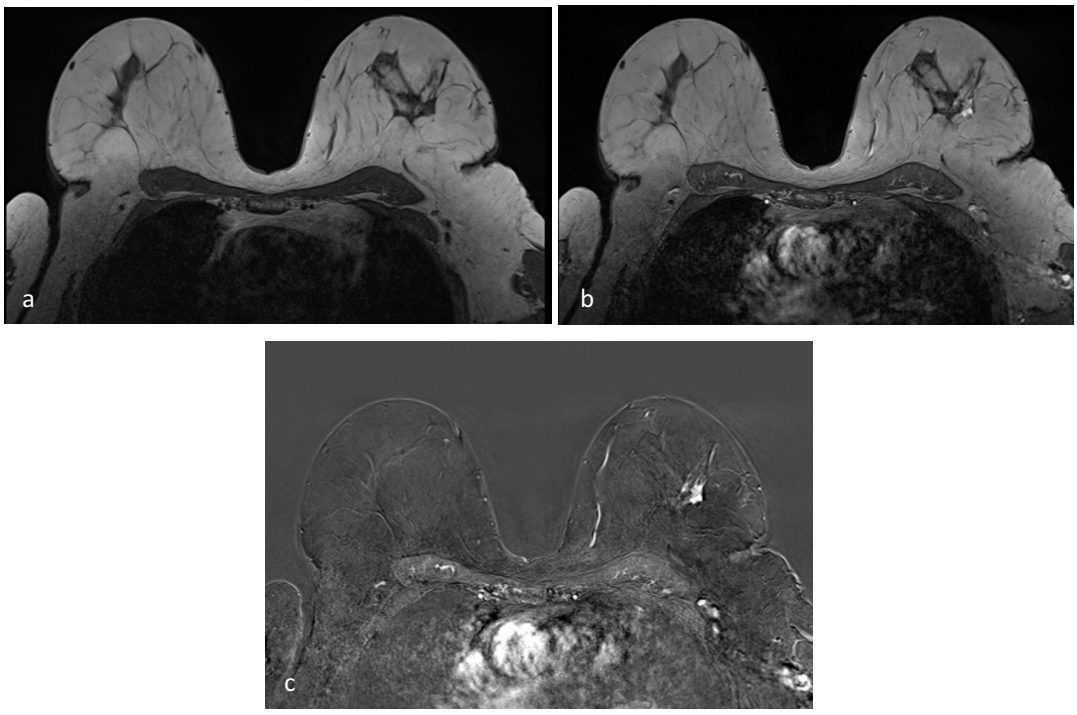

Fig. 1. Screening mammography of the 54-year-old female patient revealed a spiculated mass in the left breast. MRI was performed to evaluate the contralateral breast preoperatively. (a) T1-weighted image without contrast, (b) 1st-minute T1-weighted image with contrast, and (c) 1st-minute subtraction image; An enhancing irregular mass is observed in the outer quadrant of the left breast. The biopsy result was reported as luminal b invasive ductal carcinoma.

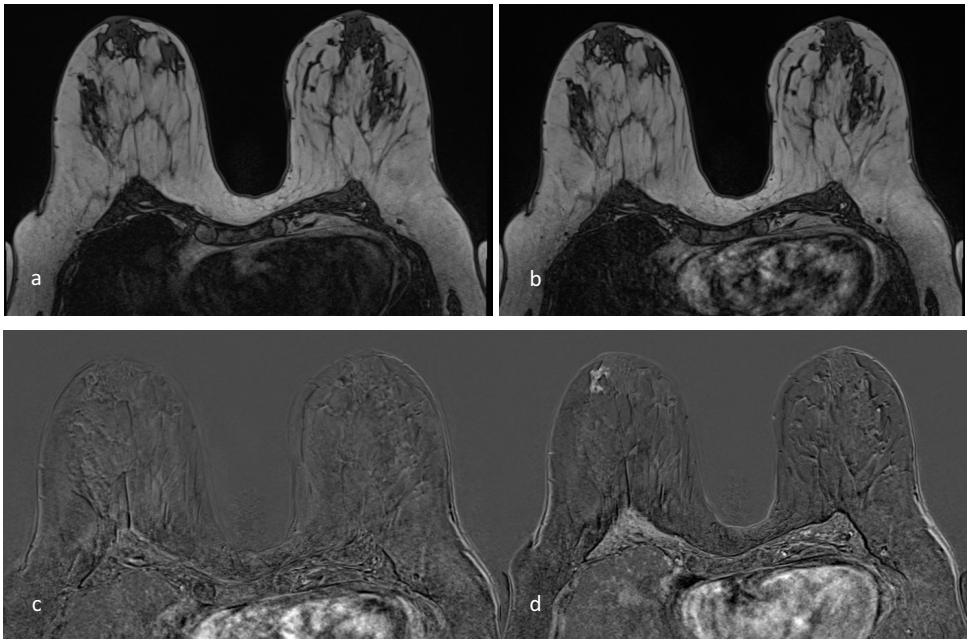

Fig. 2. A 51-year-old patient who applied to our clinic with palpable stiffness. On mammography, an irregular high-density mass was detected in the periareolar area of the right breast. Preoperative MRI images are obtained. (a) T1-weighted image without contrast, (b) 1st-minute T1-weighted image with contrast, (c) 1st-minute subtraction and (d) 2nd-minute subtraction image; An irregular enhanced mass is observed in the periareolar area of the right breast. The mass was not observed in the 1st-minute subtraction image. It became visible in the second-minute series. The biopsy result was reported as luminal b invasive ductal carcinoma.

DISCUSSION

Magnetic resonance imaging (MRI) is a multiplanar imaging method with high soft tissue resolution. Unlike mammography and ultrasonography (US), dynamic evaluation is performed in addition to morphological evaluation with MRI. The injection of a contrast agent during MRI examination is aimed to detect the pathological early contrast enhancement due to tumor neoangiogenesis. In many studies conducted in recent years, it has been shown that MRI has a higher cancer detection rate than mammography and US, and reduces the interval cancer rate [1].

The indications of breast MRI have increased in

Table 2. Masses undetected by the abbreviated MRI protocol

	Patient's Age (year)	Lesion size (mm)	Histologic type
1	74	6.1	Luminal type b invasive ductal carcinoma
2	73	10.4	Luminal type b invasive ductal carcinoma
3	63	19.2	Luminal type b invasive ductal carcinoma
4	72	40.5	Luminal type b invasive ductal carcinoma
5	66	9.7	Metaplastic carcinoma
6	39	14.1	Luminal type b invasive ductal carcinoma
7	51	22	Luminal type b invasive ductal carcinoma
8	58	16.2	Luminal type a invasive ductal carcinoma
9	37	50	Ductal carcinoma in situ

MRI = magnetic resonance imaging

recent years. Kuhl *et al*. [10] discussed whether it can be used for screening purposes or not. However, for an imaging method to be used for screening purposes, it must be easily accessible, fast, and easy to evaluate. For this purpose, an abbreviated MRI protocol has been developed [10].

Many different abbreviated MRI protocols have been used in the literature. While the first-minute T1-weighted sequence, first-minute subtraction image, and maximum intensity projection image are frequently used in studies [7, 10, 11] as the abbreviated breast MRI protocol, much other research also includes T2-weighted sequences and diffusion-weighted sequences to the protocol [13-16]. Due to the high vascular permeability secondary to neoangiogenesis, breast tumors tend to have early contrast enhancement. Sequences acquired later minutes are often obtained to characterize the lesion rather than detect it. In our study, similar to Kuhl *et al*.'s study [10] we determined the 1st minute T1-weighted sequence and the 1st-minute subtraction image as the abbreviated MRI protocol. In our clinic, the routine full diagnostic breast MRI protocol, which includes a fat-sat STIR T2W sequence, a precontrast DWI sequence, and dynamic contrast-enhanced T1W sequences, takes 25 minutes, and the abbreviated MRI protocol is com p l e t e d in 2.5 minutes.

In their study, Mango *et al*. [11] reported 96% mean sensitivity for the abbreviated MRI protocol. In the study by Panigrahi *et al*. [17], the sensitivity was reported as 81.2%, however, the sensitivity is claimed as 100% when compared to the standard MRI technique. All malignant tumors found with standard MRI were also detected with abbreviated MRI. According to Chen *et al*.'s study [7], the sensitivity was reported to be 93.8% and just one case could not be detected with abbreviated MRI.

In our single-center retrospective study, we aimed to determine the efficacy of abbreviated breast MRI in the detection of malignant lesions. In our study group, the patients were scanned with a full complete breast MRI protocol. But only the series included in the abbreviated MRI protocol were evaluated. Study results showed a high rate of invasive breast cancer detection. Nine lesions among 83 malignant masses were missed by abbreviated MRI. The sensitivity of abbreviated MRI was found to be 89.1%. When these cases were re-evaluated, all the missed lesions could be seen in the second-minute contrast-enhanced series. In the literature, there is no detailed information about the evaluation of the cases with the 2nd-minute contrast-enhanced series. We saw that some of the cancers may show delayed enhancement in our study. We thought that adding the series acquired at the second minute would allow us to detect late-enhancing tumors. This may raise the question of increased of false positivity and decreased specificity. However, in the literature, there are studies that reported high specificity of abbreviated MRI protocols including second-minute contrast-enhanced sequences. Park *et al*. [18] included 2nd minute contrast-enhanced series in their abbreviated MRI protocol and they noted a higher specificity of abbreviated MRI than full diagnostic MRI. In a different study, Kwon *et al*. [19] used first- and second-minute contrast-enhanced series and achieved a specificity of 98.2%.

Limitations

There are several limitations in our study that should be noted. First of all, it was a single center, single observer, and retrospective study. Secondly, the study group included only patients with malignant masses. False positivity, specificity, and false negativity levels could not be evaluated because the patient group did not include benign lesions. In addition, only index tumors were evaluated in malignant masses, and no evaluation was made in terms of multifocality or multicentricity. Another limitation is that the evaluation time was not noted.

CONCLUSION

Abbreviated breast MRI, which shortens MRI acquisition and evaluation time, is a highly sensitive imaging method. In this study, we found that adding a 2-minute contrast-enhanced series will increase the sensitivity of abbreviated MRI significantly. But larger studies are needed to evaluate this finding. We believe that in screening high-risk women with dense breasts, an abbreviated breast MRI may be a good alternative to a full diagnostic examination.

Authors' Contribution

Study Conception: EY, NG; Study Design: EY; Supervision: EY, NG; Funding: N/A; Materials: N/A;

Data Collection and Processing: EY; Statistical Analysis and Data Interpretation: EY, NG; Literature Review: EY; Manuscript Preparation: EY, NG and Critical Review: EY, NG.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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