Article published online: 2025-02-04

Identification of differentiating sonographic features between fibroadenomas and malignant tumors of the breast mimicking fibroadenomas: 10-year experience in 421 histologically verified cases

Identifizierung sonographischer Unterscheidungsmerkmale zwischen Fibroadenomen und malignen Fibroadenom-imitierenden Tumoren der Brust: 10-jährige Erfahrung in 421 histologisch verifizierten Fällen

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Keywords

breast cancer, breast diagnostics, fibroadenoma, ultrasound, elastography

received 20.6.2024
accepted after revision 6.11.2024
published online 2025

Bibliography

Ultraschall in Med
DOI 10.1055/a-2474-6617
ISSN 0172-4614

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Supplementary Material is available at https://doi.org/10.1055/a-2474-6617.

ABSTRACT

Purpose Ultrasound is a highly effective imaging tool for assessing abnormalities within the breast. However, especially the identification of malignant tumors of the breast mimicking fibroadenomas (MTMF) by means of breast ultrasound can be challenging. This study aimed to identify reliable imaging characteristics of MTMF.

Materials and Methods This retrospective study was approved by the local ethics review board. After screening 623 patients, 421 cases with histologically verified fibroadenomas and MTMF between 2011 and 2021 were included. Sonographic features were compared to histopathological results and an algorithm-based quantitative ranking of predictors contributing most to the correct classification of malignant tumors was conducted.

Results A total of 363 benign, 18 intermediate, and 40 malignant lesions were analyzed. Algorithm-based quantitative ranking showed that the most predictive features indicating malignancy were a hyperechoic rim (gain ratio merit 0.135 ± 0.004), an irregular border (0.057 ± 0.002), perilesional stiffening (0.054 ± 0.002), pectoral contact (0.051 ± 0.003), an irregular shape (0.029 ± 0.001), and irregular vasculature (0.027 ± 0.002).

Conclusion Ultrasound findings for fibroadenomas vary, making identification of MTMF challenging. Features such as indistinct margins and increased perilesional echogenicity are predictors for malignancy and should be considered during sonographic evaluation of fibroadenomas and MTMF.

ZUSAMMENFASSUNG

Ziel Fibroadenome sind relativ häufige benigne Läsionen der weiblichen Brust, jedoch kann die sonografische Unterscheidung zwischen gutartigen Fibroadenomen und malignen fibroadenom-imitierenden Tumoren der Brust eine Herausforderung darstellen. Ziel dieser Studie war es, zuverlässige Bild-

gebungsmerkmale zur Identifizierung fibroadenom-ähnlicher maligner Tumoren festzustellen.

Material und Methode Nach Screening von 623 Patienten wurden 421 Fälle mit histologisch verifizierten Fibroadenomen und fibroadenom-ähnlichen malignen Tumoren eingeschlossen. Die sonografischen Merkmale wurden mit dem histopathologischen Resultat verglichen, und eine algorithmusbasierte quantitative Rangordnung der Prädiktoren, die am meisten zur korrekten Klassifikation intermediärer und maligner Tumoren beitrugen, wurde durchgeführt.

Ergebnisse Insgesamt wurden 363 benigne, 18 intermediäre und 40 maligne Brustläsionen eingeschlossen. Die algorithmusbasierte quantitative Rangordnung zeigte, dass die am prädiktivsten Merkmale für Malignität ein hyperechogener Randsaum (gain ratio merit 0,135 ± 0,004), unregelmäßige Ränder (0,057 ± 0,002), periläsionale Verhärtung (0,054 ± 0,002), pektoraler Kontakt (0,051 ± 0,003), unregelmäßige Form (0,029 ± 0,001) und eine chaotische Gefäßversorgung (0,027 ± 0,002) waren.

Schlussfolgerung Bildgebende Charakteristika für Fibroadenome im Ultraschall variieren, was die Identifizierung von malignen fibroadenom-imitierenden Tumoren erschweren kann. Bei der sonografischen Beurteilung sollten daher klassische Malignitätskriterien wie unscharfe Berandung oder periläsionale Echo-Genitätssteigerung beachtet werden.

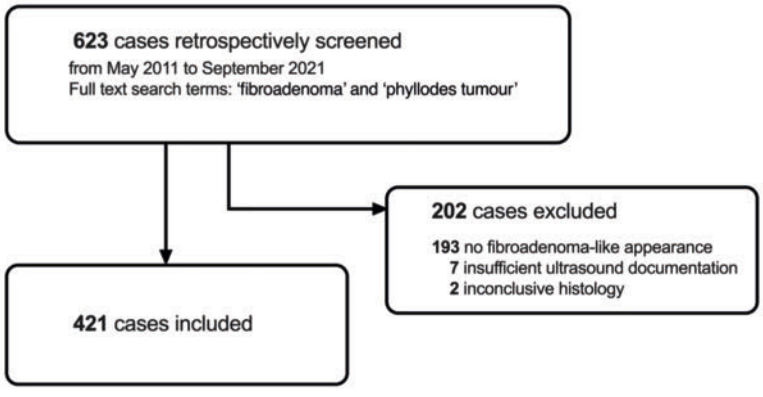
Introduction

Breast cancer is the most commonly diagnosed cancer and the second leading cause of cancer death among women [1]. Breast ultrasound has the capability to differentiate between cystic and solid masses and can highlight characteristics of solid masses that raise suspicion, necessitating a biopsy [2]. Fibroadenomas are the most common solid benign breast lesion and are typically encountered in premenopausal women under the age of 40 years but can occur at any age [3]. Clinically they are characterized by a solid, mobile, and well-defined mass that is often painless [4]. If ultrasound findings are in keeping with the diagnosis of a fibroadenoma and there is no clinical suspicion of a malignant disease, it is proposed that a biopsy is not required, and the imaging findings are classified as probably benign (BI-RADS III) with necessary follow-up examinations to demonstrate lack of growth or development of malignant features [5].

Nonetheless, several breast lesions may resemble fibroadenomas upon first examination, with only discrete distinctive features on ultrasound [6]. Phyllodes tumors and other relatively rare fibroepithelial tumors, yet also some high-degree tumors such as triple negative breast cancer (TNBC) can resemble benign fibroadenomas during ultrasound with benign morphological characteristics on ultrasound, thus the differentiation between fibroadenoma and breast cancer is sometimes difficult [7, 8, 9]. Such lesions are initially interpreted as suspicious, which could lead up to ultrasound-guided core needle biopsy. Between 55 % and 85 % of these biopsies ultimately yield benign breast lesions, leading to unwarranted treatments, heightened patient anxiety, and increased healthcare costs [10].

To avoid unnecessary biopsy of benign lesions and to select those lesions that require biopsy, an accurate characterization of breast lesions with imaging is crucial. In breast ultrasound, imaging features such as a circumscribed margin, homogeneous echo texture, parallel orientation, and gently lobulated shape indicate benignity [9, 10]. Still, overlapping imaging findings in fibroadenoma-like tumors without these typical features may mimic several other types of breast masses [11].

The objective of this retrospective study is to assess the reliability of ultrasound for characterizing features of fibroadenomas and malignant tumors of the breast mimicking fibroadenomas (MTMF) and to identify imaging features that might indicate malignancy.



▶ **Fig. 1** Flowchart of participants and screening procedure.

Methods

Study design

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Study approval was granted by the local ethical review board on October 21st, 2021. This is a retrospective single-center study of patients who underwent breast ultrasound of fibroadenomas and MTMF with available histopathological results between May 2011 and September 2021.

Screening procedure

A full-text-based search was carried out within the department's electronic medical records database (Centricity RIS-i, GE Healthcare, Chicago, United States) for all breast biopsy examinations between May 2011 and September 2021 including the full-text terms "fibroadenoma" and "phylloides tumor" in the referral diagnosis if the examination was sent for an ultrasound assessment, or in the radiological report if it was conducted in-house. Search results were then manually checked for fulfilment of inclusion and exclusion criteria (Supplementary Table 1). Of 623 screened cases, 421 cases were included. 202 patients had to be excluded for several reasons (▶ **Fig. 1**).

Sonographic features evaluation

The ultrasound images of the included patients were reviewed. For an overview of the examined sonographic features, please refer to ▶ **Table 1**. In cases with a previous depiction of the relevant lesion, the volume doubling time (VDT) was calculated following the modified Schwartz formula: $VDT = [\ln(2) \times \Delta T]/[\ln(V_2/V_1)]$ with T being the time interval between current and prior examination, V_1 being the prior and V_2 the current tumor volume.

Histologic data

Histologic data was extracted from the in-house patient data archival system (KIS Powerchart; Cerner Corporation, North Kansas City, USA) and include specific diagnosis and histopathologic classification (B2 = benign; B3 = intermediate malignant potential or B5 = malignant). If available, full resection results were used.

Statistics

All data were stored in Microsoft Excel 16.66.1 (Microsoft; Redmond, USA). The statistical software that was used was SPSS 27.0 for Windows (SPSS; Chicago, USA), GraphPad Prism 10.0.1 (GraphPad Software LLC; La Jolla, USA) and WEKA (University of Waikato; Waikato, New Zealand). Results include mean ± standard deviation (SD) and ranges in brackets or relative frequency (absolute values in brackets). Categorical variables were compared via pairwise Fisher's exact test (in case of 2 × 2 tables) or a χ^2 test. Contingency tables were used to calculate sensitivity, specificity, positive (PPV) and negative predictive value (NPV), and likelihood ratio (LR). Results include 95 % confidence intervals (CI). Statistical significance was considered for p-values < 0.05. Descriptive statistics for all patients include demographic (age, familial history of breast cancer, prior breast cancer) and disease-related factors, frequency of benign, intermediate, and malignant tumors (including subtypes) as well as the BI-RADS classification after radiological examination.

To determine the ability to correctly classify cases as a) tumors with intermediate differentiation/malignant tumors (B3 or B5) vs. benign tumors (B2) and b) malignant (B5) vs. non-malignant tu-

▶ **Table 1** List of examined lesion features.

Group	Feature	Unit/level
Localization	Side	Left/right
	Skin surface distance	mm
	Nipple distance	mm
	Sector	1–11
Geometry	Size (horizontal, vertical, sagittal)	mm
	Volume	cm^3
	Height-to-width	–
	Growth rate: Schwartz volume doubling time	Days
B-Mode features	Surrounding tissue	Fat/mixed/ fibroglandular
	Pectoral contact or impression	Yes/no
	Echogenicity	Anechoic/hypoechoic/ isoechoic/hyperechoic
	Tissue homogeneity	Yes/no
	Border sharpness	Sharp/partial/diffuse
	Contour	Oval/lobulated/ irregular
	Hyperechoic rim	Yes/no
	Cystic areas	Yes/no
	Calcifications	Yes/no
	Acoustic shadowing	Hypoechoic/none/ hyperechoic
Doppler evaluation	Peritumoral vessel count	N
	Intratumoral vessel count	N
	Intratumoral vessel density	n/cm^3
	Feeding vessel	Yes/no
	Vascular architecture	None/solitary vessel/ tree/chaotic
	Vascular distribution	None/peripheral/ central/whole Lesion
Strain elastography	Tissue stiffness (qualitative)	Soft/intermediate/ hard
	Strain pattern	Homogeneous/ heterogeneous
	Strain halo depth	mm

mors (B2 or B3), a J48 decision tree algorithm with 100-fold cross validation was employed. Results include model classification rate, true positive (TP) and false positive (FP) rates, precision, and receiver-operating characteristic (ROC) area under the curve (AUC). For a quantitative ranking of predictors, a gain ratio merit ranking algorithm with 100-fold cross validation was used. Results include rank and gain ratio merit as well as odds ratios (OR) and p-values calculated from a Fisher's exact test with a cut-off determination following Youden's J method in case of continuous variables.

Results

Patient characteristics

Overall, 421 female patients were retrospectively included from May 2011 to September 2021. The average age was 44.7 ± 12.8 years (range: 18.1 to 88.0 years). 21.4 % (n = 90) of cases were histologically verified after lesion follow-up (average observation period from first diagnosis: 20.4 ± 22.3 months). The rest of the cases were sampled at first diagnosis. 4.3 % (n = 18) of participants had breast cancer more than 5 years prior to the examination and 5.9 % (n = 25) had a familial history of breast cancer.

Examination setting and reasons for biopsy

65.8 % (n = 277) of participants were scheduled for routine mammography, while 30.6 % (n = 129) were referred for assessment from an extramural radiology practice and 3.6 % (n = 15) were referred by a gynecologist or general practitioner due to breast-related symptoms.

28.9 % (n = 121) of all lesions were radiologically classified as BI-RADS III, 66.4 % (n = 278) as BI-RADS IV, and 4.8 % (n = 20) as BI-RADS V before biopsy (▶ **Fig. 2a**). The leading reasons for biopsy were a newly developed tumor (51.8 %, n = 218), tumor growth (18.1 %, n = 76), suspicious morphology (10.7 %, n = 45), or a high-risk constellation due to known genetic breast-cancer-associated mutations or familial history of breast cancer (5.9 %, n = 25) (▶ **Fig. 2b**). 78 cases (18.5 %) underwent biopsy after an initial decision to follow-up the lesion due to lesion growth or the development of suspicious imaging characteristics. The average follow-up interval was 620.6 ± 680.0 days.

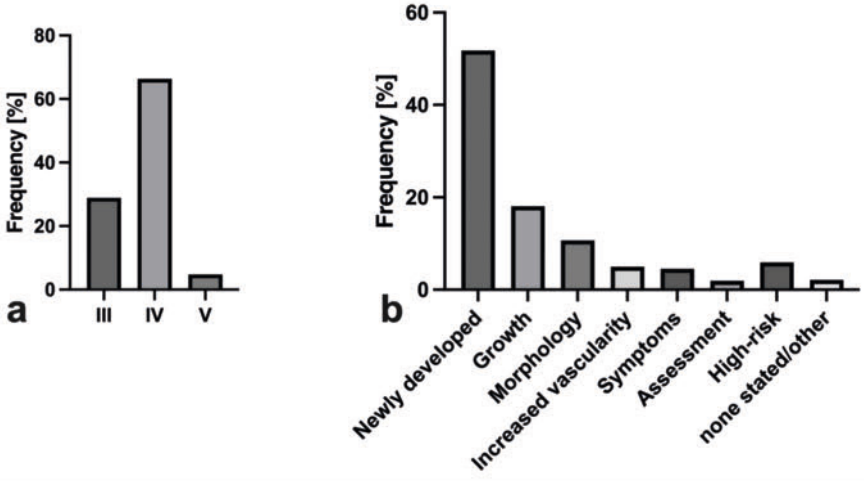
Histopathologic results

A majority of tumors was benign (86.2 %, n = 363) with a minority showing intermediate (4.3 %, n = 18) or malignant (9.5 %, n = 40) differentiation. The most common benign tumors were fibroadenoma (90.9 %, n = 319), fibrous-cystic mastopathy (7.1 %, n = 25), and adenosis (2.9 %, n = 10). Among the intermediate tumors the cases included adenomyoepitheliomas (33.3 %, n = 6), phyllodes tumors (27.8 %, n = 5), papillomatous neoplasia (22.2 % n = 4), atypical ductal hyperplasia (11.1 %, n = 2), and sclerosing adenosis (5.6 %, n = 1). Malignant tumors comprised carcinoma of no specific type (NST) (67.5 %, n = 27), invasive mucinous carcinoma (7.5 %, n = 3), ductal carcinoma in situ (DCIS) (10.0 %, n = 4), and other subtypes (15.0 %, n = 6).

General imaging findings

48.9 % of all lesions were found on the right side. Viewed by sector, most tumors were found within the upper outer sectors of the breast (Supplementary Figure 1). Lesions were on average located 6.0 ± 4.6 mm below the skin surface and 60.9 ± 27.5 mm from the nipple.

The average size was 17.5 ± 12.8 mm, 15.2 ± 10.7 mm, and 9.9 ± 6.8 mm, in horizontal, vertical, and sagittal dimensions, respectively, averaging a volume of 4.4 ± 22.7 cm^3 (range 0.1 to 418.1 cm^3). The average height-to-width ratio was 0.6 ± 0.2.



▶ **Fig. 2** Overview of BI-RADS distribution (**a**) and reasons for biopsy (**b**).

▶ **Table 2** Highest ranked predictors for correct tumor classification as "malignant".

Predictor	Rank	Gain ratio merit	Odds ratio (OR)	p-value§
Hyperechoic rim [yes]	1.0 ± 0.0	0.135 ± 0.004	12.08 (5.86 to 24.01)	< 0.0001
Border sharpness [irregular]	2.1 ± 0.32	0.057 ± 0.002	7.12 (3.49 to 14.41)	< 0.0001
Strain elastography halo depth [mm] (cut-off 2.0 mm)	3.1 ± 0.49	0.054 ± 0.002	7.26 (3.01 to 16.54)	< 0.0001
Pectoral contact [yes]	3.8 ± 0.46	0.051 ± 0.003	5.15 (2.63 to 10.05)	< 0.0001
Irregular shape [yes]	5.2 ± 0.41	0.029 ± 0.001	14.17 (2.70 to 74.31)	0.0070
Feeding vessel [yes]	5.8 ± 0.41	0.027 ± 0.002	3.48 (1.63 to 7.42)	0.0020
Echogenicity [low]	7 ± 0.22	0.018 ± 0.001	2.73 (0.91 to 8.18)	0.1106
Vascular architecture [chaotic]	8 ± 0.24	0.015 ± 0.001	6.85 (1.31 to 35.92)	0.0764
Sector [1, 2, 3, 4]	9.1 ± 0.26	0.009 ± 0.0	1.30 (0.69 to 2.42)	0.5041
Cystic areas [no]	10.1 ± 0.52	0.008 ± 0.001	2.39 (0.96 to 5.77)	0.0808

§ Fisher's exact test

Radiological assessment of probably benign lesions (BI-RADS III) and lesions suspicious for malignancy (BI-RADS IV and V) with correlation to histopathological results

Initial radiologic assessment of BI-RADS class III or higher was correlated to the final histopathological diagnosis with 93.5 % of radiological BI-RADS III lesions being benign, 4.1 % intermediate, and 2.4 % malignant. Tumors initially assessed as BI-RADS IV or higher were benign in 79.2 % of cases, intermediate in 8.4 %, and malignant in 12.4 % ($p < 0.0001$).

Accordingly, for the detection of malignancy in these lesions, the sensitivity was 92.5 % (95 % CI 80.1 to 97.4 %), the specificity was 31.5 % (27.0 to 36.3 %), the positive predictive value was 12.4 % (9.1 to 16.7 %), and the negative predictive value was 97.6 % (93.1 to 99.3 %) at a likelihood ratio of 1.4.

Algorithm-based identification of tumors with intermediate differentiation/malignant tumors (B3 or B5) vs. benign tumors (B2)

Using a J48 decision tree algorithm to identify intermediate and malignant tumors, the overall correct classification rate was 83.1 % (TP rate 83.1 %, FP rate 66.3 %, precision 79.7 %, ROC AUC 59.8 %). Accordingly, the sensitivity was 21.4 % (95 % CI 13.4 to 32.4 %), the specificity was 95.4 % (92.7 to 97.2 %), the positive predictive value was 48.4 % (32.0 to 65.2 %), and the negative predictive value was 85.9 % (82.1 to 89.0 %) with likelihood ratio of 4.7.

Algorithm-based identification of malignant (B5) vs. non-malignant tumors (B2 or B3)

Again, using a J48 decision tree algorithm to identify intermediate and malignant tumors, the overall correct classification rate was 90.0 % (TP rate 90.0 %, FP rate 70.4 %, precision 87.8 %, ROC AUC 53.4 %). Accordingly, the sensitivity was 22.5 % (95 % CI 12.3 % to 37.5 %), the specificity was 97.1 % (94.9 to 98.9 %), the positive predictive value was 45.0 % (25.8 % to 65.8 %), the negative predictive value was 92.3 % (89.2 to 94.5 %) with a likelihood ratio of 7.8.

Ranking of diagnostic properties among demographic, general, and sonographic tumor properties

Using a gain-ratio-merit-based ranking method, the predictors contributing most to correct classification of malignant tumors were presence of a hyperechoic rim, diffuse lesion border, higher strain elastography halo depth, pectoral contact (i. e., deep location), an irregular lesion shape, low echogenicity, and chaotic vascular architecture (▶ **Table 2**).

Of note, patient age, size (in all dimensions), volume, height-to-width ratio, and volume doubling time did not affect classification (▶ **Table 3**).

Discussion

This study focused on the reliability of ultrasound for the differentiation of fibroadenomas and malignant tumors of the breast mimicking fibroadenomas (MTMF) in 421 histologically verified

▶ **Table 3** Lowest ranked predictors for correct tumor classification as "malignant".

Predictor	Rank	Gain ratio merit	Odds ratio (OR)	p-value§
Schwartz volume doubling time [days] (cut-off: < 277 days)	27.6 ± 1.96	0.0 ± 0.0	2.11 (0.56 to 9.17)	0.4057
Depth [mm] (cut-off: > 7.3 mm)	27.8 ± 1.91	0.0 ± 0.0	2.23 (1.12 to 4.43)	0.0232
Height-to-width ratio (cut-off: > 0.59)	28.3 ± 3.16	0.0 ± 0.0	1.29 (0.40 to 4.15)	> 0.9999
Nipple distance [mm] (cut-off: < 84.7 mm)	30.1 ± 2.2	0.0 ± 0.0	0.24 (0.10 to 0.54)	0.0003
Volume [cm^3] (cut-off: > 0.8 cm^3)	30.9 ± 1.35	0.0 ± 0.0	2.71 (1.31 to 5.64)	0.0072
Size Z [mm] (cut-off: > 12.4 mm)	31.6 ± 1.3	0.0 ± 0.0	1.57 (0.68 to 3.82)	0.3386
Size Y [mm] (cut-off: > 12.3 mm)	32.5 ± 1.16	0.0 ± 0.0	1.90 (0.94 to 3.87)	0.0767
Size X [mm] (cut-off: > 13.3 mm)	33.0 ± 1.87	0.0 ± 0.0	1.86 (0.92 to 3.64)	0.0939
Age [years] (cut-off: > 50.6 years)	35.0 ± 0.0	0.0 ± 0.0	3.01 (1.58 to 5.72)	0.0013

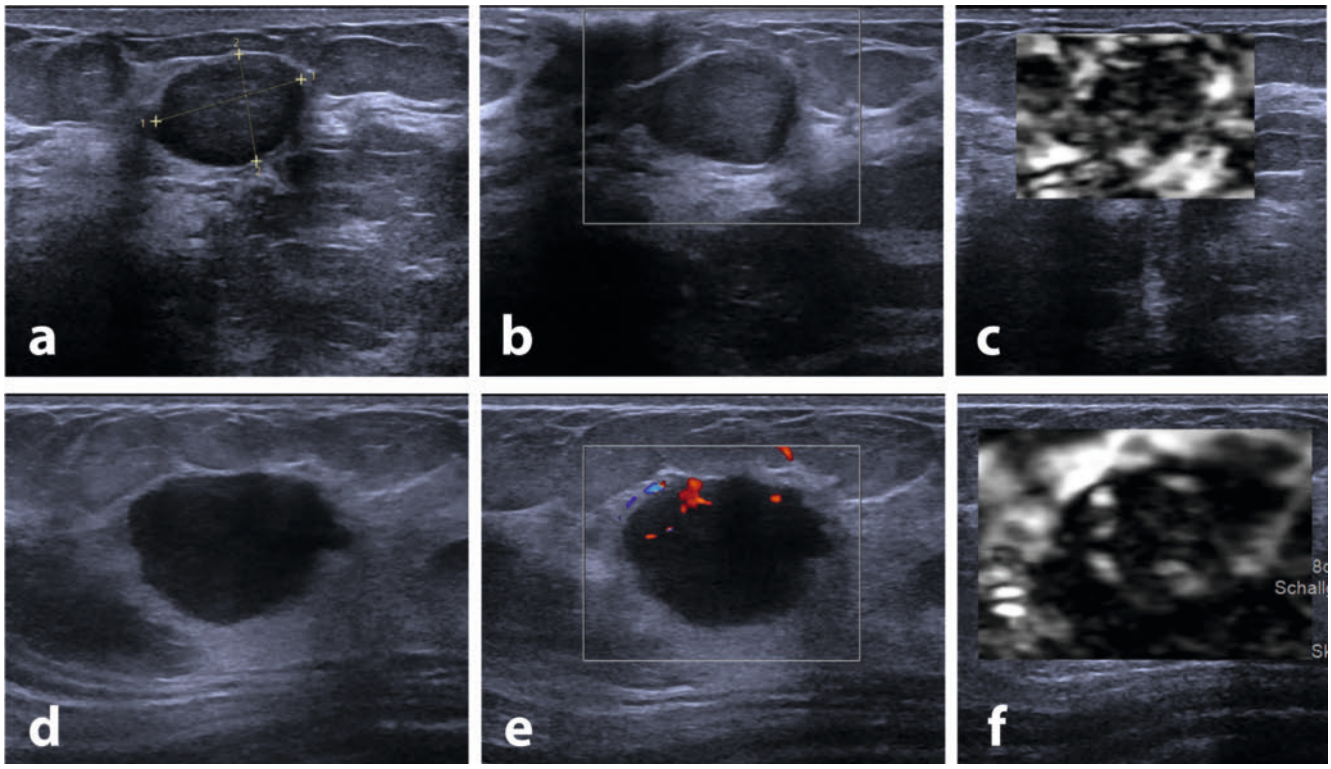
§ Fisher's exact test

cases and to determine ultrasound features which are predictive for malignancy. In our study the average age of the patients was 44.7 ± 12.8 years (range: 11.2 to 88.0 years), which is above the age in which fibroadenomas are most commonly found [4]. Typically, the size of fibroadenomas is 2 cm to 3 cm, although the range might be between 1 cm to over 10 cm [4]. In our study the average size was 1.7 cm ± 1.28 cm, and we demonstrated that the size of the lesion, height-to-width ratio as well as depth and distance to nipple were not predictive factors for malignancy. Tumors were most commonly found in the upper outer quadrant, which is the most frequent breast cancer site [12]. On the other hand, we showed that pectoral contact – i. e., deep lesion location – is a predictor for malignancy.

In our study histopathologically malignant subtypes mimicking fibroadenomas were most likely hypoechogenic and often showed at least partially diffuse border sharpness with an irregular shape. These features are typically more pronounced in malignant lesions, which often exhibit an irregular shape, diffuse margins, hypoechogenicity, posterior acoustic shadowing, and architectural distortion [13, 14]. Regardless, some malignant entities may exhibit overlapping ultrasound features with fibroadenomas like TNBC, which can present with well-circumscribed margins, indicating a rapidly proliferating tumor without a significant stromal reaction [15]. In our study we showed that the highest ranked feature that indicates malignancy in such cases is a hyperechoic rim which is associated with malignant tumor cells infiltrating into adjacent (adipose) tissue and the subsequent host's inflammatory reaction [16].

Tumor angiogenesis is well known and is associated with malignant breast lesions. Color doppler ultrasound serves as a useful complementary tool to differentiate between breast lesions [17]. Several studies showed that malignant lesions present more often with detectable intralesional vascularization [18] as well with typical tumoral vessels with an irregular course, sinusoids and arteriovenous shunts [19, 20]. Lee et. al demonstrated that malignant lesions often showed both peripheral and central vascularity, penetrating vessels, and the presence of branching vessels [21]. Our results were consistent with the literature showing that a prominent peripheral vessel ("feeding vessel") and a chaotic vascular architecture are predictors for malignancy. Raza and Baum found that malignant lesions often showed prominent peripheral vessels and an irregular branching pattern, while benign lesions commonly present avascular or with only small central vessels or vessels that are located around the periphery [22]. Benign lesions like fibroadenomas can also present with vessels within the lesions but more commonly with peripheral capsular and central segmental vessels and less commonly with prominent feeding vessels as shown by Strano et al. [23].

Ultrasound elastography is another tool for the characterization of masses in the breast by measuring tissue stiffness [24], and several studies showed that sonoelastography is useful for differentiating benign from malignant masses [25, 26]. In our study we demonstrated that evaluating lesions with elastography provides additional information and that a larger area of increased stiffness beyond the tumor surface margin is a strong surrogate parameter for malignancy as previously demonstrated [27]. Malignant breast lesions tend to appear larger on elastograms than on conventional B-mode images. This might be due to tumor cells infiltrating adjacent tissue [24]. For illustrative cases, please refer to ▶ **Fig. 3**.



▶ **Fig. 3** Comparison of a fibroadenoma (upper row) in a 21-year-old patient exhibiting a modestly uniform hypoechoic endotexture, oval shape, parallel orientation to the chest wall, sharp borders and mild posterior acoustic enhancement (**a**), no vascularization (**b**), and nonspecific elastographic finding without peritumoral stiffening (**c**) and an invasive breast cancer of no specific type (grade 3), (lower row) showing a marked hypoechoic appearance, oval shape, parallel orientation to the chest wall, partially irregular borders, posterior acoustic enhancement (**d**) as well as feeding vessels (**e**) and peritumoral stiffening (**f**).

Yet, also of note are those predictors without any significant contribution to the correct classification of tumors with intermediate or malignant differentiation (histologically B3 or B5) in a multiparametric evaluation, commonly associated with a higher risk: age and growth rate. Fibroadenomas are thought to rarely present after the age of 40 years. Therefore, a heightened suspicion of malignancy in newly diagnosed breast lesions mimicking fibroadenomas is considered necessary [4]. Furthermore, breast cancer often displays rapid growth depending on the subtype, grade, and stage of the tumor, among other things [28]. However, we showed that neither age nor doubling time had any impact on correct classification of fibroadenomas and MTMFs when also weighing other factors. Our results highlight that there are only a few somewhat robust imaging features in this subset of breast lesions, and BI-RADS classification may significantly overestimate the likelihood for intermediate or malignant differentiation in a given lesion. While 71.2 % of lesions were radiologically classified as BI-RADS IV or V, indicating suspicion for malignancy, histopathology revealed that 79.2 % of these lesions were benign. We found that, when employing a J48-based machine learning approach to identify malignant tumors (B5), correct classification and odds ratios were much higher than when trying to identify B3 und B5 tumors, thus illustrating that B3 lesions (i. e., phyllodes tumors) show a significant demographic and imaging factor overlap with benign fibroadenomas. Development of novel predictors – possibly derived from computer-aided approaches – may help solve this current impasse.

Limitations

We acknowledge that this study presents several limitations. Firstly, our analysis was performed only at a single center and followed a retrospective approach. Therefore, some details regarding patient history and clinical symptoms may not have been recorded. Retrospective evaluation of ultrasonography imaging studies can be challenging as its accuracy depends on correct initial lesion depiction. Secondly, breast ultrasound is an imaging method that is very examiner-dependent. In the clinical routine, though, even ultrasound BI-RADS classification is usually done by 2 consultants before biopsy. For possible future investigations, a prospective trial with multimodal imaging and histopathological correlation would be advisable.

Conclusion

Ultrasound-based differentiation between fibroadenomas and malignant tumors of the breast mimicking fibroadenomas still remains challenging. Our study underscores the difficulties in accurately classifying these breast lesions, particularly when comparing BI-RADS classifications with final histopathological results. The most robust ultrasound features identifying fibroadenoma-

mimicking malignant lesions are those also found in common malignant tumors of the breast such as a hyperechoic rim, irregular border, perilesional stiffening, pectoral contact, irregular shape, and irregular vascularity.

Conflict of Interest

The authors declare that they have no conflict of interest.

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