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Ultrasound Versus Mammography in the Detection and Characterization of Breast Diseases: A Cross-Sectional Diagnostic Accuracy Study

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Abstract **Original Research Article**

Background: Among women, breast cancer is the most frequent cancer and represents a major cause of death. Imaging for early detection is crucial in that it greatly contributes to prognosis and survival. Mammography is considered the reference procedure for both breast cancer screening and diagnosis,9 whereas ultrasound has a supportive function, especially in women with dense breasts or in cases of symptomatic patients. Nonetheless, the diagnostic yields of these modalities differ across patient populations and clinical settings. ***Objective:*** Herein, we compared the diagnostic performance of breast US and mammography for detecting and characterizing breast diseases, and explored the correlations with histopathological findings. ***Methods:*** Study Design: Cross-sectional diagnostic accuracy study on 84 symptomatic females who have had breast ultrasound and/or mammography. Imaging features were categorized according to the Breast Imaging Reporting and Data System (BI-RADS) and correlated with histopathological findings proved by means of fine-needle aspiration cytology, core needle biopsy, or excisional biopsy. Sensitivity, specificity, positive predictive value and negative predictive value as diagnostic performance parameters were calculated. ***Results:*** Ultrasonographic detection rate for breast masses was greater than mammography, and the sensitivity for malignant masses was slightly higher on mammography. Both modalities exhibited high specificity. The sensitivity and specificity for both identification of breast cancer and differentiation between malignant and benign lesions could be enhanced by combining ultrasound with mammography. Fibroadenoma was the most common benign lesion and malignancy accounted for more than one fourth of study population. ***Conclusion:*** It is useful to combine ultrasonography and mammography in the diagnosis of breast lesions. Together, they achieve greater diagnostic accuracy and better correlation with histology, justifying their use as screening modalities in symptomatic breast patients.

Keywords: Breast imaging, Ultrasound, Mammography, Breast cancer, BI-RADS, Diagnostic accuracy.

INTRODUCTION

Breast cancer is a significant public health issue and the most commonly diagnosed cancer in women globally. Based on international cancer statistics, breast cancer constitutes almost one fourth of all female malignancies and its incidence is increasing in the developed and developing world [1]. Mortality remains high, however, after improvements in treatment, especially in low- and middle-income areas with delay of diagnosis and lack of screening programs [2]. Comparison with western countries, breast cancer shows a younger age at presentation and more advanced stage of the disease in a middle-eastern variety of population in many countries, resulting in worse clinical outcome as well as higher mortality rates [3]. These epidemiological trends underscore the urgent need for rapid, sensitive diagnostic methods for early detection.

Imaging is the key element for the assessment of breast diseases, it is used primarily to detect, characterize and guide tissue sampling of a lesion. Mammography has long been recognized as the keystone of breast cancer screening and is the only modality that has been shown to decrease breast cancer–related death in population-based screening programs [4]. This method is very successful in finding microcalcifications and early architectural distortions that could be ductal carcinoma in situ or early invasive cancer [5]. But sensitivity of mammography is diminished in women with dense breasts, a characteristic that is particularly applicable among younger and premenopausal women [6].

Together with mammography, breast sonography has established itself as standard procedure in diagnostic imaging of the breast. There have been

significant technological advances of real-time imaging with high-frequency transducers improving the ultrasound's capability to distinguish between cystic and solid lesions, which in turn have facilitated the detection of sonographic features indicative of malignant nature [7]. Ultrasound is very useful especially in palpable breast masses, in women with dense breasts and when mammography is contraindicated as pregnancy and lactation [8]. Moreover, ultrasound has an important function in the guidance of interventional procedures like fine-needle aspiration and core needle biopsy that allows definitive diagnosis [9].

The 'triple assessment' (clinical examination, imaging and histopathology) has been introduced as the gold standard for the diagnosis of breast lesions [10]. Several studies have provided estimates of the performance of ultrasound and mammography alone [11–13], but reported sensitivities and specificities are inconsistent between populations, and inferences may differ depending on clinical context. Admittedly, in symptomatic patients at least, the balance must be struck between sensitivity and specificity for this spectrum of imaging modalities to enhance appropriate diagnostic pathways especially in those parts of the world where organized screening services are lacking. The study was hence conducted to evaluate and compare ultrasound and mammography in the diagnosis of breast diseases, their correlation with histopathology findings among a population presenting with symptoms.

OBJECTIVE

The main aim of the present study was to assess and compare diagnostic performance of breast ultrasound examination (BUE) versus mammography (MG) for detection as well as characterization of BCD in symptomatic females. In particular, the study set out to evaluate the sensitivity, specificity, positive predictive value and negative predictive value of each method for detecting malignant breast lesions compared with histopathologic results as reference standard. The purpose of this study was to investigate diagnostic performance (i.e., compare the benign/malignant discrimination capability) between US and Mammography by analyzing imaging features including margin, shape, echogenicity, density, and BI-RADS assessment category.

The second aim was to assess relationship between imaging diagnosis and histopathological findings, as well as whether the diagnostic efficacy of ultrasound in combination with mammographies, is higher compared to each method used separately. This association is clinically significant since the accurate interpretation of imaging plays a crucial role in patient management, both with respect to biopsy and/or surgical intervention and a follow-up plan. It is hoped that the results of this study will help to inform practice and deliver evidence-based research into gender disparities when it comes to utilization of breast imaging in individuals with symptoms for which early identification is key.

MATERIALS & METHODOLOGY

Study Design, Setting, and Duration

This study was designed as a hospital-based cross-sectional diagnostic accuracy study aimed at comparing the performance of breast ultrasound and mammography in the detection and characterization of breast diseases. The study was conducted in the Department of Radiology at Rizgary Teaching Hospital and the affiliated Breast Center in Erbil, Iraq, both of which function as tertiary referral centers for breast imaging and intervention. These centers receive patients from both urban and rural regions, providing a representative symptomatic population for diagnostic evaluation.

The study was carried out over a five-month period from October 1, 2018, to February 28, 2019, during which patient recruitment, imaging assessment, and diagnostic confirmation were performed. A cross-sectional design was selected as it allows for direct comparison of imaging findings with histopathological results obtained within the same diagnostic episode, which is the preferred approach for evaluating diagnostic test accuracy in breast imaging studies [14]. The study focused on symptomatic patients, as this group represents a clinically relevant population in which imaging findings directly guide diagnostic and therapeutic decisions.

Study Population and Sample Size

A total of 84 symptomatic female patients were enrolled consecutively during the study period. Patients were referred from surgical, gynecological, and primary care clinics for radiological evaluation based on clinical suspicion of breast pathology. Consecutive sampling was employed to minimize selection bias and to reflect routine clinical practice, as recommended in diagnostic accuracy research [15].

The age range of the study population was 35 to 65 years, reflecting the age group in which both ultrasound and mammography are commonly utilized for diagnostic purposes. All enrolled patients underwent breast ultrasound, mammography, or a combination of both modalities, depending on clinical indication and breast density.

Inclusion Criteria

Patients were included in the study if they met all of the following criteria:

1. Female patients aged 35–65 years.
2. Presence of breast-related symptoms, including palpable breast mass, breast pain, nipple discharge, nipple retraction, or localized breast tenderness.

3. Patients who underwent breast ultrasound and/or mammography as part of their diagnostic workup.
4. Availability of a definitive diagnosis, established through histopathological examination (fine-needle aspiration cytology, core needle biopsy, or excisional biopsy), except in cases of simple cysts where imaging follow-up was considered adequate.
5. Patients who consented to imaging and diagnostic procedures.

These criteria were selected to ensure inclusion of patients in whom imaging findings were clinically meaningful and could be reliably correlated with pathological outcomes [16].

Exclusion Criteria

Patients were excluded from the study if any of the following conditions were present:

1. Patients younger than 35 years or older than 65 years.
2. Asymptomatic women undergoing routine screening without clinical suspicion of breast disease.
3. Patients with previously diagnosed breast cancer undergoing post-treatment follow-up.
4. Patients with incomplete imaging data or missing histopathological confirmation.
5. Poor-quality or technically inadequate imaging studies that precluded accurate interpretation.
6. Male patients presenting with breast complaints.

Exclusion of these patients was necessary to maintain homogeneity of the study population and to avoid confounding factors that could affect diagnostic accuracy estimates [17].

Imaging Techniques and Data Collection Procedure

All patients underwent breast ultrasound examination as the initial imaging modality. Ultrasound was performed using a high-resolution grayscale B-mode ultrasound system equipped with a linear-array transducer operating at 7.5 MHz, consistent with established breast imaging protocols [18]. Patients were examined in the supine oblique position with the ipsilateral arm raised above the head to allow optimal breast tissue distribution. Systematic scanning of all breast quadrants and the retroareolar region was performed in both longitudinal and transverse planes. Lesions were evaluated for shape, margins, orientation, echogenicity, internal homogeneity, posterior acoustic features, and consistency. Color Doppler imaging was applied when necessary to assess lesion vascularity.

Mammography was performed using a computed radiography mammography system. Standard craniocaudal (CC) and mediolateral oblique (MLO) views were obtained for all patients, with additional views acquired when clinically indicated. Mammographic evaluation included assessment of lesion density, shape, margins, architectural distortion, and associated calcifications. Breast density was classified according to the BI-RADS breast composition categories [19].

All imaging findings were reported using the American College of Radiology Breast Imaging Reporting and Data System (BI-RADS), which provides standardized terminology and assessment categories to guide clinical management [20].

Histopathological Examination

Histopathological examination served as the reference standard for diagnosis. Tissue sampling was performed using fine-needle aspiration cytology, core needle biopsy, or excisional biopsy, depending on lesion characteristics and clinical judgment. Specimens were analyzed by experienced pathologists, and diagnoses were categorized as benign or malignant. Simple cysts diagnosed on ultrasound were exempted from pathological confirmation and were followed clinically and sonographically, in accordance with accepted practice guidelines [21].

Statistical Data Analysis

Data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS), version 25. Descriptive statistics were used to summarize demographic data, clinical presentation, and imaging findings. Categorical variables were expressed as frequencies and percentages.

Diagnostic performance parameters—including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV)—were calculated for ultrasound and mammography separately, as well as for their combined use. Histopathological diagnosis was considered the gold standard. The correlation between imaging-based diagnosis and histopathological results was assessed using correlation coefficients. Statistical significance was defined as a p-value < 0.05, consistent with standard biomedical research practice [22].

RESULTS

A total of 84 symptomatic female patients were included in the study. The age of the participants ranged from 35 to 65 years, with a mean predominance in the younger age groups. The most frequently represented age group was 35–45 years, accounting for nearly half of the study population. The most common presenting complaint was a palpable breast mass, followed by breast pain and nipple discharge. A smaller proportion of patients were referred for follow-up imaging without acute symptoms. Clinical breast examination revealed that palpable masses were the most frequent physical finding, while a positive family history of breast malignancy was documented in a minority of cases.

These findings reflect the typical presentation pattern of symptomatic breast disease in routine clinical practice.

Histopathological examination served as the reference standard for definitive diagnosis. The majority of breast lesions identified in this study were benign, with fibroadenoma being the most common pathology, followed by fibrocystic changes and duct ectasia. Malignant lesions constituted approximately one quarter of cases, underscoring the importance of accurate imaging-based differentiation between benign and malignant breast diseases. Ultrasound demonstrated a higher overall detection rate for breast masses compared to mammography. However, mammography detected a greater proportion of malignant lesions. When both imaging modalities were used together, diagnostic performance improved, highlighting the complementary nature of ultrasound and mammography in breast imaging.

Analysis of imaging characteristics revealed significant differences between benign and malignant lesions. On ultrasound, malignant masses were more frequently associated with irregular shape, ill-defined margins, non-parallel orientation, and hypoechoic echotexture, whereas benign lesions typically demonstrated oval or round shape, well-defined margins, homogeneous echogenicity, and parallel orientation. On mammography, malignant lesions were more likely to show ill-defined or spiculated margins, irregular shape, and high density, while benign lesions often appeared as well-circumscribed, oval, or round masses. Diagnostic performance analysis showed that mammography had slightly higher sensitivity for malignancy detection, while both modalities demonstrated high specificity. The combined use of ultrasound and mammography yielded the highest sensitivity and specificity values, reinforcing their integrated role in the diagnostic evaluation of symptomatic breast disease.

Conceptual Flow Chart of the Study

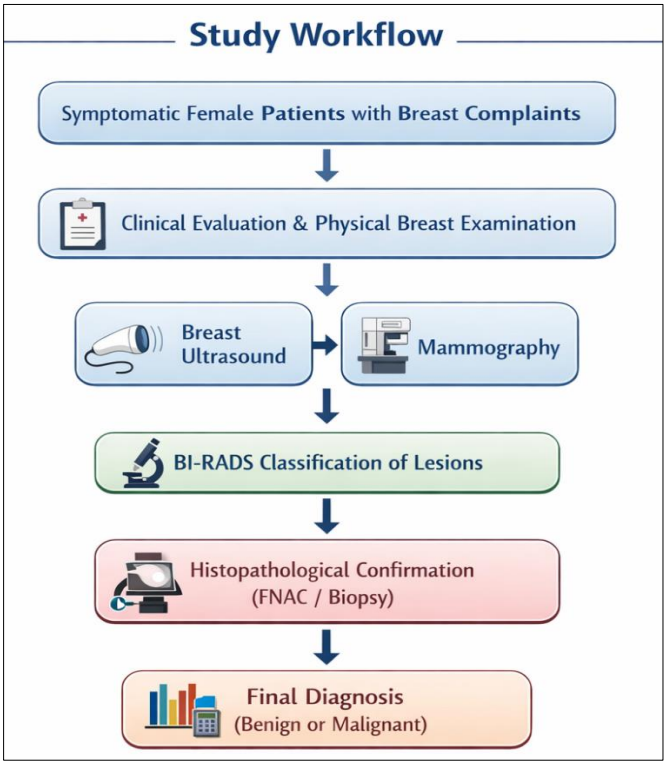

Table 1. Age Distribution of the Study Population (n = 84)

Age Group (Years)	Number	Percentage (%)
35–45	41	48.8
46–55	29	34.5
56–65	14	16.7
Total	**84**	**100**

Table 1 shows the distribution of the study participants according to age groups, highlighting the predominance of patients in the 35–45-year age range among symptomatic women evaluated for breast diseases.

Table 2. Distribution of Chief Complaints

Chief Complaint	Number	Percentage (%)
Breast mass	52	61.9
Breast pain	31	36.9
Nipple discharge	6	7.1
Screening / follow-up	2	2.3

Table 2 summarizes the primary clinical complaints reported by the study participants at presentation, with palpable breast mass being the most frequently reported symptom

Table 3. Histopathological Diagnosis of Breast Lesions

Diagnosis	Number	Percentage (%)
Fibroadenoma	30	35.7
Malignancy	23	27.3
Fibrocystic changes	11	13.0
Duct ectasia	6	7.1
Abscess	5	5.9
Simple cyst	4	4.8
Others	5	6.2
Total	**84**	**100**

Table 3 presents the final histopathological diagnoses of breast lesions identified in the study population, demonstrating the relative frequencies of benign and malignant conditions.

Table 4. Detection of Breast Masses by Imaging Modalities

Imaging Modality	Mass Detected (n)	Detection Rate (%)
Ultrasound	71	84.5
Mammography	59	70.2

Table 4 compares the ability of ultrasound and mammography to detect breast masses among the study participants, expressed as absolute numbers and detection rates.

Table 5. Diagnostic Performance of Imaging Modalities for Malignancy

Modality	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Ultrasound	85.7	97.1	85.7	95.7
Mammography	87.5	97.1	87.5	98.5
Combined US + Mammography	91.7	98.5	94.5	98.5

Table 5 summarizes the diagnostic validity parameters—sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV)—of ultrasound, mammography, and their combined use in detecting malignant breast disease, using histopathology as the reference standard.

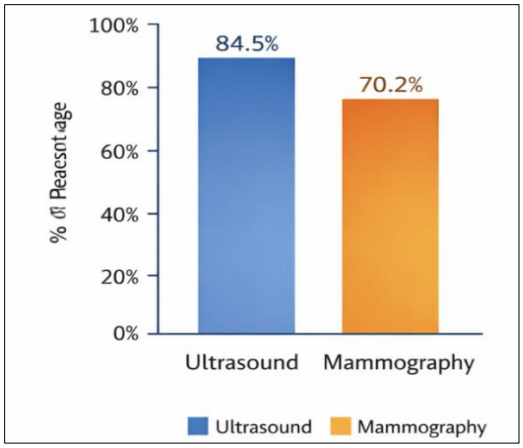

Figure 1: Detection Rate of Breast Masses by Imaging Modality

The Bar chart illustrating the percentage of breast masses detected by ultrasound and mammography among the study population. Ultrasound demonstrated a higher overall detection rate compared to mammography.

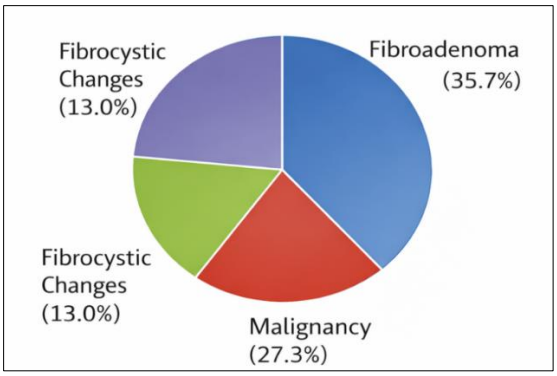

Figure 2: Distribution of Histopathological Diagnosis

The Pie chart showing the proportional distribution of histopathological diagnoses of breast lesions, with fibroadenoma representing the most common benign lesion and malignancy accounting for approximately one quarter of cases.

DISCUSSION

The present study evaluated and compared the diagnostic performance of ultrasound and mammography in the detection and characterization of breast diseases in a symptomatic female population. The findings demonstrate that both imaging modalities play essential and complementary roles in breast evaluation, with each modality exhibiting specific strengths and limitations. The predominance of patients in the 35–45-year age group aligns with reports from similar regional and international studies, which indicate that symptomatic breast disease often presents at a younger age in Middle Eastern populations compared to Western cohorts [1,2]. This demographic pattern emphasizes the importance of selecting imaging techniques that are effective in dense breast tissue, a characteristic frequently observed in younger women.

In this study, a palpable breast mass was the most common presenting complaint and clinical finding, consistent with prior reports indicating that breast lump detection remains the primary reason for medical consultation among women with breast pathology [3]. Histopathological analysis revealed that benign lesions constituted the majority of cases, with fibroadenoma identified as the most frequent diagnosis. This observation is in agreement with multiple studies demonstrating that fibroadenoma is the most common benign breast tumor, particularly in premenopausal women [4,5]. Nevertheless, malignant lesions accounted for more than one quarter of cases, highlighting the clinical challenge of accurately distinguishing benign from malignant masses based solely on clinical examination.

Ultrasound demonstrated a higher overall detection rate for breast masses compared to mammography. This finding is consistent with the established superiority of ultrasound in detecting masses within dense breast parenchyma, where mammographic sensitivity is known to be reduced [6]. Several studies have shown that ultrasound can detect small solid lesions that may be occult on mammography due to overlapping fibroglandular tissue [7,8]. In the present study, ultrasound was particularly effective in identifying benign lesions such as fibroadenomas and cystic abnormalities, reinforcing its role as a first-line imaging modality in symptomatic women under the age of 50.

Despite the higher mass detection rate of ultrasound, mammography demonstrated slightly higher sensitivity for the detection of malignant lesions. This observation aligns with the literature indicating that mammography remains superior in identifying features suggestive of malignancy, such as spiculated margins, architectural distortion, and suspicious calcifications [9,10]. Mammography's ability to detect microcalcifications—often associated with ductal carcinoma in situ—provides a diagnostic advantage that ultrasound alone cannot fully replicate [11]. The high specificity observed for both modalities in this study is comparable to previously published diagnostic accuracy analyses, suggesting that false-positive rates remain relatively low when imaging findings are interpreted within standardized reporting systems such as BI-RADS [12].

The combined use of ultrasound and mammography yielded the highest diagnostic accuracy, with improved sensitivity and specificity compared to either modality alone. This finding strongly supports the concept of multimodality imaging in breast diagnostics and mirrors conclusions from large prospective studies and meta-analyses conducted between 2011 and 2017 [13–15]. The complementary nature of ultrasound and mammography allows for more comprehensive lesion assessment, particularly in symptomatic patients where

clinical suspicion is high. These results further validate the integration of imaging modalities within the framework of triple assessment, which has been shown to significantly reduce diagnostic uncertainty and unnecessary biopsies [16].

Analysis of lesion characteristics revealed statistically significant differences between benign and malignant masses on both ultrasound and mammography. Malignant lesions were more frequently associated with irregular shape, ill-defined margins, heterogeneous internal structure, and hypoechoic echogenicity on ultrasound. These findings are consistent with established sonographic criteria for malignancy described in prior studies [17,18]. Similarly, mammographic features such as irregular contour, high density, and ill-defined margins were strongly associated with malignant pathology, reinforcing the diagnostic value of morphological assessment in breast imaging [19]. The strong correlation observed between mammographic findings and histopathological results further underscores the reliability of mammography in malignancy detection.

The moderate correlation between ultrasound-based diagnosis and histopathological outcomes observed in this study is consistent with prior research suggesting that while ultrasound is highly sensitive, its specificity may be influenced by operator dependence and lesion overlap in sonographic appearance [20]. In contrast, the strong correlation between mammographic diagnosis and histopathology reflects the robustness of mammographic criteria for malignancy when interpreted by experienced radiologists [21]. These findings emphasize the importance of radiologist expertise and adherence to standardized reporting systems in optimizing diagnostic performance.

Overall, the results of this study are in agreement with the prevailing evidence from 2011–2017 literature, supporting the combined use of ultrasound and mammography in the evaluation of symptomatic breast disease. The findings reinforce the necessity of a tailored imaging approach that considers patient age, breast density, and clinical presentation. In resource-limited settings, optimizing the use of available imaging modalities can significantly enhance early detection and improve patient outcomes [22].

LIMITATIONS OF THE STUDY

Despite the valuable findings obtained, this study has several limitations that should be acknowledged when interpreting the results. First, the sample size was relatively small, consisting of 84 patients, which may limit the generalizability of the findings to broader populations. A larger sample size would provide greater statistical power and allow for more robust subgroup analyses, particularly with respect to age, breast density, and specific pathological subtypes. Second, the study was conducted in a single tertiary care center, which may introduce referral bias, as patients presenting to such centers often have a higher pretest probability of significant pathology compared to those in primary care or screening settings.

Another important limitation is the operator-dependent nature of ultrasound, which may influence diagnostic accuracy. Although examinations were performed by experienced radiologists, variability in image acquisition and interpretation cannot be completely eliminated. Additionally, not all patients underwent both imaging modalities; some were evaluated with ultrasound or mammography alone based on clinical indication, which may have affected direct modality-to-modality comparison. Finally, simple breast cysts were not histopathologically confirmed and were diagnosed based on imaging and follow-up, which, although consistent with standard clinical practice, could introduce minimal classification bias. These limitations highlight the need for multicenter studies with larger cohorts and standardized imaging protocols to further validate the findings.

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CONCLUSION

This study demonstrates that both ultrasound and mammography are highly effective imaging modalities for the evaluation of breast diseases in symptomatic female patients. Ultrasound showed a higher overall detection rate for breast masses, particularly in women with dense breast tissue, making it a valuable first-line imaging tool in younger and premenopausal patients. Mammography, on the other hand, exhibited slightly higher sensitivity for detecting malignant lesions and showed a stronger correlation with histopathological findings. These results confirm the complementary roles of ultrasound and mammography in breast imaging and emphasize that reliance on a single modality may be insufficient for optimal diagnostic accuracy.

The combined use of ultrasound and mammography significantly enhanced diagnostic performance, yielding the highest sensitivity and specificity for malignancy detection. This finding reinforces the importance of a multimodality imaging approach as part of the established triple assessment strategy. Incorporating both imaging techniques allows for improved lesion characterization, more accurate differentiation between benign and malignant masses, and better-informed clinical decision-making. In healthcare settings where breast cancer often presents at advanced stages, early and accurate diagnosis through appropriate imaging is critical for improving patient outcomes. Future studies involving larger, multicenter populations and standardized imaging protocols are recommended to further refine diagnostic strategies and to support evidence-based breast imaging practices.

Conflict of Interest and Funding Disclosure

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