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BREAST IMAGING

ORIGINAL ARTICLE

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Ultrasound non-mass lesions of the breast: imaging features, pathologic risk, and interobserver agreement

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PURPOSE

This study aimed to evaluate the sonographic and clinical characteristics of breast non-mass lesions detected on ultrasound, identify factors associated with increasing pathological risk, and assess interobserver agreement among breast radiologists.

METHODS

This retrospective study included breast ultrasound examinations performed between January 1, 2021, and August 30, 2025. A keyword search in the picture archiving and communication system identified 2,002 examinations potentially describing non-mass findings. After exclusions, 666 potentially eligible lesions were independently evaluated by three breast radiologists. Lesions were classified as non-mass according to a predefined majority rule (≥ 2 of 3 observers) and assessed using a three-level clinical concern score. Final diagnoses were established by histopathology or ≥ 2 years of imaging follow-up. Associations between imaging and clinical variables and pathological categories were evaluated using univariable analyses and multivariable ordinal logistic regression. Interobserver agreement was assessed using kappa statistics and Gwet's AC1.

RESULTS

A total of 610 lesions in 610 patients were classified as non-mass by majority decision. Malignancy was identified in 13 of 610 lesions (2.1%). Interobserver agreement for non-mass classification was high, although agreement estimates differed between Gwet's AC1 (0.80) and Fleiss' kappa (0.24). A clinical concern score of 3 predicted malignancy with a sensitivity of 76.9% (10/13) and specificity of 98.6% (582/590). Multivariable analysis showed that architectural distortion [odds ratio (OR): 8.40; 95% confidence interval (CI): 3.89–18.16; $P < 0.001$], posterior acoustic shadowing (OR: 4.76; 95% CI: 1.84–12.28; $P = 0.001$), and vascularity (OR: 2.69; 95% CI: 1.22–5.97; $P = 0.015$) were independently associated with increasing pathological risk.

CONCLUSION

Most breast non-mass lesions detected on ultrasound are benign; however, architectural distortion, posterior acoustic shadowing, and vascularity are independently associated with increased pathological risk.

CLINICAL SIGNIFICANCE

Recognizing specific ultrasound features associated with higher pathological risk may help distinguish non-mass lesions requiring more intensive diagnostic evaluation from predominantly benign findings and support more consistent clinical management.

KEYWORDS

Breast neoplasms, ultrasonography, non-mass lesion, interobserver agreement, architectural distortion

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Breast ultrasonography is an important imaging modality for the detection and characterization of breast lesions, particularly in women with dense breast tissue where the sensitivity of mammography is reduced. The Breast Imaging Reporting and Data System (BI-RADS), developed by the American College of Radiology, provides standardized terminology for the description and reporting of breast imaging findings and aims to improve diagnostic consistency and communication among clinicians.[1] Although the BI-RADS lexicon includes detailed morphological descriptors for mass lesions, the identification and characterization of non-mass lesions on ultrasound remain less standardized in clinical practice.

The distinction between masses and non-mass findings on breast ultrasound was first described in the 1980s and was later incorporated into the guidelines of the Japanese Association of Breast and Thyroid Sonology.[2] In these guidelines, non-mass abnormalities are classified into several patterns, including ductal abnormalities, hypoechoic areas, architectural distortion, multiple small cysts, and echogenic foci.[2] According to the latest BI-RADS v2025 manual, a non-mass lesion is defined as a focal area of altered echogenicity that is distinguishable from the surrounding breast parenchyma but does not form a discrete space-occupying mass and therefore lacks definable shape or margins.[1] These lesions often appear as subtle focal disturbances of the background parenchymal pattern. Non-mass lesions may represent a broad pathological spectrum ranging from benign inflammatory or proliferative processes to atypical lesions and malignancies, particularly ductal carcinoma in situ and invasive carcinoma.[3] Because classic mass descriptors cannot be applied, diagnostic evaluation relies primarily on distribution patterns and associated sonographic features. Findings such as architectural distortion, posterior acoustic shadowing, increased vascularity, and ductal changes have been reported to be associated with an increased likelihood of malignancy.[4]

Main points

- Most ultrasound-detected breast non-mass lesions were benign, with an overall malignancy rate of 2.1% (13/610; 95% confidence interval: 1.2%–3.6%).
- Interobserver agreement for non-mass classification was high, although chance-corrected agreement estimates differed between Gwet's AC1 (0.80) and Fleiss' kappa (0.24).
- Architectural distortion, posterior acoustic shadowing, and vascularity were independently associated with increasing pathological risk.

Despite increasing recognition of non-mass lesions on ultrasound, the imaging features and clinical variables that best predict pathological risk remain incompletely defined. In addition, interobserver agreement in identifying non-mass lesions and assessing their clinical risk has been evaluated in only a limited number of studies. Therefore, the purpose of this retrospective study is to evaluate the sonographic and clinical characteristics of breast non-mass lesions detected on ultrasound, identify imaging and clinical factors associated with increasing pathological risk, and assess interobserver agreement among breast radiologists.

Methods

This retrospective study was conducted at a breast imaging center between January 1, 2021, and August 30, 2025. Ethical approval was obtained from the Scientific Committee and Hospital Administration of Güven Hospital (Approval No. 705, dated April 10, 2025), as well as from the Ufuk University Health Sciences Research Ethics Committee (Decision/Protocol No. 12024861-47, Approval Date: October 17, 2025). As Güven Hospital does not have its own ethics committee, additional ethical approval was obtained from the Ufuk University Health Sciences Research Ethics Committee. Due to the retrospective nature of the study, the requirement for individual informed consent was waived by the ethics committee.

The study was conducted at a dedicated breast center, where patients routinely undergo clinical examination by a breast surgeon as part of their regular breast follow-up before radiologic assessment. During the study period, 36,005 breast ultrasound examinations were performed, all by radiologists with dedicated expertise in breast imaging.

Imaging was obtained using three ultrasound platforms: Canon Aplio i800 (Canon Medical Systems, Otawara, Japan) equipped with an i18LX5 linear probe (5–18 MHz); GE Logiq S8 XD Clear (GE Healthcare, Chicago, IL, USA) equipped with a 6–15 MHz matrix linear probe; and Siemens Acuson S2000 (Siemens Healthineers, Erlangen, Germany) equipped with an 18L6 HD linear probe (6–18 MHz).

The picture archiving and communication system (PACS) was queried using a broad set of predefined keywords reflecting terminology used in routine breast ultrasound reports, including "adenosis," "periductal thickening," "hypoechoic area," "heterogeneous area," "heterogeneous hypoechoic area," "focal hypoechoic area," "focal parenchymal alteration," "ductal change," "ductal abnormality," "periductal change," "focal tissue alteration," "non-mass area," and "non-mass lesion." This search identified 2,002 potentially relevant examinations for subsequent image-based review. After sequential review, duplicate lesions, cases without stored images, and lesions lacking histopathologic confirmation or ≥ 2 years of imaging follow-up were excluded. Ultimately, 666 potentially eligible lesions were included for interobserver analysis.

Three breast radiologists independently reviewed static ultrasound images and were blinded to clinical, mammographic, and pathologic information. Lesions were classified as non-mass using a predefined majority rule (≥ 2 of 3 readers). For lesions classified as non-mass by majority decision, each observer assigned a 3-level clinical concern score (1 = benign, 2 = short-interval follow-up, and 3 = further diagnostic work-up). For diagnostic performance analyses, score 3 was considered high risk. A majority clinical score was generated using the same 2-of-3 rule.

Based on this classification, 610 lesions were categorized as non-mass and included in the final analysis. Demographic data were obtained from the hospital information system. Imaging descriptors of non-mass lesions were extracted from radiology reports available in the PACS. To ensure consistency between reported descriptors and imaging findings, all cases underwent consensus review by three breast radiologists under the supervision of a senior breast radiologist with extensive experience in breast imaging, and descriptors were verified against the original ultrasound images.

Final diagnosis was established by histopathologic sampling or imaging stability during a minimum follow-up of 2 years. Pathologic results were initially categorized into six groups and subsequently reduced to a three-level ordinal outcome for modeling: benign, borderline (atypical), and malignant (ductal carcinoma in situ or invasive carcinoma).

Ultrasound variables included background parenchymal pattern, echogenicity, lesion distribution, and associated findings (calcifications, architectural distortion, posterior acoustic shadowing, ductal or tubular

configuration, and vascularity). Vascularity was assessed as present or absent. No further classification according to vascular distribution (e.g., peripheral or central) or degree of vascularity was performed. Associated findings were analyzed both as a composite binary variable and as individual components. In patients with available mammography, breast density and mammographic correlates were recorded.

Clinical variables included first-degree family history, genetic mutation status, personal history of breast cancer, the presence of a second ipsilateral non-mass focus in newly diagnosed cancer, and palpability. None of the patients included in the study had nipple discharge. The associations between ultrasonographic and clinical variables and final pathological diagnosis were evaluated. Figure 1 illustrates the study flow diagram and case selection process.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics (version 29.0; IBM Corp., Armonk, NY, USA). Two-sided *P* values of < 0.05 were considered statistically significant. Interobserver agreement was assessed using percent agreement, Cohen's kappa, Fleiss' kappa, and Gwet's AC1. Quadratic weighted kappa was calculated for ordinal clinical scoring. Associations between clinical scores and pathologic categories were evaluated using Spearman correlation. Categorical variables were compared using the Pearson chi-square test when expected cell counts were adequate. For contingency tables with sparse expected cell counts, exact tests were used. Given the ordinal outcome structure (benign → borderline → malignant), proportional odds ordinal logistic regression models (SPSS polytomous universal model procedure) were constructed to identify independent predictors of increasing pathologic risk. The proportional-odds assumption was assessed using the test of parallel lines and was not violated ($P > 0.05$). Multicollinearity among variables included in the multivariable ultrasound analysis was assessed using variance inflation factors (VIFs). Four models were prespecified: ultrasound-only, clinical-only, clinical plus mammographic (subgroup), and combined clinical plus ultrasound. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported. Complete-case analysis was performed. Three mastectomy cases lacked background parenchymal assessment; therefore, combined models included 607 lesions. No imputation was performed because missing data were minimal (< 1%). The analytic cohorts and corresponding denominators used across the different analyses are summarized in Supplementary Table 1.

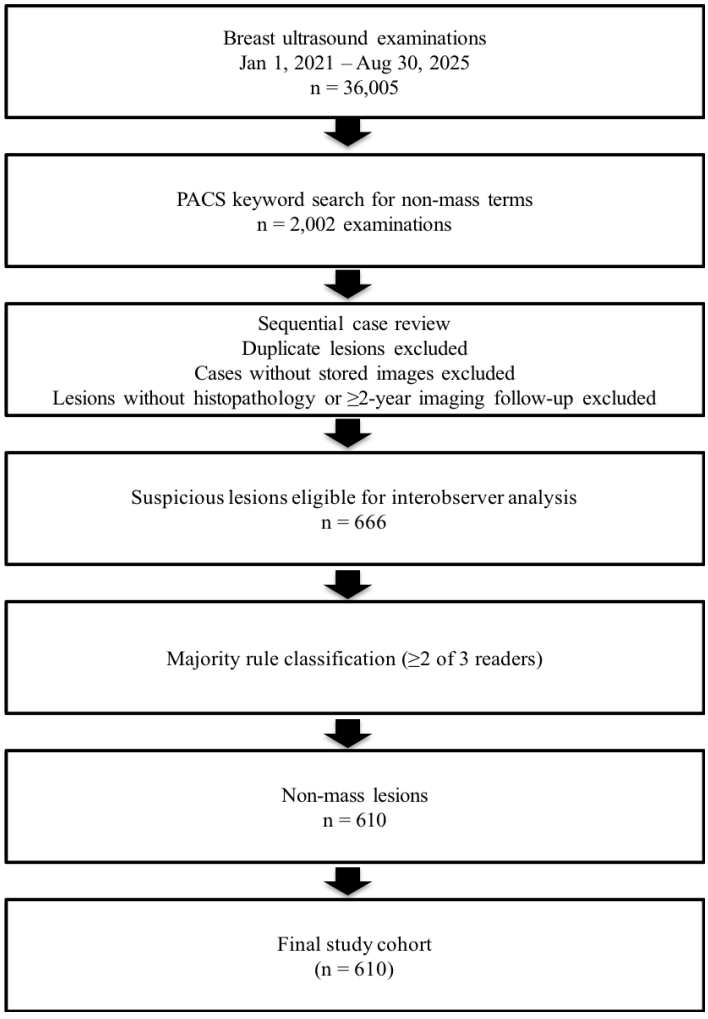


Figure 1. Study flow diagram showing case selection. A keyword search in the picture archiving and communication system identified 2,002 examinations potentially containing non-mass lesions. After exclusion of duplicate lesions, cases without stored images, and lesions lacking histopathology or ≥ 2-year imaging follow-up, 666 potentially eligible lesions remained for interobserver analysis. Using a predefined majority rule (≥ 2 of 3 readers), 610 lesions were classified as non-mass and included in the final study cohort. PACS, picture archiving and communication system.

Results

Study cohort and lesion selection

During the study period, 36,005 breast ultrasound examinations were performed. Keyword-based screening identified 2,002 examinations potentially describing non-mass findings. After exclusion of duplicate lesions and cases lacking an adequate reference standard, 666 potentially eligible lesions remained for reader evaluation. Of these, 610 of 666 lesions (91.6%) were classified as non-mass by majority decision and constituted the primary analytic cohort (Figure 1). The 610 lesions classified as non-mass by majority decision constituted the overall analytic cohort.

Interobserver agreement

Complete three-reader agreement for non-mass classification was observed in 509 of 666 cases (76.4%), with pairwise agreement ranging from 83.0% to 85.9%. Given the high prevalence of non-mass designation (610/666), agreement statistics demonstrated a prevalence effect. Gwet's AC1 indicated substantial agreement (pairwise AC1 = 0.78–0.83; overall AC1 = 0.80), whereas kappa statistics were lower (Cohen's kappa = 0.21–0.29; Fleiss' kappa = 0.24).

Among the 610 majority-classified non-mass lesions, agreement for three-level clinical concern scoring was modest. Complete three-reader agreement was observed in 182 of 610 cases (29.8%). Quadratic weighted kappa values ranged from 0.21 to 0.36. When scores were dichotomized as high risk (score 3) vs. non–high risk (scores 1 or

2), agreement improved substantially, with concordance in 576 of 610 lesions (94.4%; Fleiss' kappa = 0.43). Seven lesions demonstrating complete 1–2–3 disagreement were excluded from majority-based performance analysis, yielding 603 lesions for diagnostic performance evaluation.

Reference standard and pathologic outcomes

Final diagnosis was established by ≥ 2-year imaging follow-up in 488 of 610 lesions (80.0%) and by histopathologic sampling in 122 of 610 (20.0%). Within the six-category classification, 44 of 610 lesions (7.2%) were benign, 39 (6.4%) proliferative without atypia, 26 (4.3%) atypical, two (0.3%) ductal carcinoma *in situ*, and 11 (1.8%) invasive carcinoma. The overall malignancy rate among majority-classified non-mass lesions was 2.1% (13/610; 95% CI: 1.2%–3.6%). After reduction to a three-category system, 571 of 610 lesions (93.6%) were classified as benign, 26 (4.3%) as borderline, and 13 (2.1%) as malignant (Table 1).

Clinical concern score and diagnostic performance

Among the 603 lesions with a determinable majority score, malignancy frequency increased across clinical concern categories. For score 1, 287 of 289 lesions (99.3%) were benign. For score 2, 273 of 296 (92.2%) were benign, and 3 lesions (1.0%) were malignant. For score 3, 10 of 18 lesions (55.6%) were malignant. Of the 13 malignant lesions, 10 (76.9%) were assigned a majority score of 3, and 3 (23.1%) were assigned a score of 2.

When majority score 3 was considered high risk, sensitivity for malignancy was 76.9% (10/13; 95% CI: 49.7%–91.8%) and specificity was 98.6% (582/590; 95% CI: 97.3%–99.3%). Positive predictive value was 10 of 18 (55.6%), and negative predictive value was 582 of 585 (99.5%). Clinical concern scores demonstrated positive correlations with pathologic category, with Spearman coefficients ranging from 0.23 to 0.40 across readers (all $P < 0.001$). The majority clinical score also correlated with pathologic category ($r = 0.307$; $P < 0.001$).

Patient and imaging characteristics

The mean patient age was 49.1 ± 9.6 years (median = 47 years; range = 22–83 years). Most lesions were nonpalpable (601/610, 98.5%). A first-degree family history of breast cancer was present in 102 of 610 patients (16.7%), 105 of 610 (17.2%) had a personal history of breast cancer, and a documented pathogenic genetic mutation was present in 6 patients (1.0%). A second ipsilateral non-mass focus in newly diagnosed breast cancer was observed in 11 of 610 cases (1.8%). Ultrasound examinations were performed using Canon Aplio i800 (270/610, 44.3%), GE Logiq S8 XD Clear (237/610, 38.9%), and Siemens Acuson S2000 (103/610, 16.9%) systems (Table 2).

Background parenchymal pattern was assessable in 607 cases. In 3 patients with prior mastectomy in whom non-mass lesions were identified in the mastectomy bed, background parenchymal pattern could not be assessed. A heterogeneous pattern was present in 557 of 607 lesions (91.8%). Lesions were predominantly hypoechoic (505/610, 82.8%), and focal distribution was observed in 585 of 610 (95.9%). Overall, 413 of 610 lesions (67.7%) had no associated sonographic finding. Among associated findings, vascularity was present in 74 of 610 lesions (12.1%), architectural distortion in 55 (9.0%), ductal/tubular configuration in 53 (8.7%), calcifications in 42 (6.9%), and posterior acoustic shadowing in 35 (5.7%) (Table 3; Figure 2).

Mammographic findings

Mammography was available in 536 patients. Among these, 487 of 536 (90.9%) demonstrated high breast density (categories C or D). In 59 of 536 patients (11.0%), a mammographically detected abnormality prompted targeted ultrasound evaluation, with corresponding non-mass lesions identified. The remaining 477 of 536 patients (89.0%) had no mammographic correlate.

Association between imaging features and pathology

Univariable analyses showed that several ultrasound features were common among malignant non-mass lesions; however, these findings should be interpreted cautiously

Table 1. Final diagnostic method and pathologic outcomes (n = 610)

A. Final diagnostic method

Variable	Category	Value	n	%
Diagnostic method	≥ 2-year imaging follow-up		488	80.0
	Biopsy		122	20.0

B. Six-category pathology classification

Category	Definition	Value	n	%
0	**No biopsy/NA (follow-up)**		**488**	**80.0**
1	Benign		44	7.2
2	Proliferative without atypia		39	6.4
3	Atypical lesion		26	4.3
4	DCIS		2	0.3
5	Invasive malignancy (ductal, n = 7; lobular, n = 3; micropapillary, n = 1)		11	1.8
	Total malignant (4 + 5)		**13**	**2.1**

C. Reduced three-category pathology classification

Category	Definition	Value	n	%
1	Benign		571	93.6
2	Borderline (atypical)		26	4.3
3	Malignant (DCIS + invasive)		13	2.1

DCIS, ductal carcinoma *in situ*, NA, not applicable.

because of the small number of malignant cases and sparse observations across some categories. Predominantly hypoechoic echogenicity, focal distribution, and heterogeneous parenchymal background were each observed in 12 of 13 malignant lesions (92.3%), but none of these variables showed a statistically significant association with pathologic category ($P = 0.27$, $P = 0.081$, and $P = 0.081$, respectively). In contrast, the presence of at least one associated sonographic finding was significantly more frequent in borderline and malignant lesions ($P < 0.001$). Architectural distortion, posterior acoustic shadowing, and vascularity were significantly associated with higher pathologic categories (all $P < 0.001$), whereas ductal/tubular configuration was not associated ($P = 0.20$).

Multivariable analysis

The proportional-odds assumption was satisfied for the ordinal logistic regression analyses (test of parallel lines, $P > 0.05$).

In multivariable ordinal logistic regression including ultrasound variables (n = 607), architectural distortion was the strongest independent predictor of increasing pathologic risk (OR = 8.40; 95% CI: 3.89–18.16; $P < 0.001$), followed by posterior acoustic shadowing (OR = 4.76; 95% CI: 1.84–12.28; $P = 0.001$) and vascularity (OR = 2.69; 95% CI: 1.22–5.97; $P = 0.015$).

Table 2. Demographic and clinical characteristics and ultrasound system distribution (n = 610)

Variable	Category	Value	n	%
Age, years	Mean ± SD	49.1 ± 9.6		
	Median (range)	47 (22–83)		
Ultrasound system	Canon Aplio i800 (18LX5)		270	44.3
	GE LOGIQ S8 (XD Clear; 6–15 MHz linear)		237	38.9
	Siemens Acuson S2000 (18L6 HD)		103	16.9
First-degree family history	0		508	83.3
	1		92	15.1
	2		10	1.6
Genetic mutation	No documented mutation		604	99.0
	Present		6	1.0
Personal history of breast cancer	Absent		505	82.8
	Present		105	17.2
Second ipsilateral non-mass focus in newly diagnosed breast cancer	No		599	98.2
	Yes		11	1.8
Palpability	Nonpalpable		601	98.5
	Palpable		9	1.5

SD, standard deviation.

Table 3. Ultrasonographic characteristics of non-mass lesions (n = 610)

Variable	Category	Value	n	%
Parenchymal pattern	Homogeneously fatty		24	4.0
	Homogeneously fibroglandular		26	4.3
	Heterogeneous		557	91.8
Echogenicity	Predominantly hypoechoic		505	82.8
	Predominantly hyperechoic		12	2.0
	Mixed hypoechoic + hyperechoic		65	10.7
	Anechoic		1	0.2
	Isoechoic		27	4.4
Distribution pattern	Focal		585	95.9
	Linear–segmental		22	3.6
	Regional		3	0.5
Additional sonographic finding (overall)	None		413	67.7
	≥ 1 finding present		197	32.3
Additional findings†	Calcifications		42	6.9
	Architectural distortion		55	9.0
	Posterior acoustic shadowing		35	5.7
	Ductal/tubular structure		53	8.7
	Vascularity		74	12.1

*Parenchymal pattern could not be assessed in three mastectomized patients (n = 607). Percentages for that variable are calculated using n = 607. All other variables use n = 610.
†Component-counted; totals do not sum to 100%.

In the clinical model (n = 610), the presence of a second ipsilateral non-mass focus in newly diagnosed breast cancer was associated with higher pathologic category (OR = 10.93; $P = 0.002$), and palpability was also independently associated (OR = 6.64; $P = 0.012$).

In the subgroup model including mammographic variables (n = 536), the presence of a mammographic correlate was independently associated with higher pathologic category (OR = 8.39; $P < 0.001$).

In the combined clinical and ultrasound model (n = 607), architectural distortion, posterior acoustic shadowing, and vascularity remained independent predictors, whereas family history and the presence of a second ipsilateral non-mass focus demonstrated borderline significance (Table 4). Complete results of all four prespecified multivariable ordinal logistic regression models are provided in Supplementary Table 2. Model-fit statistics for these models are presented in Supplementary Table 3.

No substantial multicollinearity was identified among the ultrasound predictors (VIF range = 1.01–1.11).

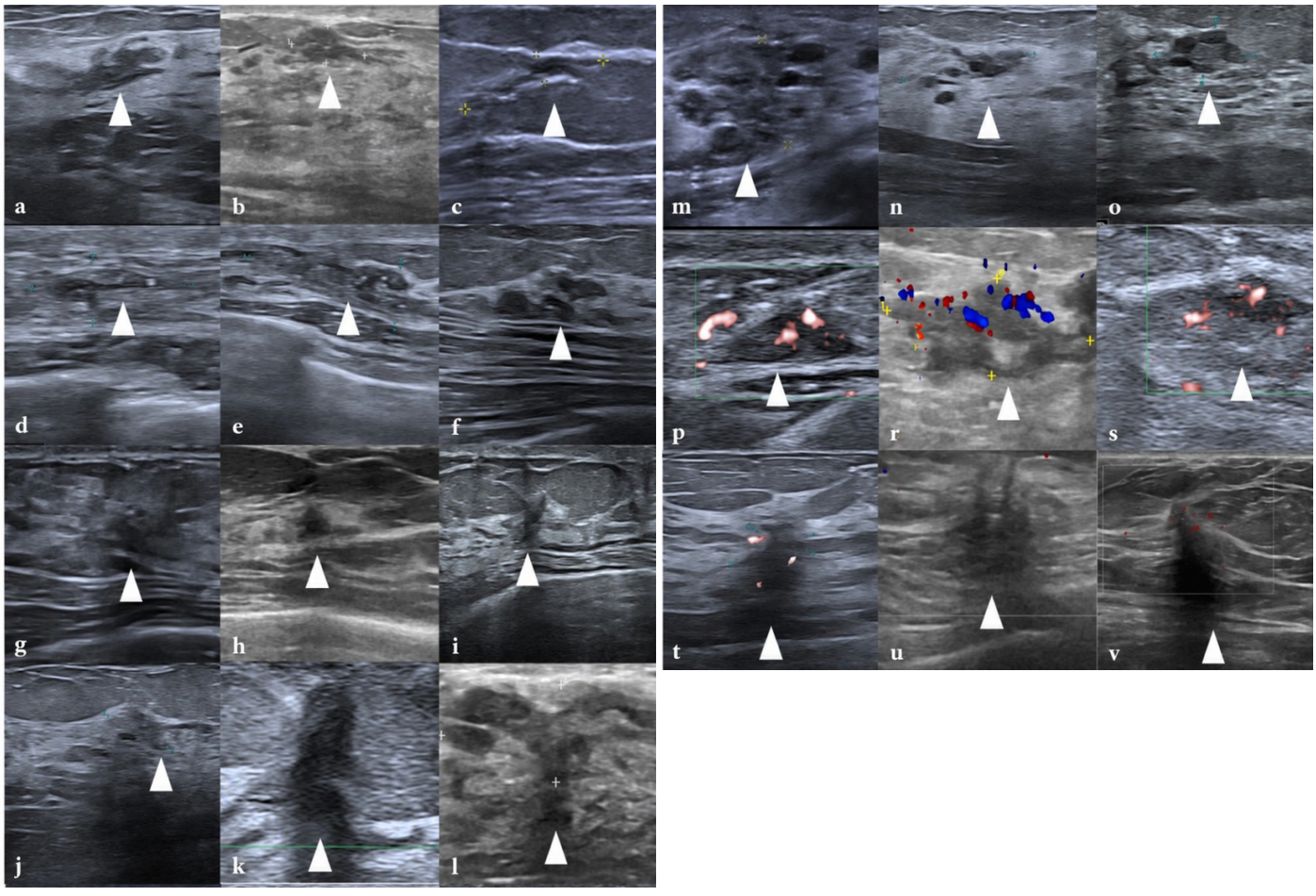


Figure 2. Representative ultrasound examples of non-mass lesions with associated findings.

(a–c) Non-mass lesions without associated ultrasonographic findings. All lesions demonstrated benign behavior during imaging follow-up.

(d–f) Non-mass lesions associated with microcalcifications. Histopathology revealed apocrine metaplasia with columnar cell hyperplasia without atypia **(d)** and columnar cell hyperplasia without atypia **(e, f)**.

(g–i) Non-mass lesions associated with architectural distortion. Histopathology demonstrated a complex sclerosing lesion with atypical columnar cell hyperplasia **(g)**, sclerosed breast stroma **(h)**, and atypical columnar cell change **(I)**.

(j–l) Non-mass lesions associated with posterior acoustic shadowing. One lesion showed benign imaging follow-up **(J)**, whereas columnar cell hyperplasia without atypia **(k)** and a complex sclerosing lesion **(l)** were identified histologically.

(m–o) Non-mass lesions associated with tubular or cystic structures. Histopathology revealed columnar cell change/hyperplasia without atypia with fibrocystic changes **(m)** and chronic inflammation **(o)**, and one lesion remained benign on follow-up **(n)**.

(p–s) Non-mass lesions demonstrating internal vascularity on color Doppler imaging. Histopathology revealed intraductal papilloma with atypia **(p)**, invasive micropapillary carcinoma **(r),** and columnar cell change/hyperplasia without atypia with sclerosing adenosis **(s).**

(t–v) Non-mass lesions demonstrating multiple associated findings. Combined posterior acoustic shadowing, architectural distortion, and internal vascularity corresponded to usual ductal hyperplasia with atypical columnar cell hyperplasia **(t).** Microcalcifications, architectural distortion, and posterior acoustic shadowing corresponded to invasive lobular carcinoma **(u).** Microcalcifications, architectural distortion, posterior acoustic shadowing, and internal vascularity corresponded to invasive ductal carcinoma **(v).**

White arrowheads indicate the corresponding non-mass lesion areas.

Table 4. Combined multivariable ordinal logistic regression model including clinical and ultrasonographic variables (excluding mammography; n = 607)

Variable	OR (95% CI)	*P* value
Architectural distortion	7.81 (3.43–17.78)	< 0.001
Posterior acoustic shadowing	5.37 (1.95–14.82)	0.001
Vascularity	2.64 (1.16–6.03)	0.021
Second ipsilateral non-mass focus in newly diagnosed cancer	6.47 (0.91–45.80)	0.062
First-degree family history	2.16 (0.98–4.77)	0.056
Palpable lesion	3.02 (0.57–15.98)	0.194
Echogenicity	0.73 (0.43–1.26)	0.264
Parenchymal pattern	0.64 (0.30–1.38)	0.253
Calcifications	1.04 (0.24–4.57)	0.961

OR, odds ratio; CI, confidence interval.

Discussion

In this study, we evaluated the relationship between sonographic features of breast non-mass lesions and pathological risk. The recent incorporation of non-mass findings into the ACR BI-RADS v2025 manual underscores the increasing clinical relevance of this lesion category and the need to characterize further its imaging features and associated pathological risk.[1] A total of 610 lesions classified as non-mass by majority decision among three observers were analyzed. Interobserver agreement for non-mass classification was high (Gwet's AC1 = 0.80), and clinical concern scores demonstrated a significant positive correlation with pathological category (Spearman r = 0.307, $P < 0.001$). The majority clinical score showed high specificity (98.6%) and moderate sensitivity (76.9%) for predicting malignancy. In multivariable ordinal logistic regression analysis, architectural distortion emerged as the strongest independent predictor of malignancy (OR = 8.40; 95% CI: 3.89–18.16; $P < 0.001$), followed by posterior acoustic shadowing (OR = 4.76; 95% CI: 1.84–12.28; $P = 0.001$) and vascularity (OR = 2.69; 95% CI: 1.22–5.97; $P = 0.015$). Although the overall malignancy rate in our cohort was low (2.1%), several sonographic features demonstrated strong associations with increased pathological risk.

Evaluation of non-mass lesions on breast ultrasound presents diagnostic challenges because classic descriptors used for mass lesions cannot be applied. These lesions represent focal areas of altered echogenicity that are distinguishable from surrounding breast parenchyma but do not form a discrete mass and therefore lack definable shape or margins.[5] Interpretation therefore relies primarily on echogenicity patterns, distribution characteristics, and associated sonographic findings. Non-mass lesions represent a broad pathological spectrum ranging from benign proliferative changes to invasive malignancies.[5,6] In addition, terminology and classification of non-mass lesions remain incompletely standardized in the literature, which may limit comparisons across studies.

Previous studies have reported that the malignancy rate of ultrasound-detected non-mass lesions is generally low, typically ranging from approximately 1% to 10%.[4-6] In contrast, Park et al. reported a malignancy rate of 46.2% in a cohort consisting exclusively of biopsied lesions.[7] The lower malignancy rate observed in our study (2.1%) likely reflects the imaging-based design of the cohort rather than biopsy-selected populations.

Several imaging characteristics have been reported to be associated with malignancy in non-mass lesions. Mixed echogenicity patterns have been described as more frequent in malignant lesions in some studies, although other reports did not demonstrate a significant association.[8,9] Similarly, in our study, most malignant lesions exhibited a hypoechoic pattern; however, echogenicity was not independently associated with pathological risk in multivariable analysis. Lesion distribution patterns have also been investigated as potential predictors of malignancy. Segmental or linear distribution patterns have been associated with malignant disease in several studies,[7-10] likely reflecting tumor spread along the ductal system. In our cohort, however, most lesions demonstrated a focal distribution pattern, which likely reflects the predominance of benign lesions in an imaging-based population.

Associated sonographic findings may provide additional diagnostic clues. Calcifications, posterior acoustic shadowing, ductal changes, architectural distortion, and hypervascularity have all been reported to show varying associations with malignancy.[7-9,11-14] In the present study, architectural distortion, posterior acoustic shadowing, and vascularity were independently associated with increased pathological risk, supporting the importance of these features in the evaluation of non-mass lesions. In contrast, calcifications and ductal/tubular configurations were not independently associated with pathologic category in multivariable analysis.

Clinical and multimodal imaging context also contribute to risk stratification. In our cohort, the presence of a second ipsilateral non-mass focus in patients with newly diagnosed breast cancer and lesion palpability were associated with increased pathological risk. In addition, the presence of a mammographic correlate was strongly associated with a higher pathological category, supporting the value of multimodal imaging assessment. Previous studies have also reported that malignant non-mass lesions are frequently accompanied by suspicious mammographic findings such as calcifications or asymmetry, whereas malignancy rates are lower when mammography is negative.[7,8,15] These findings suggest that integrating ultrasound findings with mammographic and clinical information may improve risk stratification.

This study has several limitations. First, the retrospective single-center design may limit generalizability. Second, the relatively small number of borderline and malignant lesions resulted in wide CIs in some regression estimates. Third, case identification relied on a keyword-based PACS search strategy, which may have introduced selection bias and may not have captured all non-mass lesions present during the study period. The interobserver evaluation was performed using stored static ultrasound images rather than real-time scanning, which may have limited complete assessment of lesion morphology. Finally, although most lesions had long-term imaging follow-up or histopathologic confirmation, reliance on imaging stability for a subset of cases represents a potential limitation of the reference standard. In addition, breast magnetic resonance imaging (MRI) was not systematically incorporated into the study design; therefore, correlations between ultrasound-detected non-mass lesions and MRI non-mass enhancement could not be evaluated.

In conclusion, in this imaging-based cohort, most breast non-mass lesions detected on ultrasound are benign; however, certain

sonographic features are strongly associated with increased pathological risk. In particular, architectural distortion, posterior acoustic shadowing, and vascularity emerged as independent predictors of increasing pathological risk. Integration of sonographic features with clinical and mammographic information may improve risk stratification and clinical decision-making for non-mass breast lesions. Future multicenter studies may further refine diagnostic classification and management strategies.

Footnotes

Conflict of interest disclosure

Serap Gültekin serves as Section Editor for Diagnostic and Interventional Radiology. She had no involvement in the peer review of this article and had no access to information regarding its peer review. The other authors declared no conflicts of interest.

Supplementary Tables 1-3: https://d2v96fx-pocvxx.cloudfront.net/cf9d60d6-523c-458a-a2e6-78728d3ffbb0/content-images/6da54194-ce7f-49d3-9ac1-516650583be5.pdf

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