

DIAGNOSTIC ACCURACY OF ULTRASOUND ALONE VERSUS COMBINED ULTRASOUND AND MAMMOGRAPHY IN THE DIAGNOSIS OF BREAST CANCER, TAKING HISTOPATHOLOGY AS GOLD STANDARD

Ifrah Maryam¹, Safa khalil², Umairia Bint-e-Rehan³, Mehreen Nawab⁴, Kashif Siddique⁵
^{1,2,3} MBBS, FCPS Postgraduate Trainee, Department of Radiology, Shaukat Khanum Memorial Cancer Hospital and Research Centre, Lahore, Pakistan.
^{4,5} MBBS, FCPS, FRCR, Department of Radiology, Shaukat Khanum Memorial Cancer Hospital and Research Centre, Lahore, Pakistan
 Correspondence to Ifrah Maryam, iframaryam.56@gmail.com

Received: 15 August, 2026; Revised: 22 August, 2026; Accepted: 9 September, 2026; Available Online: 26 September, 2026

ABSTRACT

Background: Accurate preoperative diagnosis of breast cancer is essential for appropriate management. Ultrasound is widely used for evaluating breast lesions, while mammography may provide additional diagnostic information. Combining both imaging modalities may improve diagnostic performance compared with ultrasound alone.

Objectives: To determine and compare the diagnostic accuracy of ultrasound alone and combined ultrasound and mammography in the diagnosis of breast cancer, using histopathology as the gold standard.

Study design & Setting: A cross-sectional validation study was conducted in the Department of Radiology, Shaukat Khanum Hospital, Lahore from 13 May 2026 to 13 August 2026.

Methodology: A total of 106 patients aged 25–70 years presenting with a breast lump lasting more than one month were included through non-probability consecutive sampling. Bilateral mammography and bilateral breast ultrasonography were performed. Ultrasound alone and combined ultrasound with mammography were independently categorized according to BI-RADS, with categories ≥ 4 considered positive. Histopathology was used as the reference standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy, and receiver operating characteristic (ROC) analysis were performed using SPSS.

Results: Histopathology confirmed breast cancer in 97 (91.5%) patients. Ultrasound alone demonstrated 89.7% sensitivity, 88.9% specificity, 98.9% PPV, 44.4% NPV, and 89.6% diagnostic accuracy. Combined ultrasound and mammography demonstrated higher sensitivity (97.9%), PPV (99.0%), NPV (80.0%), and diagnostic accuracy (97.2%), with specificity of 88.9%. Agreement with histopathology was moderate for ultrasound alone ($\kappa=0.541$) and strong for combined imaging ($\kappa=0.827$). ROC analysis showed AUCs of 0.893 and 0.934, respectively.

Conclusion: Combined ultrasound and mammography demonstrated superior diagnostic performance compared with ultrasound alone and may provide greater accuracy for breast cancer detection.

Keywords: Breast cancer; Diagnostic accuracy; Histopathology; Mammography; Ultrasonography

How to cite this article: Maryam I, Khalil S, Bint-e-Rehan U, Nawab M, Siddique K., Diagnostic Accuracy of Ultrasound Alone Versus Combined Ultrasound and Mammography in the Diagnosis of Breast Cancer, Taking Histopathology as Gold Standard. Int J Drug Deliv Technol. 2026;16(81s): 1205-1211; DOI: 10.25258/ijddt.16.81s.151.

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Breast cancer (BC) ranks second in cancers among females, with an age-adjusted incidence and mortality rate of nearly 25.8 and 12.7 per 100,000 individuals, respectively.¹ Among its patients, the most common complaint is the occurrence of breast lump, which has a relatively high prognostic value for malignancy.² Delayed disease presentation can be due to lack of awareness, illiteracy or financial constraints and results in late

diagnosis. Early screening and diagnosis of BC are vital as it decreases the BC mortality rate and hikes the rate of successful outcomes with comprehensive medical treatment.³

Approximately 10–15% of patients underwent BCT for operable breast cancer develop locoregional recurrence within 10 years.⁴ Thus, cancer detection in this patient group is of paramount importance. The BI-RADS categories are the standard assessment categories for breast masses in mammography, ultrasonography and

*Author for Correspondence: iframaryam.56@gmail.com

magnetic resonance imaging (MRI). Each category corresponds with a certain probability range that the mass will be a malignancy. These categories are applied to patients who have not undergone breast operations as well as post-BCT patients.^{5,6} In a study, the USG diagnosed malignant breast lesion among 46% and benign breast lesion among 54% patients. In this study, the mammography diagnosed malignant breast lesions among 47% patients and benign breast lesions among 53% patients.⁷

Ultrasonography and mammography have complementary roles in the evaluation of breast lesions. Ultrasonography is particularly useful for assessing palpable breast lumps and provides important information regarding lesion morphology, echogenicity, margins, orientation, and architectural distortion.⁸ Mammography offers additional information regarding breast density, masses, microcalcifications, and architectural distortion that may not be adequately demonstrated on ultrasonography.^{9,10} However, both modalities can produce false-positive or false-negative findings when used independently. Combining ultrasonography with mammography may therefore improve the detection and characterization of malignant lesions by integrating their complementary imaging features.¹¹ The BI-RADS classification provides a standardized approach for reporting findings and estimating the likelihood of malignancy. Despite advances in breast imaging, histopathological examination remains the definitive method for confirming malignancy.¹²

The rationale of the study is to compare the diagnostic accuracy of ultrasound versus combined ultrasound and mammography in the diagnosis of breast cancer. Mammography is highly efficient in detecting the type of breast lumps. But the literature above showed that ultrasound is more accurate in detecting breast malignancy as compared to mammography. My study will not only help to reassess their diagnostic accuracies but will also provide the local statistics. My results will provide us the better imaging modality with high diagnostic accuracy and then based on these results, that particular imaging modality can be applied as a first line screening and diagnostic tool for breast cancer which will help the clinicians for selection of proper treatment option and to reduce the number of pure diagnostic biopsies, so that patient's morbidity and mortality can be minimized. The objective was to determine the diagnostic accuracy of ultrasound alone versus combined ultrasound and mammography in the diagnosis of breast cancer, taking histopathology as gold standard.

OPERATIONAL DEFINITIONS

1. Diagnostic Accuracy

Diagnostic accuracy was assessed in terms of sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Sensitivity was the ability of ultrasound alone or combined ultrasound and mammography to correctly detect breast cancer, while specificity was the ability to correctly identify benign lesions. PPV was the probability that positive imaging findings represented breast cancer, whereas NPV was the

probability that negative findings represented benign lesions.

2. Imaging and Histopathological Findings

True positive and true negative findings were defined as malignant and benign imaging findings, respectively, confirmed by histopathology, while false positive and false negative findings were those discordant with histopathology. Breast cancer on ultrasound was considered positive when suspicious features such as hypoechogenicity, irregular or asymmetrical shape, spiculated margins, calcifications, duct extension, non-compressibility, or architectural distortion were present. Combined ultrasound and mammography was considered positive when suspicious features such as a hyperdense mass, irregular shape, spiculated margins, microcalcifications, or architectural distortion were present. Histopathological diagnosis of breast cancer was based on cellular atypia/pleomorphism, mitotic activity, and increased nuclear-to-cytoplasmic ratio. Histopathology was taken as the gold standard.

3. Breast Imaging Reporting and Data System (BI-RADS)

Breast Imaging Reporting and Data System (BI-RADS) was a standardized breast-imaging risk assessment and reporting system developed by the American College of Radiology for mammography, ultrasonography, and MRI.

METHODS

After approval from the Institutional Ethical Review Committee (IRB/26/15), a cross-sectional validation study was conducted in the Department of Radiology, Shaukat Khanum Hospital, Lahore from 13 May 2026 to 13 August 2026. A sample of 106 cases was included using non-probability consecutive sampling. The sample size was calculated at a 95% confidence level with a 12% margin of error, considering a breast cancer prevalence of 54.0%, sensitivity of 69.90%, and specificity of 84.09% for ultrasonography. Patients aged 25–70 years presenting with breast lumps for more than one month were included, while pregnant or lactating women, patients previously diagnosed with breast carcinoma, and those who underwent only FNAC after mammography were excluded. Written informed consent was obtained from all participants. Demographic and clinical information, including age, duration of lump, marital status, residence, BMI, and lesion size, was recorded. Bilateral mammography was performed in mediolateral oblique and craniocaudal views using a digital mammography system, while bilateral handheld breast ultrasonography was performed in transverse and sagittal planes using color Doppler and a high-resolution transducer with a frequency of at least 12 MHz. Ultrasonographic findings alone and combined ultrasound and mammography findings were independently evaluated and classified according to BI-RADS version 5 into categories 0–5. A BI-RADS score ≥ 4 was considered positive, while a score < 4 was considered negative. The imaging findings were compared with histopathological reports taken as the gold standard, and all data were recorded on a structured proforma.

The collected data were analyzed using SPSS version 20.0. The Shapiro–Wilk test was used to assess normality. Continuous variables including age, BMI, duration of lump, and lesion size were expressed as mean $\pm$ SD or median (IQR), while categorical variables were presented as frequencies and percentages. 2 $\times$ 2 contingency tables were used to calculate sensitivity, specificity, PPV, NPV, and diagnostic accuracy of ultrasound alone and combined ultrasound and mammography. ROC curves and likelihood ratios were also calculated. Stratification was performed according to age, duration of lump, BMI, lesion size, and place of residence, followed by post-stratification calculation of diagnostic accuracy. The chi-square test was applied, and a p-value ≤ 0.05 was considered statistically significant.

RESULTS

The mean age of the study participants was 44.03 ± 9.72 years, with most participants aged 41–50 years (39.6%). The mean duration of breast lump was 5.44 ± 5.64 months, mean BMI was 27.99 ± 4.91 kg/m², and mean lump size was 38.00 ± 22.89 mm, as given in Table 1.

Table 1. Demographic and Clinical Characteristics of Study Participants (n=106)

Variable	Mean $\pm$ SD
Age (years)	44.03 $\pm$ 9.72
≤ 40 years	37 (34.9)
41–50 years	42 (39.6)
> 50 years	27 (25.5)
Duration of lump (months)	5.44 $\pm$ 5.64
BMI (kg/m ²)	27.99 $\pm$ 4.91
Size of lump (mm)	38.00 $\pm$ 22.89

Breast cancer was identified in 83.0% of patients on ultrasound, 90.6% on combined ultrasound and mammography, and 91.5% on histopathology. On ultrasound, BI-RADS 4C was the most frequent category (43.4%), whereas BI-RADS 5 was most frequent on combined imaging (48.1%), as given in Table 2.

Table 2. Distribution of Breast Cancer According to Ultrasound, Combined Ultrasound and Mammography, and Histopathology (n=106)

Diagnostic modality	Absent, n (%)	Present, n (%)
Ultrasound alone	18 (17.0)	88 (83.0)
Combined ultrasound + mammography	10 (9.4)	96 (90.6)
Histopathology	9 (8.5)	97 (91.5)
BI-RADS distribution		
BI-RADS category	Ultrasound alone, n (%)	Combined USG + mammography, n (%)
3	3 (2.8)	2 (1.9)
4A	15 (14.2)	8 (7.5)

4B	16 (15.1)	8 (7.5)
4C	46 (43.4)	36 (34.0)
5	26 (24.5)	51 (48.9)
Total	106 (100.0)	106 (100.0)

Compared with histopathology, ultrasound alone correctly identified 87 true-positive and 8 true-negative cases, with 1 false-positive and 10 false-negative cases. It demonstrated 89.7% sensitivity, 88.9% specificity, 98.9% PPV, 44.4% NPV, and 89.6% diagnostic accuracy, with significant agreement with histopathology ($\kappa=0.541$, $p<0.001$), as given in Table 3.

Table 3. Diagnostic Findings of Ultrasound Alone Compared with Histopathology (n=106)

Ultrasound	Histopathology absent	Histopathology present	Total
Cancer absent	8 (TN)	10 (FN)	18
Cancer present	1 (FP)	87 (TP)	88
Total	9	97	106
Diagnostic measure	Result		
True positive (TP)	87		
True negative (TN)	8		
False positive (FP)	1		
False negative (FN)	10		
Sensitivity	89.7%		
Specificity	88.9%		
Positive predictive value	98.9%		
Negative predictive value	44.4%		
Diagnostic accuracy	89.6%		
Pearson χ^2	36.073		
p-value	<0.001		
Kappa agreement	0.541		
Kappa p-value	<0.001		

Combined ultrasound and mammography correctly identified 95 true-positive and 8 true-negative cases, with only 1 false-positive and 2 false-negative cases. The combined approach demonstrated 97.9% sensitivity, 88.9% specificity, 99.0% PPV, 80.0% NPV, and 97.2% diagnostic accuracy, with strong agreement with histopathology ($\kappa=0.827$, $p<0.001$), as given in Table 4.

Table 4. Diagnostic Findings of Combined Ultrasound and Mammography Compared with Histopathology (n=106)

Combined USG + mammograp hy	Histopatholo gy absent	Histopatholo gy present	Tota l
Cancer absent	8 (TN)	2 (FN)	10
Cancer present	1 (FP)	95 (TP)	96
Total	9	97	106
Diagnostic measure	Result		
True positive (TP)	95		
True negative (TN)	8		
False positive (FP)	1		
False negative (FN)	2		
Sensitivity	97.9%		
Specificity	88.9%		
Positive predictive value	99.0%		
Negative predictive value	80.0%		
Diagnostic accuracy	97.2%		
Pearson χ^2	72.671		
p-value	<0.001		
Kappa agreement	0.827		
Kappa p-value	<0.001		

Combined ultrasound and mammography showed higher diagnostic performance than ultrasound alone, particularly for sensitivity (97.9% vs. 89.7%), NPV (80.0% vs. 44.4%), and diagnostic accuracy (97.2% vs. 89.6%), while specificity remained identical at 88.9%, as given in Table 5.

Table 5. Diagnostic Accuracy of Ultrasound Alone and Combined Ultrasound and Mammography

Diagnostic parameter	Ultrasound alone	Combined USG + mammography
Sensitivity	89.7%	97.9%
Specificity	88.9%	88.9%
Positive predictive value	98.9%	99.0%
Negative predictive value	44.4%	80.0%
Diagnostic accuracy	89.6%	97.2%
Kappa agreement	0.541	0.827

Note: Histopathology was considered the gold standard.

ROC analysis demonstrated excellent discriminatory performance for both modalities, with an AUC of 0.893 for ultrasound alone and 0.934 for combined ultrasound and mammography. The combined approach therefore showed a higher AUC, with sensitivity increasing from 89.7% to 97.9%, while specificity remained 88.9%, as given in Table 6.

Table 6. ROC Analysis of Ultrasound Alone and Combined Ultrasound and Mammography

Imaging modality	AUC	Sensitivity	Specificity
Ultrasound alone	0.893	89.7%	88.9%
Combined USG + mammography	0.934	97.9%	88.9%

Age-stratified analysis showed that ultrasound alone had diagnostic accuracy of 86.5%, 95.2%, and 85.2% among patients aged ≤ 40 , 41–50, and > 50 years, respectively. Combined ultrasound and mammography demonstrated higher accuracy, reaching 91.9% in patients ≤ 40 years and 100.0% in both older age groups, as given in Table 7.

Table 7. Stratified Diagnostic Accuracy According to Age

Age grou p	Sensitivi ty (%)	Specifichi ty (%)	PP V (%)	NP V (%)	Accura cy (%)
Ultrasound alone					
≤ 40 years	88.2	66.7	96.8	33.3	86.5
41–50 years	94.6	100.0	100.0	71.4	95.2
> 50 years	84.6	100.0	100.0	20.0	85.2
Overa ll	89.7	88.9	98.9	44.4	89.6
Combined USG + Mammography					
≤ 40 years	94.1	66.7	97.0	50.0	91.9
41–50 years	100.0	100.0	100.0	100.0	100.0
> 50 years	100.0	100.0	100.0	100.0	100.0
Overa ll	97.9	88.9	99.0	80.0	97.2

According to duration of the breast lump, ultrasound alone showed diagnostic accuracy ranging from 86.3% to 91.0%, whereas combined ultrasound and mammography demonstrated higher accuracy ranging from 96.4% to 97.9% across the duration groups, as given in Table 8.

Table 8. Stratified Diagnostic Accuracy According to Duration of Breast Lump

Durati on of lump	Sensitivi ty (%)	Specifichi ty (%)	PP V (%)	NP V (%)	Accu racy (%)
Ultrasound alone					
≤ 3	91.7	85.7	97.	60.	91.0

months			8	0	
4–6 months	90.2	90.0	97.4	60.0	90.2
>6 months	85.7	88.9	98.0	44.4	86.3
Overall	89.7	88.9	98.9	44.4	89.6
Combined USG + Mammography					
≤3 months	97.2	85.7	98.6	75.0	96.4
4–6 months	98.0	90.0	98.0	90.0	97.9
>6 months	97.1	88.9	98.5	80.0	96.9
Overall	97.9	88.9	99.0	80.0	97.2

Across BMI categories, ultrasound alone demonstrated diagnostic accuracy ranging from 86.9% to 91.5%, while combined ultrasound and mammography showed consistently higher accuracy, ranging from 95.7% to 98.0%, as given in Table 9.

Table 9. Stratified Diagnostic Accuracy According to BMI

BMI category	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Ultrasound alone					
<25 kg/m ²	87.5	83.3	97.2	45.5	86.9
25–29.9 kg/m ²	91.7	90.0	98.5	50.0	91.5
≥30 kg/m ²	90.0	90.9	100.0	50.0	90.2
Overall	89.7	88.9	98.9	44.4	89.6
Combined USG + Mammography					
<25 kg/m ²	97.1	83.3	98.5	83.3	95.7
25–29.9 kg/m ²	98.1	90.0	99.0	90.0	97.8
≥30 kg/m ²	98.0	90.9	100.0	90.0	98.0
Overall	97.9	88.9	99.0	80.0	97.2

According to lesion size, ultrasound alone showed diagnostic accuracy of 85.7%–92.6%, while combined ultrasound and mammography demonstrated higher accuracy ranging from 94.7% to 100.0%. The highest diagnostic performance of both approaches was observed among lesions >50 mm, as given in Table 10.

Table 10. Stratified Diagnostic Accuracy According to Lesion Size

Lesion size	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
-------------	-----------------	-----------------	---------	---------	--------------

				(%)	
Ultrasound alone					
≤20 mm	85.7	85.7	96.8	50.0	85.7
21–50 mm	91.5	90.0	98.8	50.0	91.3
>50 mm	92.3	90.0	100.0	60.0	92.6
Overall	89.7	88.9	98.9	44.4	89.6
Combined USG + Mammography					
≤20 mm	96.4	85.7	98.2	75.0	94.7
21–50 mm	98.4	90.0	99.0	90.0	97.8
>50 mm	100.0	90.0	100.0	100.0	100.0
Overall	97.9	88.9	99.0	80.0	97.2

According to place of residence, ultrasound alone demonstrated diagnostic accuracy of 90.6% in urban and 88.2% in rural patients. Combined ultrasound and mammography showed higher accuracy in both groups, at 97.6% and 96.6%, respectively, as given in Table 11.

Table 11. Stratified Diagnostic Accuracy According to Place of Residence

Place of residence	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Ultrasound alone					
Urban	90.5	90.0	99.0	47.4	90.6
Rural	88.6	87.5	98.7	41.2	88.2
Overall	89.7	88.9	98.9	44.4	89.6
Combined USG + Mammography					
Urban	98.0	90.0	99.0	90.0	97.6
Rural	97.7	87.5	99.0	77.8	96.6
Overall	97.9	88.9	99.0	80.0	97.2

DISCUSSION

Breast cancer is one of the most common malignancies among women and early diagnosis is essential for timely treatment and improved outcomes. Imaging plays a central role in the evaluation of breast lumps, with ultrasonography being particularly useful for characterizing breast lesions.¹² Mammography provides additional information regarding lesion morphology, density, calcifications, and architectural distortion. However, either modality alone may have limitations in

accurately distinguishing malignant from benign lesions. Combining ultrasonography with mammography may improve lesion characterization and diagnostic confidence. Histopathological examination remains the definitive reference standard for confirming breast malignancy.¹³ Therefore, comparing ultrasound alone with combined ultrasound and mammography against histopathology is important for evaluating their diagnostic accuracy.

The present study evaluated the diagnostic accuracy of ultrasound (USG) alone and combined USG with mammography, using histopathology as the gold standard. USG alone demonstrated a sensitivity of 89.7%, specificity of 88.9%, PPV of 98.9%, NPV of 44.4%, and diagnostic accuracy of 89.6%. With combined USG and mammography, sensitivity increased to 97.9%, specificity remained 88.9%, PPV was 99.0%, NPV increased to 80.0%, and diagnostic accuracy reached 97.2%. The AUC also increased from 0.893 for USG alone to 0.934 for combined imaging.

Srirambhatla et al. (2016), in 147 women with 155 histopathologically confirmed breast masses, reported mammography sensitivity of 89%, specificity of 80%, and PPV of 69%, while sonomammography showed sensitivity of 95%, specificity of 79%, PPV of 68%, and NPV of 97%. Our USG sensitivity of 89.7% was comparable with their mammographic sensitivity, while our specificity (88.9%) and PPV (98.9%) were higher. The lower NPV in our study may be explained by the high prevalence of malignancy, with 91.5% of participants being histopathologically positive.¹⁴

Gupta et al. (2017) reported sensitivity of 78.05%, specificity of 100%, PPV of 100%, and NPV of 50% for sonomammography. Compared with their findings, our USG showed higher sensitivity (89.7%), slightly lower specificity (88.9%), similar PPV (98.9%), and lower NPV (44.4%). Overall, our findings indicate better sensitivity and comparable diagnostic performance of USG.¹⁵ Yamakanamardi et al. (2021) identified irregular shape and calcifications on mammography and hypoechoic appearance on sonomammography as significant indicators of malignancy. Their combined approach achieved sensitivity of 90.4%, specificity of 82.4%, PPV of 95%, NPV of 67%, and accuracy of 88.9%. In comparison, our combined imaging achieved higher sensitivity (97.9%), specificity (88.9%), PPV (99.0%), NPV (80.0%), and accuracy (97.2%), supporting the added value of combining both modalities.¹⁶

Shabbir et al. (2025) reported mammography sensitivity of 76.2% and specificity of 79.5%, compared with 90.5% and 85.9%, respectively, for USG. Combined imaging increased sensitivity to 95.2%, specificity to 91.0%, and accuracy to 92.5%. Their findings closely support our results, where USG sensitivity was 89.7% and combined imaging increased sensitivity to 97.9% and accuracy to 97.2%. The similar improvement following combination of modalities reinforces the diagnostic advantage of multimodality assessment.¹⁷ Khan et al. (2023), studying women with dense breasts, reported USG sensitivity of 91.67%, specificity of 83.93%, PPV of 89.53%, NPV of

87.04%, and accuracy of 88.57%. Our USG showed comparable sensitivity (89.7%) and slightly higher specificity (88.9%) and accuracy (89.6%). However, our PPV was substantially higher (98.9%), whereas NPV was lower (44.4%), again reflecting differences in disease prevalence and study populations.¹⁸ Alotaibi et al. (2025) reported USG accuracy of 86.3% and highlighted its usefulness in dense breast tissue, whereas mammography performed better for calcifications and architectural distortion ($p < 0.001$). These findings support the complementary roles of the two modalities. In our study, the addition of mammography to USG increased sensitivity from 89.7% to 97.9% and accuracy from 89.6% to 97.2%, indicating that mammography provided additional diagnostic information beyond USG alone.¹⁹

Kalim et al. (2022) reported sensitivity and specificity of 76.3% and 77.7% for mammography and 77.3% and 87.7% for sonoelastography. Their combined approach improved sensitivity to 90.9%, specificity to 86.6%, and accuracy to 89%. Similarly, our combined USG and mammography substantially improved diagnostic performance, achieving sensitivity of 97.9%, specificity of 88.9%, and accuracy of 97.2%. Thus, both studies demonstrate the benefit of complementary imaging modalities.²⁰ Shafiq et al. (2022) reported USG sensitivity of 69.64%, specificity of 84.09%, PPV of 68.52%, NPV of 84.78%, and accuracy of 76%, while mammography showed sensitivity of 60.71%, specificity of 70.45%, PPV of 58.49%, NPV of 72.34%, and accuracy of 65%. Our USG demonstrated higher sensitivity (89.7%), specificity (88.9%), PPV (98.9%), and accuracy (89.6%). However, our NPV was lower (44.4%), most likely because of the much higher prevalence of malignancy in our study population.²¹

Overall, the findings of the present study are consistent with previous evidence showing that USG provides good diagnostic performance, while combining USG with mammography improves cancer detection. The increase in sensitivity from 89.7% to 97.9%, accuracy from 89.6% to 97.2%, NPV from 44.4% to 80.0%, and AUC from 0.893 to 0.934 demonstrates the diagnostic advantage of combined imaging in women presenting with a breast lump.

STUDY LIMITATIONS

This study was conducted at a single tertiary-care center with a relatively small sample size, which may limit the generalizability of the findings. The non-probability consecutive sampling may have introduced selection bias. Operator-dependent interpretation of ultrasound and the high prevalence of malignancy in the study population may have influenced diagnostic performance estimates.

CONCLUSION

Combined ultrasound and mammography demonstrated higher sensitivity, negative predictive value, diagnostic accuracy, and agreement with histopathology than ultrasound alone. The combined approach also showed a higher ROC-AUC than ultrasound alone. These findings

support the complementary use of both imaging modalities in the diagnostic evaluation of suspected breast cancer.

Acknowledgement: We sincerely acknowledge the support and guidance of our mentors, colleagues, and the staff of the participating hospital for their valuable assistance throughout this study.

REFERENCE

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. *CA Cancer J. Clin.* 2021;71:209–49.
2. Wilkinson L, Gathani T. Understanding breast cancer as a global health concern. *Br. J. Radiol.* 2022;95:20211033.
3. He J, Chen W, Li N. China guideline for the screening and early detection of female breast cancer (2021, Beijing). *China Cancer.* 2021;43(4):357–82.
4. Lee JM, Arao RF, Sprague BL, Kerlikowske K, Lehman CD, Smith RA, et al. Performance of screening ultrasonography as an adjunct to screening mammography in women across the spectrum of breast cancer risk. *JAMA Int Med.* 2019;179:658–67.
5. Pathanasethpong P, Nawapun S, Chadbunchachai P, Somintara O, Apivatanasiri C, Boonrod A. The diagnostic accuracy of mammography and ultrasonography for recurrent breast cancer after breast conserving treatment. *Eur J Radiol Open.* 2023;11:100514.
6. Pandia A, Samantaray S, Mohapatara JS, Dash S. A comparative analysis of mammography breast imaging reporting and data system score and fine needle aspiration cytology in the evaluation of palpable breast lump. *Int J Res Med Sci.* 2019;7:2644–9.
7. Shafiq M, Shamshad L, Ahmed N, Saleem S, Shahid R, Mazhar MA, et al. Diagnostic accuracy of mammography versus ultrasound in prediction of malignancy with palpable breast lesion. *Pak J Med Dent.* 2022;11(3): 11-16.
8. Xu Z, Zhong S, Gao Y, Huo J, Xu W, Huang W, Huang X, Zhang C, Zhou J, Dan Q, Li L. Optimizing breast lesions diagnosis and decision-making with a deep learning fusion model integrating ultrasound and mammography: a dual-center retrospective study. *Breast Cancer Research.* 2025 May 14;27(1):80.
9. Singla V, Singh T, Gulati M. Ultrasound Breast and Its Advancements. In *Imaging in Management of Breast Diseases: Volume 1, Overview of Modalities* 2025 Apr 18 (pp. 111-133). Singapore: Springer Nature Singapore.
10. Ibrahim SE, Mohamed WA, Elnokrashy AF. Beyond masses and calcifications: a review of architectural distortion detection for early breast cancer diagnosis. *Benha Journal of Engineering Science and Technology.* 2025 Jul 1;2(1):126-36.
11. Gareeballah A, Rahman JS, Faqihi WA, Ali S, Elbashir M, Haj N, Abdulrhman KM, Ahmed RA, Hazazi A, Ali B. Evaluation of the diagnostic accuracy of mammography and ultrasonography for breast cancer diagnosis using histopathology as the reference standard: a cross-sectional study. *Annals of Medicine and Surgery.* 2025 Nov 18;88(1):159.
12. Muyisa R, Watumwa E, Malembe J, Wahangire J, Kalivanda G, Sita AS, Kamwira S. Barriers to timely diagnosis and management of breast cancer in Africa: implications for improved outcomes. *Health Sciences Review.* 2025 Mar 1;14:100221.
13. Chinedu SN, Ogbodo PN, Effiong ME. Disparities in diagnosis, treatment, and outcomes of early-onset breast cancer: a global perspective. *Critical Reviews in Oncology/Hematology.* 2026 Mar 6:105251.
14. Srirambhatla A, Kumar P, Chinta S. Diagnostic accuracy of mammography and sonomammography in evaluation of symptomatic women. *Sch J App Med Sci.* 2016;4(11D):4157-60.
15. Gupta P, Chatterje S, Sharma V, Singh KK, Gupta D. Efficacy of x-ray mammography, sonomammography and MR mammography for evaluation of breast lesions in women. *Indian J Appl Res.* 2017;7(3):26-30.
16. Yamakanamardi S, Hiremath BV. Accuracy of mammography and sonomammography and its correlation with histopathology in the detection of breast cancer. *Int Surg J.* 2021;8:624-30.
17. Shabbir S, Khatoon A, Shahid A, Shakir FTZ, Khan MN, Dar MF. Enhancing Diagnostic Accuracy in Symptomatic Breast Diseases: The Role of Ultrasound with Mammography. *Ann Pak Inst Med Sci.* 2025; 21(4):649-654.
18. Khan ZG, Saleem M, Bhutta MR, Najeeb M, Fatima U, Yousuf M. Diagnostic Accuracy of Ultrasonography in the Diagnosis of Breast Carcinoma in Mammographically Dense Breasts: Histopathology as the Gold Standard. *J Soc Obstet Gynaecol Pak.* 2023; 13(4):398-402.
19. Alotaibi SA, Gareeballah A, Rahman JS, Faqihi WA, Ali S, Elbashir M, Haj N, Abdulrhman KM, Ahmed RA, Hazazi A, Ali B. Evaluation of the diagnostic accuracy of mammography and ultrasonography for breast cancer diagnosis using histopathology as the reference standard: a cross-sectional study. *Annals of Medicine and Surgery.* 2025 Nov 18;88(1):159.
20. Kalim MS, Ahmed A, Awan WS, Sarfraz S. Diagnostic Accuracy of Combining Sonoelastography with Mammography in Solid Breast Lesions Keeping Histopathology as Gold Standard. *Biomedica.* 2022 Mar 31;38(1):10.

Shafiq M, Shamshad L, Ahmed N, Saleem S, Shahid R, Mazhar MA. Diagnostic accuracy of mammography versus ultrasound in prediction of malignancy with palpable breast lesion. *Pakistan Journal of Medicine and Dentistry.* 2022;11(3):11-6.

