Correlation of Radiological and Pathological Tumor Sizes in Breast Cancer Based on Molecular Subtypes and Accompanying DCIS: A Retrospective Multicenter Study

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Purpose: This study aims to compare radiological tumor sizes obtained by mammography (MMG), ultrasonography (US), and magnetic resonance imaging (MRI) with pathological sizes to determine if molecular subtypes and the presence of accompanying ductal carcinoma in-situ (DCIS) affect accuracy.

Methods: A total of 559 cases diagnosed with breast cancer in 11 different centers between 2010–2023 were included in the study. The patients' MMG, US, and MRI images were re-evaluated, and radiological findings and tumor sizes were recorded. Histological diagnosis (invasive/in-situ/mixed), receptor status, Ki-67 index, and tumor size were recorded from the pathology reports. Pathologic tumor size (pT) was accepted as the gold standard.

Results: The mean pT was 21.1 ± 14.9 (2.7–100) mm in Luminal A tumors, 20.6 ± 12.6 (2–70) mm in Luminal B tumors, 26.3 ± 14.7 (6–80) mm in HER-2(+) tumors, 26.3 ± 14.7 (8–125) mm in triple (-) (TN) tumors. The highest agreement in invasive tumors was obtained with MRI (MRI r:0.831, US r:0.769, MMG r:0.650). In DCIS cases, the agreement was strong with MRI (r:0.770) and intermediate with MMG and US (r:0.517 and r:0.593, respectively). In mixed tumors, agreement was strong with MRI (r:0.817), intermediate with US (r:0.656), and low with MMG (r:0.499). Based on molecular subtypes, MRI had a strong correlation ($r > 0.7$) in both invasive and mixed tumors of all subtypes. US had a strong correlation in all invasive tumors ($r > 0.7$). The correlation was intermediate in Luminal mixed tumors. Mammography had a strong correlation only in invasive Luminal A tumors ($r > 0.7$), and an intermediate correlation in the other invasive tumor subtypes. Regarding mixed tumors, its correlation level was intermediate in Luminal B and TN tumors, and low in Luminal A and HER-2(+) tumors.

Conclusion: This multicenter study shows that MRI is the most reliable method for determining preoperative tumor size of invasive and in-situ tumors and all molecular subtypes. The correlation levels of all modalities decreased in pure and mixed DCIS cases, however the difference was minimal with MRI.

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INTRODUCTION

Globally, breast cancer is the most frequently diagnosed malignancy, accounting for over two million cases each year (1). It is also the leading cause of cancer death in women worldwide. Breast cancer is the most common female cancer and the second most common cause of cancer death in women (2). In the United States, breast cancer accounts for approximately 300,000 cases each year and is responsible for over 40,000 deaths (2). In the diagnosis and treatment of early-stage breast cancer, accurate determination of tumor size is critical for determining tumor stage, understanding the course of the disease, and formulating an appropriate treatment plan (3,4). Tumor size at the time of diagnosis is important in terms of surgery planning as well as the decision of neoadjuvant chemotherapy (NAC), and tumor size reduction after NAC is an important prognostic factor. Moreover, it has also been shown that tumor size at the time of diagnosis, independent of chemotherapy response, is an independent indicator of prognosis, especially in breast cancer patients without axillary lymph node involvement (3).

Imaging techniques are the main tools for assessing tumor size and extent at the time of diagnosis, with mammography (MMG), ultrasonography (US), and magnetic resonance imaging (MRI) being the most commonly used modalities. Each imaging technique has advantages and limitations. Evaluating the compatibility of these techniques with each other and histopathological results is important for accurate diagnosis and treatment. However, breast cancer is a heterogeneous disease and has different molecular and histological subtypes. The imaging characteristics and presentation of each subtype vary.

The accuracy of imaging methods in determining preoperative tumor size has been investigated before (5–7). However, only invasive tumors were included in most of these studies and the numbers of cohorts are significantly low. Moreover, only a few studies evaluate their accuracy based on different molecular subtypes (8–10). The present study aims to investigate the accuracy of imaging techniques in tumor size assessment in different molecular subtypes of breast cancer and to determine if accompanying DCIS affects accuracy. The study was planned as a multicenter study to ensure that there are enough cases from all molecular subtypes and that the results are not affected by differences in personal experience.

MATERIAL AND METHODS

A total of 11 university hospitals participated in the study (Turkish Breast Radiology Collaborative TR-BRC 2023–01). Data were entered into a common database (Verifast, Veritas, Clinical Research, 2024 © Copyright VeritasCRO). Patients who were diagnosed with breast cancer between 2010 and 2023, and who underwent MMG, US, and MRI before primary surgery were included in the study. Patients who received NAC preoperatively, whose radiological images or postoperative pathology results were unavailable, and who had positive margins at surgical pathology were excluded from the study. Patients with more than one-month interval between imaging and operation were also excluded.

Preoperative MMG, US, and MRI images were accessed via PACS systems and retrospectively reviewed by radiologists with at least 5 years of experience in breast imaging at each center. Lesion type, breast density, number of lesions, and lesion size (largest diameter) were determined, blinded to the histopathological findings. In the presence of more than one lesion in the same breast, the size and radiological features of the largest lesion were included in the study. In cases with tumors in both breasts, two breasts were evaluated separately.

Only 2D digital MMG findings were included in this study for standardization. Although some centers used 3D digital breast tomosynthesis (DBT), we instructed them not to give additional findings detected on 3D DBT, and not to include cases with only DBT and synthetic mamograms available.

MANDATORY DATA TO BE ENTERED INTO THE SYSTEM

General Information

Patient number, patient age, lesion location (right/left, quadrant), physical examination findings (palpable/non-palpable).

Imaging Findings

Date of examination, number of lesions (single/multifocal/multicentric), dominant lesion size, breast density on MMG (type A-D), background parenchymal enhancement (BPE) on MRI (minimal, mild, moderate, marked), and dominant lesion type on each modality were recorded. Lesion type was entered as mass/calcification/asymmetry/distortion for MMG and mass/non-mass lesion for US and MRI.

Histopathological Findings

Date of operation, histopathological diagnosis, tumor grade (low/intermediate/high for DCIS, grade 1/2/3 for invasive tumors), tumor size (pT), histological type, additional foci (multifocal/multicentric/bilateral), receptor status of index lesion HER-2 status (+/-), and Ki-67 index value. HER-2 status was accepted as positive if it was 3+ or the FISH test was positive.

The tumor size in the postoperative pathology report was accepted as the gold standard. Histopathological results were

evaluated in three categories; isolated invasive carcinoma, isolated DCIS, and invasive carcinoma accompanied by DCIS (mixed tumor). In mixed tumors, the characteristics of both invasive and in-situ tumor components were entered into the system separately, and the size of the largest lesion detected on imaging was compared to the total size of invasive and in-situ carcinomas on the pathology report.

Molecular subtypes were determined only for invasive cancers, and the invasive components of mixed tumors. They were classified according to Estrogen receptor (ER), Progesterone receptor (PR), HER-2 status, and Ki-67 level. The cut-off value for the Ki-67 proliferative index was accepted as 14 (11).

STATISTICAL ANALYSIS

Some of the criteria were dichotomized as follows for statistical analysis: For breast density as fatty (type A or B) versus dense (type C or D), for BPE on MRI as low (minimal or mild) versus increased (moderate or marked), for tumor grade in DCIS as low (low or intermediate) versus high grade, and for tumor grade in invasive cancers as low (grade 1 or 2) versus high (grade 3).

The data were analyzed with IBM Data Analysis for Social Sciences software package version 23.0 (IBM Corp., Armonk, NY). Frequency and percentage for categorical data, mean, standard deviation (SD), median, minimum, and maximum for continuous data were given as descriptive values. For intergroup comparisons, "Mann Whitney U-Test" was used for two groups, "Kruskal Wallis H-Test" for more than two groups, "Chi-Square or Fisher's Exact Test" was used to compare categorical variables, and "Spearman Correlation Analysis" was used to analyze the relationship between continuous variables. The results were considered statistically significant when the p-value was less than 0.05.

In the correlation analysis of tumor size, the correlation coefficient values were accepted as follows: Between 0,00–0,29: weak, 0.30–0.49: low, 0,50–0,69: intermediate, 0,70–0,89: strong, 0.90–1.00: very strong.

RESULTS

A total of 556 patients with 559 lesions were included in the study. Three patients had bilateral breast cancer. The mean patient age was 52 ± 12 years (26–91), and 51% (n:283) were younger than 50 years. 59.6% (n:333) of the lesions were palpable. The most common location was the upper outer quadrant (60%), with no difference between the right and left sides.

While 67.4% (n:377) of tumors were invasive, 25.2% (n:141) were mixed, and 7.3% (n:41) were pure DCIS. Regarding invasive and mixed cancers, 47.9% (n:248) were Luminal A, 22.4% (n:116) were Luminal B, 16.6% (n:86) were HER-2(+), and 13.1% (n:68) were TN. Pathological findings can be seen in Table 1.

TABLE 1. Distribution of Pathological Findings

Variables (n:559)	Size	N (%)
Tumor Type		
DCIS		41 (7,3)
Mixed tumors		141 (25,2)
Invasive cancers		377 (67,4)
DCIS Grade (n: 182)		
Low/Medium		73 (40,1)
High		109 (59,9)
Tumor Size (mm)		
DCIS	31,8 ± 18 (1–100)	
Mixed tumors	28,8 ± 20,7 (3–130)	
Invasive cancers (n:518)	22,6 ± 15,8 (2–125)	
< 1 cm		73 (14,1)
1–2 cm		185 (35,7)
≥ 2 cm		260 (50,2)
Invasive tumor Grade		
Grade I-II		327 (63,1)
Grade III		191 (36,9)
Invasive Tumor Histopathological Type		
Invasive Ductal		425 (82)
Invasive Lobular		55 (10,6)
Other		38 (7,3)
Molecular Subtype (invasive and mixed tumors)		
Luminal A	21.1 ± 14.9 (2.7–100)	248 (47,9)
Luminal B	20.6 ± 12.6 (2–70)	116 (22,4)
HER–2 (+)	26. 3 ± 14.7 (6–80)	86 (16,6)
TN	26. 3 ± 14.7 (8–125)	68 (13,1)

DCIS, ductal carcinoma in-situ; TN, triple-negative breast cancer

TABLE 2. Evaluation of MMG, US, and MRI Findings

Variables	MMG n (%) (n: 544)	US n (%) (n:545)	MRI n (%) (n:530)	Histopathology n (%) (n:559)
Breast density				
Fatty (type A+B)	207 (38,1)			
Dense (type C+D)	337 (61,9)			
BPE				
Low (minimal+mild)			348 (65,7)	
Increased (moderate+marked)			182 (34,3)	
Lesion				
Not detected	47 (8,6)	25 (4,6)	2 (0,4)	
Detected	497 (91,4)	520 (95,4)	528 (99,6)	
Lesion Type				
Mass	345 (69,4)	437 (84)	380 (71,7)	
Non-mass	152 (30,6)	60 (11,5)	78 (14,7)	
(Calcification)	74 (14,9)			
(Asymmetry)	61 (12,3)			
(Distortion)	17 (3,4)			
Mass+Non-mass	47 (8,6)	23 (4,5)	72 (13,6)	
Mean Lesion Size (mm)	27,2 ± 18,1	19,9 ± 12,3	25,8 ± 18,3	24,81 ± 14,1

BPE, background parenchymal enhancement

MMG, US, and MRI findings were reported for 544, 545, and 530 women respectively. MRI had the highest sensitivity (99.6%). The majority of DCIS cases presented as calcifications on MMG (75.7%) and non-mass findings on US (63.3%) and MRI (78.4%), whereas the majority of invasive tumors presented as masses on MMG (77.7%), US (89.8%) and MRI (81.3%). Mixed tumors also presented as masses in most cases (MMG: 63.6%; US: 78.9%; MRI: 60.9%). Radiological findings are summarized in Table 2.

All radiological measurements correlated significantly with pT. In invasive cancers, the highest agreement was obtained with MRI (r:0.831), with a similar strong agreement with US (r:0.769), and moderate agreement with MMG (r:0.650). In DCIS cases, the agreement was strong with MRI (r:0.770), while intermediate with MMG and US (r:0.517 and r:0.593 respectively). In mixed tumors, agreement was strong with MRI (r:0.817), intermediate with US (r:0.656), and low with MMG (r:0.499) (Table 4). The highest correlation with pT was in invasive tumors, while correlation levels decreased in the presence of DCIS. However, although decreased in DCIS; correlation was still strong in all cases with MRI (Fig 1) (Table 3).

In invasive cancers, the mean tumor size was 21.1 ± 14.9 (2.7–100) mm for Luminal A tumors, 20.6 ± 12.5 (2–70) mm for Luminal B tumors, 26.3 ± 14.6 (6–80) mm for HER-2(+) tumors, 26.9 ± 22.2 (8–125) mm in TN tumors. Tumor size at the time of diagnosis was significantly larger in HER-2(+) and TN subtypes compared to luminal tumors (p:0.003). Except TN cancers, MMG tended to overestimate, and US tended to

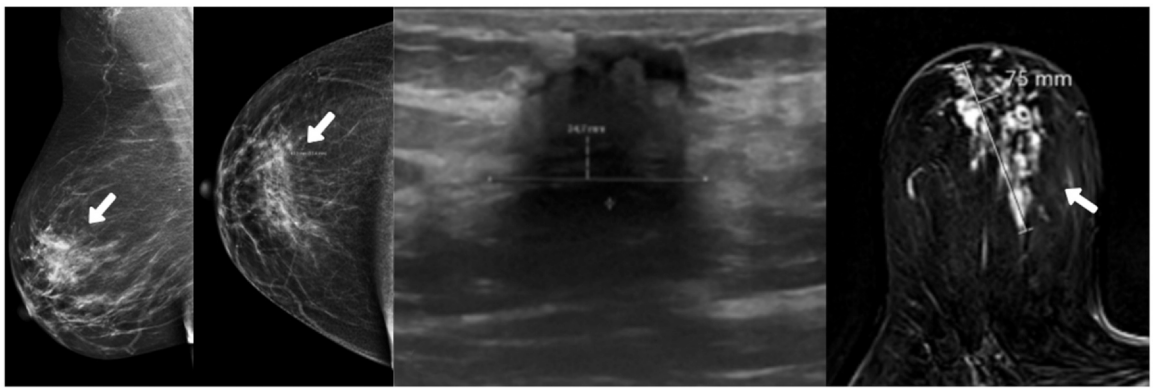

Figure 1. A 58-year-old woman had a 42 mm focal asymmetry on screening MMG (arrow). A 25 mm heterogeneous non-mass hypoechoic lesion was observed on US and a 75 mm asymmetric segmental non-mass enhancement was observed on MRI (arrow). The postoperative pathology result was DCIS (high grade) with a size of 100 mm. It is noteworthy that in tumors that present as non-mass lesions such as DCIS, MRI is the most accurate for pathological tumor dimensions.

TABLE 3. Correlation of Radiological Tumor Sizes with Histopathological Tumor Size in Invasive, In-situ, and Mixed Tumors

Variables (Size)		MMG	US	MRI	DCIS	Mixed	Invasive
MMG	r	1000	0685	0717	0517	0499	0650
	p	-	< 0001	< 0001	0001	< 0001	< 0001
US	r	0685	1000	0800	0593	0656	0769
	p	< 0001	-	< 0001	< 0001	< 0001	< 0001
MRI	r	0717	0800	1000	0770	0817	0831
	p	< 0001	< 0001	-	< 0001	< 0001	< 0001

p, probability value; r, correlation coefficient

TABLE 4. Comparison of Histopathological and Radiological Tumor Sizes of Mixed and Invasive Tumors Based on Molecular Subtypes

	Tumor size	Mixed (Mean ± SD)	Invasive carcinoma (Mean ± SD)
Luminal A	Histopathological	35.78 ± 21.13	21.13 ± 14.88
	MMG	29.97 ± 19.31	23.02 ± 14.71
	US	21.98 ± 13.96	17.93 ± 11.47
	MRI	29.78 ± 20.36	21.98 ± 14.59
Luminal B	Histopathological	38.77 ± 27.51	20.62 ± 12.49
	MMG	27.60 ± 13.68	23.78 ± 14.88
	US	21.13 ± 8.57	16.79 ± 9.11
	MRI	32.87 ± 21.85	19.81 ± 11.65
HER2 (+)	Histopathological	45.82 ± 45.13	26.27 ± 14.53
	MMG	36.5 ± 26.99	33.69 ± 19.59
	US	23.21 ± 15.05	21.96 ± 12.40
	MRI	33.41 ± 22.62	26.44 ± 15.98
TN	Histopathological	37.93 ± 35.67	26.86 ± 22.19
	MMG	35.07 ± 33.87	25.08 ± 13.44
	US	21.41 ± 8.89	22.88 ± 14.64
	MRI	31.13 ± 23.25	25.54 ± 21.48

TN, triple-negative breast cancer

underestimate tumor size in invasive cancers, while MRI provided the closest measurements to pathology. In TN lesions, all modalities underestimated size, although the mean difference was < 2 mm with MMG and MRI. In mixed tumors, tumor sizes were underestimated in all subtypes with all modalities (Table 4).

MRI had a strong correlation to histopathology in both invasive and mixed tumors of all subtypes (Fig 2). US had a strong correlation in all invasive tumors. In mixed tumors, the correlation was strong in HER-2(+) and TN tumors, but intermediate in Luminal tumors. In HER-2(+) and TN tumors, the performance of US and MRI were similar. Mammography had a strong correlation only in invasive Luminal A tumors, and an intermediate correlation in the other invasive tumor subtypes. In terms of mixed tumors, its correlation level was intermediate in Luminal B and TN tumors, and low in Luminal A and HER-2(+) tumors (Table 5).

DISCUSSION

In this retrospective multicenter study, tumor sizes measured by MMG, US, and MRI were compared to histopathological tumor size based on different molecular subtypes and the presence or absence of accompanying DCIS. Study results showed that MRI was the most accurate radiological method for determining tumor size, in invasive and in-situ tumors and in all molecular subtypes.

Several factors may affect the accuracy of tumor size measurement in radiology. The most important handicap for MMG is dense breast tissue (12). Although the sensitivity of MMG has increased with the use of tomosynthesis, it is still limited compared to other methods (12). In our study, the lowest correlation was achieved with MMG in all tumors including DCIS.

US is more sensitive and more accurate in the determination of size compared to MMG. Cortadellas et al. reported that US was the best method for tumor size measurement, better than clinical examination and other imaging methods (4). However, sonographic evaluation is subjective and can be affected by many factors related to the device, patient, and operator. In addition, size determination could be inaccurate in lesions with subtle margins, lesions with posterior acoustic shadowing or peripheral halo, and lesions that are too large to fit in the image window (13–15). Tumor histology can also affect the determination of size. Pritt et al have reported that US underestimates tumor size in invasive lobular

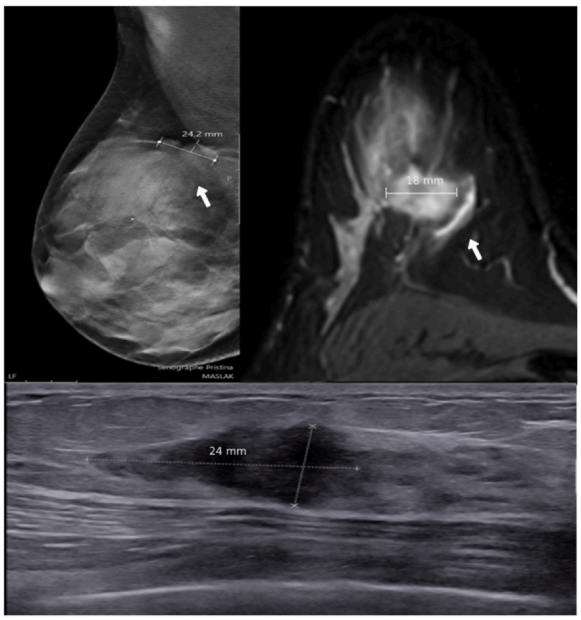

Figure 2. A 41-year-old woman with a non-palpable mass (24 mm) in the upper outer quadrant of the right breast on screening MMG. Its diameter is also 24 mm on US, but 18 mm on MRI (arrows). Histopathology showed an IDC measuring 18 mm (NOS, grade I, ER: %100, PR: %90, HER-2 (-), Ki-67:13). MRI provided the best result in this case, while there was significant overestimation with MMG and US.

carcinomas (ILCs) and in tumors with intraductal components. Bosch et al. have also shown that the difference between pT and US dimensions was low in IDC (mean difference 0.3 cm), whereas it was significantly higher in DCIS with or without an invasive component (mean difference 0.74 cm) and ILC (mean difference 2.43 cm) (14). In our study, the correlation of sonographic tumor size was strong in invasive tumors, but intermediate in DCIS and mixed tumors. The decrease in accuracy in the presence of DCIS was more pronounced in luminal tumors. US tended to underestimate tumor size in all cases; still, its accuracy was higher than MMG in both DCIS and mixed tumors, while it was lower than MRI.

Although MRI is generally accepted to be the most sensitive method for the detection of breast cancer, there is no consensus on whether the size measurements are accurate or not. Several factors such as BPE, contrast enhancement kinetics, histopathological type (IDC,ILC,DCIS), molecular subtype, and lesion type (mass/non-mass) may affect the accuracy of tumor size measurement on MRI. The presence of concomitant DCIS and benign or high-risk proliferative lesions in the surrounding parenchyma may also affect size determination (14–18). Many studies have concluded that MRI overestimates the tumor size (10–80%), thus causing unnecessary mastectomies (4,19,20). This possibility is higher when there is increased BPE, especially in DCIS cases (18).

TABLE 5. Correlation of Radiological Tumor Sizes with Histopathological Tumor Sizes Based on Molecular Subtypes

Subtype			MMG Lesion Size	US Lesion Size	MRI Lesion Size	Mixed Tumor Size	Invasive Tumor Size
Luminal A	MMG	r	1000	**0716**	**0708**	**0432**	**0712**
	Lesion Size	p	-	**< 0001**	**< 0001**	**< 0001**	**< 0001**
	US Lesion Size	r	**0716**	1000	**0796**	**0640**	**0761**
		p	**< 0001**	-	**< 0001**	**< 0001**	**< 0001**
	MRI Lesion Size	r	**0708**	**0796**	1000	**0822**	**0856**
		p	**< 0001**	**< 0001**	-	**< 0001**	**< 0001**
Luminal B	MMG	r	1000	**0618**	**0711**	**0587**	**0516**
	Dominant Size	p	-	**< 0001**	**< 0001**	**0003**	**< 0001**
	US Lesion Size	r	**0618**	1000	**0824**	**0619**	**0745**
		p	**< 0001**	-	**< 0001**	**0002**	**< 0001**
	MRI Lesion Size	r	**0711**	**0824**	1000	**0880**	**0815**
		p	**< 0001**	**< 0001**	-	**< 0001**	**< 0001**
HER–2 (+)	MMG	r	1000	**0578**	**0627**	**0483**	**0534**
	Dominant Size	p	-	**< 0001**	**< 0001**	**0027**	**< 0001**
	US Lesion Size	r	**0578**	1000	**0723**	**0741**	**0754**
		p	**< 0001**	-	**< 0001**	**< 0001**	**< 0001**
	MRI Lesion Size	r	**0627**	**0723**	1000	**0782**	**0715**
		p	**< 0001**	**< 0001**	-	**< 0001**	**< 0001**
TN (-)	MMG	r	1000	**0724**	**0803**	**0595**	**0659**
	Dominant Size	p	-	**< 0001**	**< 0001**	**0025**	**< 0001**
	US Lesion Size	r	**0724**	1000	**0817**	**0817**	**0792**
		p	**< 0001**	-	**< 0001**	**0001**	**< 0001**
	MRI Lesion Size	r	**0803**	**0817**	1000	**0760**	**0858**
		p	**< 0001**	**< 0001**	-	**0001**	**< 0001**

p, probability value; r, correlation coefficient; TN, triple-negative breast cancer

Moreover, benign or high-risk proliferative lesions, which usually accompany DCIS, may demonstrate suspicious enhancement on MRI; thus causing an overestimation of tumor size (20,21). Nevertheless, MRI was the most accurate imaging method in our study. Size measurement in MRI had a strong correlation with histopathological sizes, in invasive, in-situ, and mixed tumors, as well as all molecular subtypes. Based on mean tumor sizes, there was no overestimation. On the contrary, there was some underestimation in mixed tumors.

To the best of our knowledge, there are only three studies that have evaluated the accuracy of radiological tumor size measurements in different molecular subtypes of breast cancer (8–10). Botty et al. compared MMG, US, and MRI in 87 HER-2(+) breast cancer patients, and concluded that US was the most accurate method for preoperative determination of tumor size in HER-2(+) tumors and that MRI overestimated tumor size in 40% of the cases (10). Woo et al have evaluated 996 lesions of all subtypes using only US and MRI. They have reported that while MRI had a stronger correlation in Luminal A and HER-2(+) tumors, US was slightly better in TN cancers (9). Sezgin et al have compared all three imaging methods in all subtypes, similar to our study, however, they evaluated only 91 lesions (8). They showed that Luminal A type cancers were underestimated with all three modalities, especially in large tumors. However, no statistically significant difference was observed between radiological modalities in determining tumor size in other molecular subtypes (8). Compared to these three studies, ours is the only multicenter one, comparing all three modalities in a large group of patients and including both invasive and mixed tumors of all subtypes. Similar to Woo et al, our results have shown that US and MRI measurements are strongly correlated to pT in both HER-2(+) and TN cancers, with US slightly better in the HER-2 (+) type and MRI slightly better in the TN type. Contrary to Sezgin et al, we have shown that both US and MRI performed very well in invasive luminal tumors. MMG measurements also showed a strong correlation in invasive Luminal A tumors, but only an intermediate correlation in the other subtypes.

In the present study, tumor size at diagnosis was significantly larger in HER-2(+) and TN subtypes compared to luminal tumors (p:0.003). TN and HER2(+) tumors have high genetic instability, high mutation-proliferation and mitosis rates, and a rapid growth pattern (22). This may explain their larger size at diagnosis compared to luminal tumors. It has also been reported that the tumor size of aggressive tumors such as HER-2(+) and TN subtypes can be determined more accurately because they usually present as circumscribed mass lesions (15,20). On the other hand, Ploumen et al have reported that the presence of an in-situ component in more than half of HER-2(+) tumors is an important limiting factor in determining size, especially on US (23). In our study, the presence of DCIS did not affect the accuracy of MRI significantly, however, the correlation levels were lower with US in luminal-type mixed tumors, and mixed luminal A and HER-2(+) tumors with MMG. The role of accompanying DCIS on tumor measurement in different molecular subtypes has not been investigated in other studies as far as we know.

There are some limitations in this study. First of all, this is a retrospective study, with relatively few patients, although the number of patients was higher compared to many studies. There were missing data in some cases. The size of the lesions was relatively large in this multicenter study, and this may be one of the reasons why all imaging modalities had high sensitivity and performed rather well. Moreover, the comparison of mixed tumors was difficult, and we chose to compare the largest area demonstrated on imaging modalities with the total size on the pathology report. However, this may not represent the most accurate tumor extent in some cases. We did not evaluate the effects of factors such as lesion type, breast density, BPE, histologic tumor type, and the presence of proliferative changes in the surrounding parenchyma on the accuracy of tumor measurement in this study. We plan to evaluate them in a future study, after increasing the number of patients. However, because it was a multicenter study, we could include many cases from all breast cancer subtypes, and because it collected data from many experienced institutions from all over our country, it represents the current situation more objectively. Moreover, we evaluated the accuracy of tumor size measurement for both invasive and mixed tumors in different subtypes, which has not been investigated before. In this context, this is the first multicentric study to comprehensively evaluate all three modalities according to molecular subtypes and the presence of accompanying DCIS.

CONCLUSION

Radiological imaging modalities have an important role not only in the diagnosis of breast cancer but also in treatment planning, prediction of prognosis, evaluation of response to treatment, and post-treatment follow-up. Since each molecular and histological subtype of breast cancer has different characteristics, the effectiveness and use of radiological imaging methods may also vary. In terms of personalized treatment planning and patient management, it is necessary to be aware of the radiological characteristics of each tumor type and to use radiological modalities effectively by knowing the strengths and weaknesses of each imaging modality.

The results of this study show that MRI is the best method for preoperative evaluation in both invasive and in-situ tumors and in all molecular subtypes. In this context, MRI can be used for tumor size determination in all types of breast cancer. US also performs well in invasive cancers of all subtypes, as well as mixed HER-2(+) and TN tumors, but it tends to underestimate tumor size. On the other hand, MMG demonstrated intermediate or low levels of correlation in all tumors except invasive Luminal A subtype. The correlation levels of all modalities decreased in pure and mixed DCIS cases, however the difference was minimal with MRI.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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