HİTİT MEDICAL JOURNAL
HİTİT ÜNİVERSİTESİ TIP FAKÜLTESİ DERGİSİ
e-ISSN: 2687-4717 Cilt|Volume: 7 • Sayı|Issue: 2 - Haziran|June 2025

Contribution to Diagnosis of Microflow Imaging in Breast Lesions

Meme Lezyonlarında Mikroakım Görüntülemenin Tanıya Katkısı

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Makale Bilgisi | Article Information
Makale Türü | Article Type: Araştırma Makalesi | Research Article
Doi: https://doi.org/10.52827/hititmedj.1580731
Geliş Tarihi | Received: 06.11.2024
Kabul Tarihi | Accepted: 04.03.2025
Yayım Tarihi | Published: 23.06.2025

Atıf | Cite As
Sarman S, Beyhan M. Contribution to Diagnosis of Microflow Imaging in Breast Lesions. Hitit Medical Journal 2025;7(2):188-197. https://doi.org/10.52827/hititmedj.1580731

Hakem Değerlendirmesi: Alan editörü tarafından atanan en az iki farklı kurumda çalışan bağımsız hakemler tarafından değerlendirilmiştir.
Etik Beyanı: Çalışma için 23/09/2021 tarihinde Tokat Gaziosmanpaşa Üniversitesi Tıp Fakültesi Klinik Araştırmalar Etik Kurulu'ndan onay alınmıştır. Karar no: 21-KAEK-203.
İntihal Kontrolleri: Evet (iThenticate)
Çıkar Çatışması: Yazarlar çalışma ile ilgili çıkar çatışması beyan etmemiştir.
Şikayetler: hmj@hitit.edu.tr
Katkı Beyanı: Fikir/Hipotez: MB Tasarım: SS, MB Veri Toplama/Veri İşleme: SS, MB Veri Analizi: SS, MB Makalenin Hazırlanması: SS, MB.
Hasta Onamı: Tüm hastalardan yazılı bilgilendirilmiş onam ve yayın için izin alınmıştır.
Finansal Destek: Bu çalışma Tokat Gaziosmanpaşa Üniversitesi Bilimsel Araştırma Projelerinden 2020/71 no'lu "Radyoloji Anabilim Dalı Ultrasonografi Ünitesine Üst Düzey Dopplerli Ultrasonografi Alımı" projesi sonucu alınan cihazda yapılmıştır.

Teşekkür: Yazarlar, bu makalenin istatistiksel analiz değerlendirmeleri için Dr. Osman Demir'e (MD, Tokat Gaziosmanpaşa Üniversitesi, Tıp Fakültesi, Biyoistatistik AD) teşekkürlerini sunarlar.

Peer Review: Evaluated by independent reviewers working in the at least two different institutions appointed by the field editor.
Ethical Statement: Approval for the study was obtained from the Tokat Gaziosmanpaşa University Faculty of Medicine Research Ethics Committee on 23/09/2021. Decision no: 21-KAEK-203
Plagiarism Check: Yes (iThenticate)
Conflict of Interest: The authors declared that, there are no conflicts of interest.
Complaints: hmj@hitit.edu.tr
Authorship Contribution: Idea/Hypothesis: MB Design: SS, MB Data Collection/Data Processing: SS, MB Data Analysis: SS, MB Manuscript Preparation: SS, MB.
Informed Consent: Written informed consent and consent for publication were obtained from all patients.
Financial Disclosure: This study was conducted on the device purchased as a result of the project titled "Acquisition of High-Level Doppler Ultrasonography to the Ultrasonography Unit of the Radiology Department" from Tokat Gaziosmanpaşa University Scientific Research Projects numbered 2020/71.

Acknowledgement: The authors would like to thank Dr. Osman Demir (MD, Tokat Gaziosmanpaşa University, Faculty of Medicine, Department of Biostatistics) for his statistical analysis evaluations of this article.

The Contribution of Microflow Imaging to Diagnosis in Breast Lesions

ABSTRACT

Objective: In recent years, the cancer detection rate in breast biopsies varies between 10-31%. Appropriate classification is required to prevent unnecessary biopsies in breast lesions. The aim of our study is to investigate the contribution of microflow imaging to the diagnosis of benign and malignant breast lesions.

Material and Method: After local ethics committee approval, 109 lesions of 104 patients older than 18 years were prospectively included in the study. B-mode ultrasonography, color Doppler ultrasonography, power Doppler ultrasonography and microflow imaging were performed on all patients. B-mode ultrasonography findings were classified according to the BI-RADS category, color Doppler ultrasonography, power Doppler ultrasonography and microflow imaging findings were classified according to the ADLER method. Sensitivity, specificity, negative predictive values and positive predictive values of Doppler ultrasonographic methods were calculated.

Results: Histopathologically, 68 of the breast lesions were benign and 41 were malignant. There was a statistically significant difference between benign and malignant lesions on power Doppler ultrasonography and microflow imaging. Negative predictive values were higher than positive predictive values on Doppler ultrasonography examination methods. Doppler ultrasonography examinations were found to be more likely to identify malignant lesions.

Conclusion: Vascular findings on power Doppler ultrasonography and microflow imaging can be used as criteria to differentiate benign from malignant breast lesions. Thus, benign breast lesions can be monitored and unnecessary biopsies can be prevented.

Keywords: Breast cancer, color Doppler ultrasonography, microflow imaging, power Doppler ultrasonography.

ÖZET

Amaç: Son yıllarda yapılan meme biyopsilerinde kanser saptama oranı %10-31 arasında değişmektedir. Meme lezyonlarında gereksiz biyopsilerin önlenmesi için uygun sınıflandırma gerekmektedir. Çalışmamızın amacı benign ve malign meme lezyonlarında mikroakım görüntülemenin tanıya katkısını araştırmaktır.

Gereç ve Yöntem: Çalışmaya yerel etik kurul onayı alındıktan sonra prospektif olarak 18 yaşından büyük 104 hastanın 109 lezyonu dahil edildi. Hastaların hepsine B-mod ultrasonografi, renkli Doppler ultrasonografi, power Doppler ultrasonografi ve mikroakım görüntüleme yapıldı. B-mod ultrasonografi bulguları BI-RADS kategorisine göre, renkli Doppler ultrasonografi, power Doppler ultrasonografi ve mikroakım görüntüleme bulguları ise ADLER metoduna göre sınıflandırıldı. Doppler ultrasonografik yöntemlerin duyarlılık, özgüllük, negatif prediktif değerleri ve pozitif prediktif değerleri hesaplandı.

Bulgular: Toplam 30 hasta çalışmaya dahil edildi. Hastalarda trakea-özofageal fistül geliştiğinde mekanik ventilasyonHistopatolojik olarak meme lezyonlarının 68'i benign, 41'i maligndi. Power Doppler ultrasonografi ve mikroakım görüntülemede benign ve malign lezyonlar arasında istatistiksel olarak anlamlı farklılık mevcuttu. Doppler ultrasonografi inceleme yöntemlerinde negatif prediktif değerler pozitif prediktif değerlerden daha yüksekti. Doppler ultrasonografi incelemelerinin malign lezyonları tanımlama olasılığı daha yüksek bulundu.

Sonuç: Power Doppler ultrasonografi ve mikroakım görüntülemelerdeki vasküler bulgular benign ve malign meme lezyonlarının ayrımında bir kriter olarak kullanılabilir. Bu sayede benign meme lezyonları takip edilerek gereksiz biyopsiler önlenebilir.

Anahtar Sözcükler: Meme kanseri, mikroakım görüntüleme, renkli Doppler ultrasonografi, power Doppler ultrasonografi.

Introduction

Breast cancer, which is the most commonly diagnosed cancer in women, is the second most frequently diagnosed cancer worldwide after lung cancer without gender difference. However, due to its higher prevalence in developed countries and the high survival rates, it ranks fifth among cancer-related deaths (1).

Breast ultrasonography (US), a component of the examination of breast lesions, is more frequently used in diagnosis and screening than other screening techniques due to its low cost and the absence of ionizing radiation. It is widely used in patients with dense breast tissue, high-risk patients, young women (<30 years), the characterization of lesions that are not defined by mammography, the evaluation of palpable mass lesions, and for guiding interventional procedures (2, 3). At the present time, due to the importance of early diagnosis in breast cancer, the necessity not to miss early-stage lesions and the anxiety created by judicial processes, core needle biopsies or excisional biopsies are performed. This approach causes anxiety in the patient, prolongs the recovery period of the patient, and increases the treatment cost. The positivity rate for cancer in biopsies performed by the core needle biopsy approach varies between 10-31%. In other words, 70-90% of the biopsies are performed on benign lesions (4). Therefore, correct classification of breast lesions and avoiding unnecessary biopsies are essential.

Breast cancer requires microvascular angiogenesis for growth, spread, and survival of cancer cells. Tumor vascularity is important in such cases as tumor volume and cell cycle (5, 6). Based on angiogenesis, contrast-enhanced mammography is reported to be a promising technology for the diagnosis of breast cancer and determination of tumor size as a new method (7). However, the currently used color Doppler US (CDUS) and power Doppler US (PDUS) methods focus on the macrovascular structure of the tissue and do not provide sufficient information about small and slow-flowing microvascular structures due to artifacts and low vascular sensitivity (5, 6). Therefore, slow-flow imaging techniques, another new method developed recently, that does not involve radiation, are used. Advanced Doppler techniques are now commercially available in many high-end US systems [e.g., Superb Microvascular Imaging (SMI), Canon Medical; Slow Flow, Siemens Healthineers; Microvascular Imaging (MVI), GE Healthcare; MicroFlow Imaging (MFI), Philips; and MV-flow, Samsung] (8). In these techniques, smart wall filter systems separate low-velocity vascular flow signals originating from small vascular structures from motion signals originating from patient movement, pulse and respiration and signals from vascular structures are not suppressed. Therefore, microvessels (up to 0.1 mm) that cannot be visualized on conventional Doppler methods due to filter systems are visualized (5, 9, 10). The aim of our study is to evaluate whether the new method, microflow imaging (MFI), contributes to the differential diagnosis of benign and malignant breast lesions and to compare its diagnostic efficacy with other methods used to investigate vascularity, such as CDUS and PDUS.

Material and Method

Patients who applied to Tokat Gaziosmanpaşa University Hospital Interventional Radiology Clinic for breast biopsy between November 2021 and November 2023 were evaluated ultrasonography before biopsy. Patients with a history of previous cancer and surgery in the same breast and patients with a history of chemoradiotherapy were excluded. Our study was conducted prospectively with the approval of the local ethics committee (21-KAEK-203). The study adhered to the principles of the World Medical Association Declaration of Helsinki and good clinical practice guidelines, and informed consent forms were obtained from all patients. The study was performed with an 18-4 MHz probe on the Philips Epiq Elite (obtained as a result of the project “Acquisition of High-Level Doppler Ultrasonography to the Ultrasonography Unit of the Radiology Department” from our University Scientific Research Projects numbered 2020/71), and all lesions were examined by the same radiology research assistant doctor with at least 3 years of experience in B-mode US, CDUS, PDUS, and MFI.

B-mode US findings were evaluated according to the BI-RADS 2013 atlas, and the dimensions of the lesions, localization 1 (right, left), localization 2 (upper outer, upper inner, lower outer, lower inner, and retroareolar), orientation features (parallel, nonparallel), echo pattern (hypoechoic, hyperechoic, complex, and anechoic), margin characteristics (well-defined, ill-defined, spiculated, and microlobulated) and, if any posterior acoustic features (acoustic shadowing, acoustic enhancement) were evaluated. While measuring the lesion dimensions, the longest single dimension was recorded.

For CDUS, PDUS, and MFI applications, probe pressure was not applied, and the device filter and gain settings were adjusted to optimal Doppler parameters. CDUS, PDUS, and MFI findings were classified according to the ADLER method, and all results were recorded. According to the ADLER method, in an imaging area, if no vascular structure was observed, it was classified as grade 0; if one or two small vessels (<1 mm) were observed, classified as grade 1; if one large vessel and/or more than two small vessels were visible, classified as grade 2; and if four or more vascular structures were detected, classified as grade 3 (11). Statistical analyses were first conducted using this classification, and then, ADLER grades 0 and 1 were named as Group 1 and ADLER grades 2 and 3 were named as Group 2. Statistical analyses were conducted for these two groups, which were coded as CDUS_2, PDUS_2, and MFI_2.

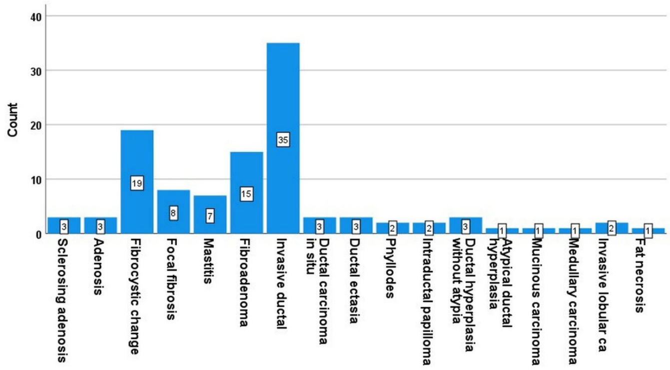
Statistical Analysis

Descriptive analyses were performed to provide information about the general characteristics of the study groups. Data for continuous variables are presented as mean ± standard deviation, and categorical variables as n (%). The normality of continuous variables were tested using the Shapiro-Wilk test. The significance of the difference in means between groups for quantitative variables was assessed using the Two-Sample t-test. To evaluate the relationship between qualitative variables, cross-tabulations and chi-square tests were used. Sensitivity, specificity, positive predictive, and negative predictive values were used for the variables associated with malignancy classification. ROC analysis was conducted to calculate the area under the curve. A *p-value* of less than *0.05* was considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 27.0 (Armonk, NY: IBM Corp).

Results

A total of 109 lesions from 104 female patients included in the study were evaluated and the age range of the patients ranged from 18 to 76 years. The mean age of patients with benign lesions was 41.3 ± 12.4, and the mean age of patients with malignant lesions was 54.8 ± 12.2, and the mean age in malignant lesions was statistically significantly higher (*p<0.001*). The mean size of malignant lesions was 22.7 mm, while the mean size of benign lesions was measured as 18.9 mm. The mean lesion size was higher in malignant lesions, but there was not a statistically significant difference (*p=0.123*). 68 benign (62.4%) and 41 malignant (37.6%) lesions were detected in the study. The graph describing the pathology results of the breast lesions in the study is shown in Figure I.

Figure I. Graph Describing Pathology Results of Breast Lesions



On the preoperative Doppler examination of the lesions; while CDUS, PDUS, MFI examinations were categorized as ADLER grade 0, 1, 2, 3 and comparison between benign and malignant lesions were made, there was no statistically significant difference (*p=0.067*; *p=0.074*; *p=0.079*, respectively). However, when ADLER 0 and ADLER 1 were classified as group 1, and ADLER 2 and ADLER 3 were classified as group 2, the lesions evaluated in group 1 with the PDUS examination were statistically significantly benign, while the lesions classified in group 2 were statistically significantly malignant (*p=0.013*). Similarly, with MFI imaging, the lesions evaluated as group 1 were statistically significantly detected as benign (Figures II, III), while the lesions classified as group 2 were statistically significantly detected as malignant (*p=0.013*) (Table I) (Figure IV).

Table I. Distribution of Qualitative Variables on Color and Power Doppler Ultrasonography and Microflow Imaging According to Benign and Malignant Biopsy Group

Variables		Biopsy Pathology		X^2	*p*
		Benign	**Malign**		
		n (%)	n (%)		
CDUS_2	1	43 (63.2)	19 (46.3)	2.976	*0.084*
	2	25 (36.8)	22 (53.7)		
PDUS_2	1	40 (58.8)a	14 (34.1)b	6.231	*0.013*
	2	28 (41.2)a	27 (65.9)b		
MFI_2	1	31 (45.6)a	9 (22)b	6.152	*0.013*
	2	37 (54.4)a	32 (78)b		
CDUS	Adler 0	38 (55.9)	13 (31.7)	7.153	*0.067*
	Adler 1	5 (7.4)	6 (14.6)		
	Adler 2	18 (26.5)	13 (31.7)		
	Adler 3	7 (10.3)	9 (22)		
PDUS	Adler 0	35 (51.5)	11 (26.8)	6.922	*0.074*
	Adler 1	5 (7.4)	3 (7.3)		
	Adler 2	19 (27.9)	17 (41.5)		
	Adler 3	9 (13.2)	10 (24.4)		
MFI	Adler 0	15 (22.1)	4 (9.8)	6.794	*0.079*
	Adler 1	16 (23.5)	5 (12.2)		
	Adler 2	14 (20.6)	15 (36.6)		
	Adler 3	23 (33.8)	17 (41.5)		

Pearson chi-square test was used. (ab): The common letter in the row indicates statistical insignificance

CDUS: Color Doppler Ultrasonography; PDUS: Power Doppler Ultrasonography, MFI: Microflow imaging

The localization, border features, echo pattern, orientation and posterior acoustic features of the lesions were compared between malignant and benign groups by using Pearson chi-square test. As a result, no statistically significant difference was determined between malignant and benign groups with respect to localization 1, localization 2 and echo pattern (*p=0.145*; *p=0.738*; *p=0.286*, respectively). However, four lesions showing hyperechoic features were all reported as benign. When the border features were compared, well-defined border features were significantly higher in benign lesions than malignant lesions. Ill-defined and spiculated border feature were significantly higher in malignant lesions than benign lesions (*p<0.001*). Microlobulated border feature was present in four lesions and these lesions described as malignant. When the orientation features were compared, parallel orientation was significantly higher in benign lesions than in malignant lesions. The nonparallel orientation feature was significantly higher in malignant lesions than in benign lesions (*p<0.001*). In lesions which did not perform posterior acoustic features and showed posterior enhancement, there was no statistically significant difference between benign and malignant groups. However, all twelve lesions showing posterior enhancement were diagnosed as benign. The characteristic of posterior acoustic shadowing, on the other hand, was significantly higher in malignant lesions compared to benign lesions (*p<0.001*). Lesions categorized as BI-RADS 3 and BI-RADS 4a were statistically significantly resulted to be benign (Figures II, III). Statistically significant malignant pathology results were obtained in lesions categorized as BI-RADS 4b (*p<0.001*). Preoperative sonographic BI-RADS categories of the lesions were compared between malignant and benign groups and all 18 lesions categorized as BI-RADS 4c and BI-RADS 5 were diagnosed as malignant (Table II) (Figure IV).

Figure II. A 32-year-old female patient's well-circumscribed, oval-shaped lesion in the upper outer quadrant of the left breast was evaluated as BI-RADS 3 (a). Pathological diagnosis was reported as fibrocystic change. Color Doppler (b) and power Doppler (c) ultrasonography examinations of the patient did not reveal any significant vascularization in the lesion, while microflow imaging (d) shows 2 punctate vascular structures within the lesion (arrows).

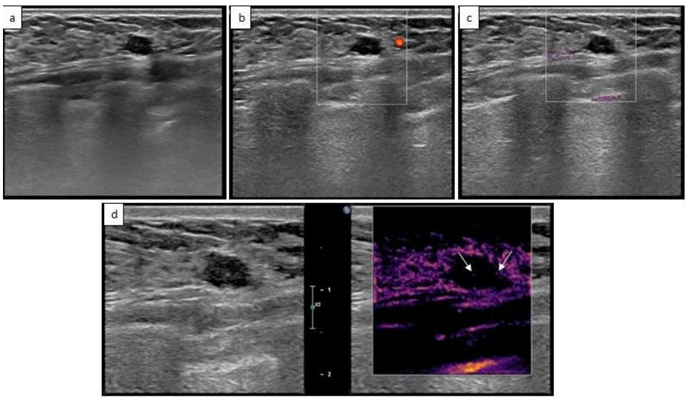


Table II. Distribution of Qualitative Variables According to Localization, Border, Orientation, Echogenicity, Posterior Acoustic Feature and BI-RADS Classification of Breast Lesions by Benign and Malignant Biopsy Group

Variables		Biopsy Pathology		X^2	*p*
		Benign	Malign		
		n (%)	n (%)		
Localization 1	Right	38 (55.9)	17 (41.5)	2.127	*0.145*
	Left	30 (44.1)	24 (58.5)		
Localization 2	Upper outer	36 (52.9)	24 (58.5)	1.99	*0.738*
	Upper inner	10 (14.7)	8 (19.5)		
	Lower outer	8 (11.8)	4 (9.8)		
	Lower inner	8 (11.8)	2 (4.9)		
	Retroareolar	6 (8.8)	3 (7.3)		
Margin features	Well-defined	50 (73.5)a	2 (4.9)b	52.562	*<0.001*
	Ill-defined	17 (25)a	27(65.9)b		
	Spiculated	1 (1.5)a	8 (19.5)b		
	Microlobulated	0 (0)	4 (9.8)		
Orientation	Parallel	45 (66.2)a	6 (14.6)b	27.293	*<0.001*
	Nonparallel	23 (33.8)a	35(85.4)b		
Echogenicity	Hypoechoic	56 (82.4)	36 (87.8)	2.506	*0.286*
	Hyperechoic	4 (5.9)	0 (0)		
	Complex	8 (11.8)	5 (12.2)		
	Anechoic	0 (0)	0 (0)		
Posterior acoustic features	None	51 (75)	30 (73.2)	13.857	*<0.001*
	Enhancement	12 (17.6)	0 (0)		
	Shadowing	5 (7.4)a	11(26.8)b		
BI-RADS	BI-RADS 3	40 (58.8)a	1 (2.4)b	74.566	*<0.001*
	BI-RADS 4a	27 (39.7)a	8 (19.5)b		
	BI-RADS 4b	1 (1.5)a	14(34.1)b		
	BI-RADS 4c	0 (0)	3 (7.3)		
	BI-RADS 5	0 (0)	15 (36.6)		

Pearson chi-square test was used. (ab): The common letter in the row indicates statistical insignificance,
BI-RADS: Breast imaging reporting and data system

When the ROC analysis results were examined in evaluating the diagnostic performance of Doppler tests; The area under the curve for CDUS is calculated as 0.584 and is not statistically significant (*p=0.141*). On PDUS examination, the area under the curve was 0.623 and is statistically significant (*p=0.031*). On the MFI examination, the value under the curve is 0.618 and is statistically significant (*p=0.039*). The sensitivity values of CDUS, PDUS and MFI examinations are 0.53, 0.65, 0.78, respectively. The probabilities of diagnosing a malignant lesion as malignant are 53%, 65% and 78%, respectively. The specificity values of CDUS, PDUS and MFI examinations are 0.63, 0.58, 0.45, respectively. The probabilities of diagnosing a benign lesion as benign are 63%, 58%, and 45%, respectively. The positive predictive values of CDUS, PDUS, and MFI examinations are 0.46, 0.49, and 0.46, respectively. The probabilities of lesions evaluated as malignant by these tests to be truly malignant are 46%, 49%, and 46%, respectively. The negative predictive values of CDUS, PDUS, and MFI examinations are 0.69, 0.74, and 0.77, respectively. The probabilities of lesions evaluated as benign by these tests to be truly benign are 69%, 74%, and 77%, respectively (Table III). When the positive and negative predictive values are examined, the negative predictive values are higher on Doppler examination methods than the positive predictive values. These examination methods were found to have a higher possibility for diagnosing malignant lesions (Figure V).

Table III. ROC Analysis Results for Malignant Classification

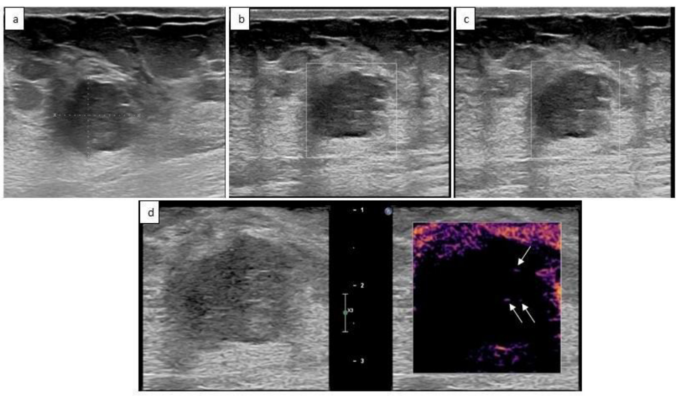
Variables	AUC (95% GA)	Se	Sp	PPV	NPV	*p*
CDUS_2	0.584	0.537	0.632	0.468	0.693	*0.141*
PDUS_2	0.623	0.658	0.588	0.491	0.741	*0.031*
MFI_2	0.618	0.781	0.456	0.464	0.775	*0.039*

AUC: Area under the curve; Se: Sensitivity, Sp: Specificity; PPV: Positive predictive value; NPV: Negative predictive value

Discussion

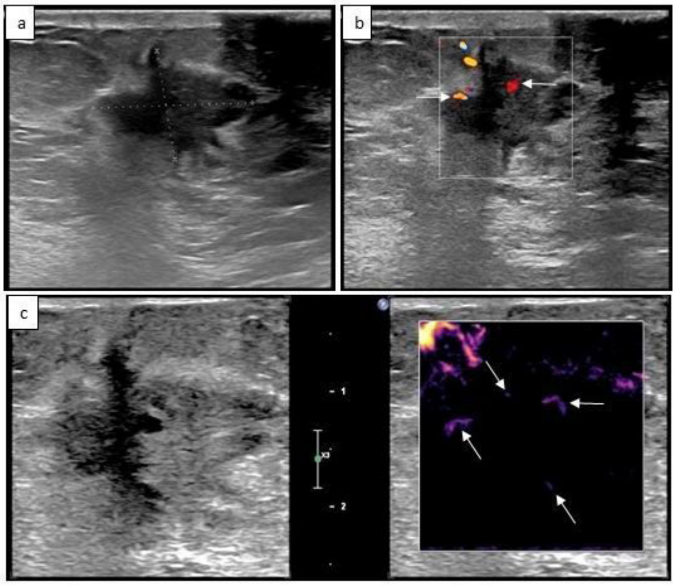
In Mao et al.'s study, 57 malignant and 66 benign lesions were examined, and the mean lesion size was found to be 2.1 cm in benign lesions and 2.4 cm in malignant lesions. Similar to our study, no statistically significant difference was detected in lesion size between benign and malignant lesions. While no significant difference was found between SMI and CDUS in detecting blood flow in benign lesions, they showed that SMI was more sensitive in malignant lesions. They used ROC analyses to evaluate the diagnostic performance of distinguishing malignant lesions from benign lesions in their study and outcomes were as following AUC: 0.73, sensitivity 66.7%, specificity 68.2% for CDUS, and AUC: 0.81, sensitivity 73.7%, specificity 80.3% for SMI (5). In our study, AUC values were lower for CDUS and MFI (0.584; 0.618, respectively), but similarly, AUC values were found to be higher for MFI. While sensitivity was higher for MFI in our study, specificity was higher for CDUS than MFI. For the study in the literature, SMI technique was used and the evaluation was performed by 3 radiologists. It was thought that the difference between the statistical datas were because of the use of a different brand of device in our study and the evaluation being performed by a single radiologist.

Figure III. A 36-year-old female patient's ill-defined lesion in the upper inner quadrant of the right breast, with occasionally angled edges, was evaluated as BI-RADS 4 (a). Pathological diagnosis was reported as benign phyllodes tumor. No significant vascularization was detected in the patient's color Doppler (b) and power Doppler (c) ultrasonography examinations, while microflow imaging (d) shows 3 point vascular structures in the lesion (arrows).



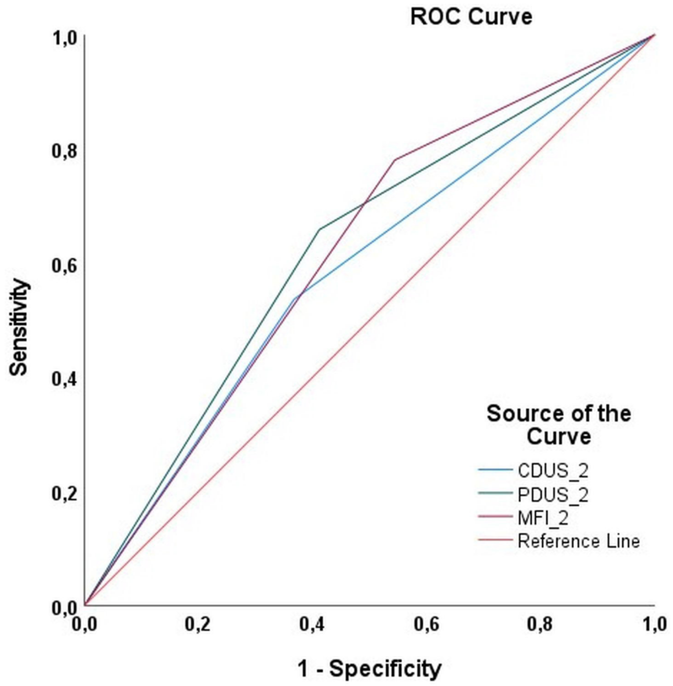
Similar to our study, in which the mean age was statistically significantly higher in the malignant group, Yongfeng et al. compared the diagnostic efficacy of PDUS and SMI with a total of 135 lesions, 94 of which were benign and 41 of which were malignant, and the mean age was found to be 46 in the malignant group and 36 in the benign group. They found no statistically significant difference in the evaluation of lesion size and location in the malignant and benign groups, similar to our study. In their study, the number of blood vessels and their distribution pattern were evaluated, and it was reported that benign lesions were in avascular or hypovascular character, while most of malignant lesions were hypervascular character. When hypervascularity was used as a criterion, the sensitivity and negative predictive value of SMI were found to be higher than PDUS. When the existence of penetrating vessels was used as a criterion, the sensitivity and negative predictive value of SMI were found to be higher than PDUS. When branching vascularization was used as a criterion, the sensitivity, specificity, positive and negative predictive values of SMI were found to be higher than PDUS (12). In our study, the sensitivity and negative predictive value of MFI were found to be higher than PDUS. Also, negative predictive value was found to be higher than positive predictive value in all three Doppler methods.

Figure IV. The ill-defined, lobulated contoured lesion in the upper outer quadrant of the right breast of a 45-year-old female patient was evaluated as BI-RADS 5 (a). Pathological diagnosis was reported as invasive ductal carcinoma. On the patient's color Doppler examination (b), two large vascular structures (arrows) were detected in the lesion, while on microflow imaging (c), two large and two small (arrows) punctate vascular structures were shown within the lesion.



In their study comparing the diagnostic efficacy of PDUS, RDUS and SMI in detecting penetrating vessels, Zhan et al. evaluated 82 avascular lesions, 45 of which were benign and 37 were malignant, and showed that SMI detected more penetrating vessels than RDUS and PDUS and was helpful in the differential diagnosis of malignant and benign lesions, especially in BI-RADS 4 lesions (10). In our study, it was shown that PDUS and MFI methods can be used in the differential diagnosis of benign-malignant breast lesions and their diagnostic performances are similar.

Figure V. In the ROC curve, the curves of CDUS, PDUS and MFI diagnostic tests are on the reference curve, and PDUS and MFI methods can be used in the differential diagnosis of benign-malignant breast lesions.



Xiao et al. evaluated 132 breast lesions in which they compared the diagnostic performance of contrast-enhanced US (CEUS) and super-B microvascular imaging (SMI) Doppler and 58 of the lesions were diagnosed as malignant and 74 were diagnosed as benign. The number of blood vessels were less than 3 in benign lesions and more than 3 in malignant lesions. In their study, the morphological features and distribution characteristics of the vessels were also found to be different between benign and malignant lesions. It was found out that large, tortuous, radial and penetrating vessels were more frequent in malignant lesions, while annular vessels were frequent in benign lesions. The vascular microarchitecture is also different in benign lesions. Avascularity, linear and curvilinear patterns and branching patterns were found in benign lesions, and root hair-like and crab claw-like patterns were found in malignant lesions, and no significant difference in diagnostic performance was detected between CEUS and SMI Doppler (2). In our study, it was shown that PDUS and MFI methods can be used in the differential diagnosis of benign-malignant breast lesions and their diagnostic performances are close.

In another study evaluating the diagnostic performance of SMI Doppler, 85 breast lesions, 47 of which were benign and 38 were malignant, were examined and more penetrating vascular structures were detected in malignant lesions than in benign lesions using SMI and CEUS. The number of penetrating vascular structures detected with SMI and CEUS in malignant lesions was found to be significantly higher than the number of penetrating vascular structures detected with CDUS and PDUS. However, no significant difference was found between SMI and CEUS. In statistical evaluations using penetrating vascular structures as a criterion for the diagnosis of malignancy, the sensitivity, specificity, positive predictive value, negative predictive value and accuracy values of SMI and CEUS were found to be higher than CDUS and PDUS. When classifying the vascular features of breast tumors in 5 different ways (avascular, linear shaped, branched shaped, root hair-like branching and crab claw-like shaped); Diao et al. reported that benign lesions showed mostly avascular, linear and branched patterns, malignant lesions mostly showed root hair-like branching and crab claw-like shaped patterns. When root hair-like branching patterns and crab claw-like shaped patterns were used as diagnostic criteria for malignancy; SMI and CEUS were found to be superior to CDUS and PDUS in terms of sensitivity and negative predictive value in the diagnosis of malignancy, however, no significant difference was observed between vascular distribution, internal vascularity, and internal vascular features in SMI and CEUS (13). In our study, MFI was shown to have a higher probability to identify malignant lesions than the other two Doppler US methods.

When a total of 210 benign and malignant breast lesions were evaluated in which the contribution of shearwave elastography and microvascular Doppler ultrasound methods to diagnosis was investigated, lesion size and patient age were found to be higher in the malignant group and were statistically significant (14). In our study, there was a significant difference between the malignant and benign groups with patient age, but no significant difference was found with lesion size. The diagnostic performance of SMI Doppler in breast lesions, 30 of which were reported as malignant and 116 of which were reported as BI-RADS 4 according to the ADLER classification, was evaluated by Zhu et al. The AUC values for US+RDUS and US+SMI were found to be 0.760 and 0.852, respectively, and the difference between the AUC values between US+RDUS and US+SMI was evaluated as statistically significant (15). In our study, it was shown that statistically significant diagnostic evaluations could be made when the AUC values of PDUS and MFI were examined.

When CDUS and SMI Doppler were compared in malignant-benign groups; a statistically significant difference was found between the malignant-benign groups with CDUS and SMI Doppler variables, and grade 0 group on CDUS and SMI Doppler, benign lesion numbers were shown in significantly higher than malignant lesions. Detected benign lesion numbers were significantly lower than malignant lesions in grade 3 on CDUS, and in grades 2 and 3 on SMI Doppler (16). In our study, lesions with vascularity grade 2-3 on PDUS and MFI were statistically significantly malignant. When evaluated in general, according to our study, the differential diagnosis of benign-malignant breast lesions can be made with the use of MFI. MFI can contribute to the clinical management of cases with breast lesions, prevent additional radiological examination methods and unnecessary biopsies, reduce patient anxiety, shorten treatment times, and reduce treatment costs. In addition, since Doppler US does not contain radiation, it can be used safely in follow-up examinations.

There are some limitations to our study. Firstly, the number of patients included in the study was relatively small. Secondly, all patients were evaluated by a single radiologist, and interobserver variability could not be assessed. Thirdly, grading was assessed according to the number of vessels rather than morphological features such as penetration and branching patterns, which are reported to be highly suggestive of malignancy. Fourth, ultrasonographic images were evaluated using the MFI technique, which is less commonly used in the literature. Lastly, ultrasonographic contrast material could not be used.

Conclusion

In patients with breast lesions, in addition to B-mode US findings, PDUS and especially MFI methods used to investigate vascularity can contribute to the differential diagnosis of benign and malignant lesions. MFI will reduce additional radiological examination methods by contributing to the clinical management of cases with breast lesions, and can be used safely in follow-up examinations since it does not contain radiation. For these reasons, by following benign breast lesions; unnecessary biopsies will be prevented, treatment costs and patient treatment times will be limited and patient concerns can be reduced.

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