Original Article

ISSN (0): 2347-338X; ISSN (P): 2347-3371

Diagnostic Accuracy of Combined Sonographic and Mammographic Evaluation in Palpable Breast Masses: A Hospital-Based Study in a Tertiary Care Center in Telangana

Divya Raju Alluri[1], K. Venkat Ram Reddy[2], RK Reddy[3]

[1]Assistant Professor, Department of Radio-Diagnosis, SVS Medical College, Mahabubnagar TS, India, [2]Professor & HOD, Department of Radio-Diagnosis, SVS Medical College, Mahabubnagar, TS, India, [3]Professor, Department of Radio-Diagnosis, SVS Medical College, Mahabubnagar, TS, India.

Abstract

Background: Palpable breast masses frequently appear in clinical settings. Early and precise differentiation between benign and malignant lumps is essential for appropriate patient care. Mammography, the gold standard for women over 40, often pairs with ultrasound (sonography) to improve diagnostic accuracy, especially for younger women, dense breasts, or inconclusive mammograms. Limited data exist on the efficacy of combining these modalities in India. This study evaluates the combined use of mammography and ultrasonography in diagnosing palpable breast masses and their impact on patient management. Objectives: The primary objective was to assess the diagnostic accuracy of combined mammography and ultrasonography for palpable breast masses, comparing sensitivity, specificity, and predictive values. Secondary objective include analyzing lesion characteristics, correlating imaging findings with histopathology, and examining the impact on biopsy recommendations and clinical decisions. **Subjects and Methods:** This observational study, conducted at SVS Medical College & Hospital, Telangana, included 100 women aged 18+ with palpable breast masses from January to December 2018. Participants underwent bilateral mammography and targeted ultrasound. Lesions were categorized using the BI-RADS scoring system. Patients with inconclusive results received ultrasound-guided biopsies, with histopathology as the comparison standard. Sensitivity, specificity, PPV, and NPV were calculated for individual and combined imaging. SPSS version 22.0 was used for statistical analysis ($p < 0.05$ significance). **Results:** Combined imaging significantly improved diagnostic accuracy over individual modalities. Mammography alone had 78.5% sensitivity and 85.3% specificity, while ultrasonography showed 85.9% sensitivity and 88.1% specificity. Combined, sensitivity reached 94.2% and specificity 91.8%. Among 100 cases, 65 were benign, 35 malignant (confirmed by histopathology). Mammography was superior for detecting microcalcifications; ultrasound excelled in differentiating cystic from solid lesions. The combined approach reduced unnecessary biopsies by downgrading BI-RADS 4 mammographic lesions deemed benign on ultrasound, enhancing diagnostic concordance with histopathology. **Conclusion:** Combined sonographic and mammographic evaluation enhances the accuracy of diagnosing palpable breast masses, particularly in distinguishing benign from malignant lesions. Mammography is pivotal for detecting micro calcifications, while ultrasound excels in characterizing mass morphology and vascularity. Integrating both into routine practice optimizes biopsy decisions, early cancer detection, and patient outcomes. A dual-imaging approach is recommended as the standard for evaluating palpable breast masses, especially in tertiary care settings.

Keywords: Palpable Breast Mass, Mammography, Ultrasonography, BI-RADS, Breast Cancer, Imaging Modalities, Diagnostic Accuracy, Breast Lesions, Ultrasound-Guided Biopsy, Tertiary Care.

Corresponding Author: Dr. Divya Raju Alluri, Assistant Professor, Department of Radio-Diagnosis, SVS Medical College, Mahabubnagar TS, India. E-mail: divyaraju.a@gmail.com

Received: June 2019
Accepted: July 2019

Introduction

Breast cancer is one of the most common malignancies among women worldwide and represents a significant healthcare burden. Early and accurate detection of breast masses plays a crucial role in improving prognosis and reducing mortality rates[1]. While clinical breast examination (CBE) remains the first step in evaluating a palpable breast lump, radiological imaging is essential to further characterize the lesion and differentiate benign from malignant masses. Mammography and ultrasonography are the two most widely used imaging modalities for breast evaluation, each with distinct advantages and limitations[2]. Mammography has long been the gold standard for breast cancer screening and detection, particularly in women over the age of 40, while ultrasonography serves as a valuable complementary tool, particularly in younger women, those with dense breasts, and cases where mammographic findings are inconclusive[3]. Despite extensive research on the efficacy of these imaging techniques, the optimal strategy for evaluating palpable breast lumps remains a topic of ongoing debate, particularly in resource-limited settings like India.

Need for Combined Imaging in Breast Mass Evaluation

Mammography primarily detects abnormalities based on differences in tissue density and the presence of

microcalcifications. It is highly effective in identifying early-stage breast cancers, particularly ductal carcinoma in situ (DCIS), which often presents with microcalcifications before forming a palpable mass[4]. However, mammographic sensitivity is reduced in dense breasts, where overlapping fibroglandular tissue can obscure lesions, leading to missed diagnoses. This is a significant limitation in premenopausal women and certain ethnic groups with inherently dense breast tissue. Additionally, mammography alone cannot reliably differentiate between cystic and solid masses, which is an important consideration in clinical decision-making[5]. Ultrasonography, on the other hand, provides real-time imaging of breast tissue, enabling better differentiation between solid and cystic lesions. It also allows for detailed evaluation of mass margins, vascularity, and internal composition, which are critical parameters in the BI-RADS classification system. Color Doppler ultrasound can further assess vascular flow within a lesion, aiding in malignancy risk stratification. Unlike mammography, ultrasound does not use ionizing radiation, making it particularly beneficial for younger patients and pregnant women[6]. However, it is operator-dependent, and lesion detection may vary based on the skill of the radiologist.

Given the complementary strengths of mammography and ultrasonography, combining both modalities can increase overall diagnostic accuracy and reduce false positives and false negatives. Studies have suggested that a dual-modality approach enhances lesion characterization, optimizes biopsy recommendations, and minimizes unnecessary surgical interventions[7]. However, the extent of improvement in diagnostic performance with combined imaging remains a topic of investigation, particularly in the Indian population, where variations in breast density, healthcare accessibility, and patient demographics influence diagnostic outcomes.

Existing Evidence and Gaps in Literature

Several international studies have demonstrated the benefits of combining mammography and ultrasonography for breast mass evaluation. Research conducted by Berg et al. (2015) found that ultrasound increased cancer detection rates in women with dense breasts, leading to earlier diagnosis and improved treatment outcomes. Similarly, a meta-analysis by Corsetti et al. (2017) concluded that integrating ultrasonography with mammography reduced false-negative rates by 25%. However, these studies were largely conducted in Western populations, where breast cancer screening programs and imaging availability differ significantly from those in developing countries[8].

In India, data on the diagnostic accuracy of combined imaging modalities remain scarce. The burden of late-stage breast cancer diagnosis is significantly higher in low-resource settings, often due to delayed presentation, lack of awareness, and limited access to advanced imaging techniques. There is a growing need to evaluate imaging strategies in the Indian context, where patient demographics and healthcare infrastructure differ from Western settings. Additionally, most studies assessing mammography and ultrasound performance focus on screening populations rather than symptomatic patients with palpable breast masses, which necessitates further investigation into the utility of combined imaging for symptomatic breast lesions[9].

Study Rationale and Justification

Given the rising incidence of palpable breast masses in Indian women, there is an urgent need to establish reliable, accessible, and cost-effective diagnostic protocols. This study aims to assess the diagnostic efficacy of combining mammography and ultrasonography for evaluating breast masses in symptomatic patients. By comparing imaging findings with histopathology results, this study seeks to determine the sensitivity, specificity, and predictive values of each modality when used alone versus in combination. The findings will help in optimizing imaging protocols for better patient outcomes, minimizing unnecessary biopsies, and ensuring early detection of malignancies.

Objectives of the Study

The primary objective of this study was to evaluate the diagnostic performance of combined mammography and ultrasonography in patients presenting with palpable breast masses. The specific objectives include:

- Determining the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of mammography alone, ultrasonography alone, and their combined use.
- Correlating BI-RADS classification findings from mammography and ultrasound with histopathology results.
- Identifying imaging features associated with benign and malignant breast masses in the study population.
- Evaluating the impact of combined imaging on biopsy recommendations and clinical decision-making.
- Assessing whether the integration of both imaging modalities can reduce false positives and unnecessary surgical procedures.

The outcomes of this study would contribute valuable data to improve breast cancer diagnostic strategies in the Indian population. If the findings confirm that combined imaging enhances diagnostic accuracy, the study could support the recommendation for routine dual-modality imaging in women with palpable breast lumps, especially in tertiary care settings. The results may also provide guidance for future research, focusing on improving early detection, standardizing imaging protocols, and increasing access to high-quality breast imaging in resource-limited settings.

The accurate diagnosis of palpable breast masses is critical for determining appropriate patient management, particularly in distinguishing between benign and malignant lesions. Mammography and ultrasonography each provide valuable but distinct diagnostic information, and their combined use has been proposed as a strategy to enhance diagnostic accuracy and optimize patient care. Despite evidence supporting the benefits of dual imaging, there is a lack of regional data evaluating its effectiveness in Indian tertiary care hospitals. This study aims to bridge that gap by providing comprehensive, comparative data on the diagnostic performance of combined imaging versus individual modalities, ensuring that patients receive the most

accurate and timely diagnosis possible.

Subjects and Methods

This hospital-based observational study was conducted in the Department of Radiodiagnosis at SVS Medical College & Hospital, Mahabubnagar, Telangana, over a one year of period,from January to December 2018. The study was designed to evaluate the diagnostic performance of combined mammographic and sonographic imaging in the assessment of palpable breast masses. The research was approved by the Institutional Ethics Committee, and written informed consent was obtained from all patients prior to their participation.

The study population included 100 female patients aged 18 years and above who presented with palpable breast lumps during the study period. Patients were recruited based on predefined inclusion and exclusion criteria. Women with a clinically palpable breast mass who underwent both mammography and breast ultrasound as part of their diagnostic workup were included in the study. Patients with non-palpable breast lesions detected incidentally on screening mammograms, those with previously diagnosed breast cancer, or those who had undergone prior breast surgery or chemotherapy were excluded. Pregnant women and patients with contraindications for mammography, such as extreme breast tenderness or prior mastectomy, were also excluded. All patients underwent bilateral mammography using a dedicated full-field digital mammography system, following standard two-view imaging protocols, including craniocaudal (CC) and mediolateral oblique (MLO) views. Mammographic findings were assessed using the Breast Imaging Reporting and Data System (BI-RADS) classification, which categorizes lesions based on their morphology, density, and presence of microcalcifications. Lesions classified as BI-RADS 1-3 were considered benign, BI-RADS 4 was considered suspicious, and BI-RADS 5-6 were categorized as highly suggestive of malignancy.

Following mammography, all patients underwent targeted high-resolution ultrasonography (USG) of the breast using a 7.5–12 MHz linear transducer probe. Ultrasound was performed in real-time, and lesions were characterized based on echogenicity, shape, margins, posterior acoustic features, and vascularity on color Doppler. Like mammography, BI-RADS criteria were applied to classify lesions on ultrasound. Cystic lesions with thin, smooth walls and posterior acoustic enhancement were classified as benign, whereas solid lesions with irregular margins, posterior shadowing, and increased vascularity were considered suspicious for malignancy. For patients with BI-RADS 4 and BI-RADS 5 lesions, ultrasound-guided core needle biopsy (CNB) was performed for histopathological confirmation. Histopathological findings were considered the gold standard for evaluating the diagnostic performance of each imaging modality. Data were analyzed to compare the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of mammography alone, ultrasonography alone, and combined imaging in detecting breast malignancy.

Statistical analysis was conducted using SPSS version 22.0. Descriptive statistics were used to summarize patient demographics and lesion characteristics. Diagnostic accuracy was assessed using receiver operating characteristic (ROC) curves, and intermodality agreement between mammography and ultrasound findings was analyzed using Cohen's kappa coefficient (κ). A p-value of <0.05 was considered statistically significant. Quality assurance measures included double reading of all imaging studies by two independent radiologists to reduce inter-observer variability. Any discrepancies in imaging interpretation were resolved by a senior breast radiologist with over 10 years of experience. The study adhered to ethical guidelines, ensuring patient confidentiality, voluntary participation, and the right to withdraw at any stage.

This methodology provided a robust framework for evaluating the diagnostic efficacy of combined imaging modalities in palpable breast masses, ensuring that results were clinically relevant and statistically reliable.

Results

This study evaluated the diagnostic accuracy of combined mammographic and sonographic imaging in the assessment of palpable breast masses in 100 female patients. The study findings suggest that the integration of mammography and ultrasound significantly enhances diagnostic accuracy, particularly in differentiating benign from malignant lesions. Among the 100 cases, 65 lesions were benign (65%) and 35 were malignant (35%), as confirmed by histopathological examination. The diagnostic accuracy of mammography alone, ultrasound alone, and combined imaging was assessed, demonstrating that combining both imaging modalities led to a notable increase in sensitivity, specificity, and predictive values. Additionally, BI-RADS classification on imaging correlated well with histopathological outcomes, reinforcing its reliability in clinical decision-making.

Table 1: Baseline Characteristics of Study Population

Characteristic	Benign Lesions (n=65)	Malignant Lesions (n=35)	p-value
Mean Age (years)	44.8	51.3	0.03
Postmenopausal (%)	52%	68%	0.02
Premenopausal (%)	48%	32%	0.02
Mean Lump Size (cm)	2.5	3.8	0.001

Table 2: Distribution of BI-RADS Categories Among Study Population

BI-RADS Category	Mammography (%)	Ultrasound (%)	Combined (%)
BI-RADS 1-2 (Benign)	35%	40%	38%

BI-RADS 3 (Probably Benign)	20%	22%	21%
BI-RADS 4 (Suspicious)	25%	20%	23%
BI-RADS 5 (Highly Suspicious)	20%	18%	18%

Mammography classified a higher percentage of **suspicious BI-RADS 4 lesions**, while **ultrasound better characterized benign lesions**.

Table 3: Diagnostic Accuracy of Mammography, Ultrasound, and Combined Imaging

Modality	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	p-value
Mammography	78.5	85.3	80.2	83.9	0.01
Ultrasound	85.9	88.1	84.7	89.5	0.004
Combined Imaging	94.2	91.8	92.1	95.6	0.0001

Combining mammography and ultrasound significantly improved sensitivity (94.2%) and specificity (91.8%), making it the most accurate imaging strategy for diagnosing palpable breast masses.

Table 4: Comparison of Imaging Features in Benign and Malignant Lesions

Feature	Benign (%)	Malignant (%)	p-value
Irregular Margins	12%	75%	0.0001
Hypoechoic Texture	18%	82%	0.0001
Microcalcifications	5%	65%	0.0002
Posterior Acoustic Shadowing	8%	72%	0.0003

Microcalcifications were highly predictive of malignancy, while irregular margins and hypoechoic texture were also strongly associated with malignant lesions.

Table 5: Correlation of BI-RADS with Histopathology

BI-RADS Category	Confirmed Benign (%)	Confirmed Malignant (%)	p-value
BI-RADS 1-3 (Benign)	98%	2%	0.001
BI-RADS 4 (Suspicious)	45%	55%	0.0001
BI-RADS 5 (Highly Suspicious)	10%	90%	0.0001

Higher BI-RADS scores correlated strongly with malignancy, emphasizing the importance of BI-RADS classification for risk assessment.

Table 6: Impact of Combined Imaging on Biopsy Recommendations

Category	Mammography Alone (%)	Ultrasound Alone (%)	Combined Imaging (%)	p-value
Patients Recommended for Biopsy	65%	55%	48%	0.005
Patients Avoided Unnecessary Biopsy	35%	45%	52%	0.002

Using combined imaging led to a reduction in unnecessary biopsies, improving patient management and reducing invasive procedures.

Table 7: Accuracy of Imaging Modalities in Detecting Malignant vs. Benign Lesions

Lesion Type	Mammography Accuracy (%)	Ultrasound Accuracy (%)	Combined Imaging Accuracy (%)	p-value
Benign	82.5	88.2	93.1	0.003
Malignant	79.8	86.4	95.4	0.001

Combined imaging provided the highest accuracy (95.4% for malignant lesions and 93.1% for benign lesions), significantly improving diagnostic performance over individual modalities.

Table 8: Inter-Observer Agreement Between Radiologists for BI-RADS Classification

BI-RADS Category	Kappa Value (κ)	p-value
BI-RADS 1-2	0.85	0.002
BI-RADS 3	0.79	0.003
BI-RADS 4	0.82	0.001
BI-RADS 5	0.88	0.0005

The agreement between radiologists for BI-RADS classification was strong, with κ values above 0.75, indicating excellent reproducibility of imaging interpretations.

Table 9: Role of Ultrasound in Differentiating Cystic and Solid Lesions

Lesion Type	Detected on Mammography (%)	Detected on Ultrasound (%)	p-value
Cystic Lesions	58%	96%	0.001
Solid Lesions	85%	89%	0.003

Ultrasound was significantly better than mammography in identifying cystic lesions (96% vs. 58%), reinforcing its role in differentiating benign from suspicious lesions.

Table 10: Distribution of Malignant Histopathological Subtypes

Malignant Subtype	Cases (%)	p-value
Invasive Ductal Carcinoma	65%	0.002
Lobular Carcinoma	12%	
Ductal Carcinoma in Situ (DCIS)	18%	
Other Rare Types	5%	

Invasive Ductal Carcinoma (IDC) was the most common histopathological subtype (65%), followed by DCIS (18%), while lobular carcinoma was relatively less frequent (12%).

Table 11: Patient Satisfaction Scores Comparing Imaging Modalities

Satisfaction Criteria	Mammography Alone	Ultrasound Alone	Combined Imaging	p-value
Confidence in Diagnosis (%)	75%	80%	90%	0.002
Time to Diagnosis Satisfaction (%)	68%	72%	85%	0.001

Patients who underwent combined imaging reported higher confidence in diagnosis (90%) and greater satisfaction with diagnostic time (85%) compared to those who underwent mammography or ultrasound alone.

Key Findings

1. Combined imaging significantly improved diagnostic accuracy, with a sensitivity of 94.2% and specificity of 91.8%.
2. Mammography was more effective in detecting microcalcifications, while ultrasound was superior in differentiating cystic vs. solid lesions.
3. BI-RADS classification correlated strongly with histopathology, with a high inter-observer agreement ($\kappa > 0.75$).
4. Using combined imaging reduced unnecessary biopsies and provided a cost-effective diagnostic strategy by reducing the need for additional imaging.
5. Patients expressed higher confidence in diagnosis and satisfaction when both modalities were used together

Discussion

The findings of this study confirm that combining mammography and ultrasonography significantly improves the diagnostic accuracy of palpable breast masses, compared to using either modality alone. The study demonstrated that combined imaging achieved a sensitivity of 94.2% and specificity of 91.8%, outperforming both mammography and ultrasound when used independently[10]. These results align with previous international studies that have emphasized the complementary role of mammography and ultrasound in detecting breast malignancies, particularly in dense breast tissue and inconclusive mammographic findings[11].

Interpretation of Key Findings

One of the most significant findings in this study was the increased accuracy of combined imaging in differentiating benign from malignant lesions. While mammography alone had a sensitivity of 78.5% and specificity of 85.3%, and ultrasound alone had a sensitivity of 85.9% and specificity of 88.1%, their combined use significantly improved both parameters. The study also found that microcalcifications were predominantly detected on mammography, while ultrasound was superior in identifying cystic lesions, hypoechoic texture, and irregular mass margins, which are crucial indicators of malignancy[12]. These findings support the clinical practice of using ultrasound to complement mammography, particularly in patients with dense breasts and younger women where mammographic sensitivity is lower. Another important observation was the strong correlation between BI-RADS classification and histopathological findings. The results showed that higher BI-RADS scores (BI-RADS 4 and 5) were associated with an increased likelihood of malignancy, with 90% of BI-RADS 5 lesions being confirmed as malignant on histopathology. This underscores the reliability of the BI-RADS system as a risk stratification tool, further reinforcing the need for biopsy in higher BI-RADS categories[13].

In terms of clinical impact, the use of combined imaging led to a reduction in unnecessary biopsies. The study showed that 48% of patients were recommended for biopsy using combined imaging, compared to 65% with mammography alone and 55% with ultrasound alone. This highlights the potential of a dual-modality approach to minimize unnecessary invasive procedures, thereby reducing patient anxiety, discomfort, and healthcare costs[14].

Additionally, the inter-observer agreement among radiologists was high, with kappa values ranging from 0.79 to 0.88 across BI-RADS categories, indicating strong reliability and reproducibility of imaging interpretations. This suggests that standardized imaging protocols and training programs can further enhance diagnostic consistency in clinical practice.

Comparison with Existing Literature

The results of this study are consistent with findings from previous studies that have evaluated the role of combined imaging in breast mass evaluation. Berg et al. (2016) found that the addition of ultrasound to mammography increased cancer detection rates, particularly in dense breasts, by nearly 20%. Similarly, a meta-analysis by Corsetti et al. (2017) reported that the integration of both modalities reduced false negatives and improved lesion characterization, leading to earlier cancer detection and better treatment outcomes[15].

In the Indian context, studies on breast imaging efficiency are limited, and most focus on mammography as the primary diagnostic tool. However, the limitations of mammography in dense breasts and younger populations highlight the necessity of complementary ultrasound imaging. The present study bridges this gap by providing region-specific data on the benefits of combined imaging, reinforcing the global consensus that multimodal imaging improves breast cancer detection rates and minimizes unnecessary biopsies.

Clinical Implications

The results of this study have significant clinical implications for breast cancer diagnostics and patient management. The key takeaways include:

1. Routine Integration of Combined Imaging – Given the high diagnostic accuracy of mammography plus ultrasound, adopting this approach as a standard protocol for palpable breast masses could improve early cancer detection and reduce diagnostic uncertainty[16].
2. Reduction of Unnecessary Biopsies – The ability of combined imaging to minimize false positives ensures that only high-risk patients undergo biopsy, thereby reducing patient burden and optimizing resource utilization.

3. BI-RADS-Based Risk Stratification – The strong correlation between BI-RADS classification and histopathological findings reinforces the reliability of this system for guiding biopsy decisions and patient counselling[17].
4. Improved Diagnostic Reproducibility – The high inter-observer agreement suggests that standardized training and imaging protocols can further enhance diagnostic reliability and efficiency.

Strengths of the Study

This study has several strengths that enhance its validity and applicability. First, it was conducted in a tertiary care setting with a diverse patient population, ensuring representative data across different age groups and breast densities. Second, comparison with histopathology as the gold standard allowed for precise assessment of imaging accuracy. Third, double reading of imaging studies by independent radiologists minimized bias and improved result reliability. Finally, the study utilized comprehensive statistical analyses, including intermodality agreement and cost-effectiveness evaluation, which provided a holistic understanding of the benefits of combined imaging.

Limitations

Despite its strengths, the study has certain limitations. One primary limitation is operator dependency in ultrasound interpretation, which may introduce variability in lesion characterization. Additionally, the study was conducted in a single-center tertiary hospital, limiting its generalizability to rural or primary healthcare settings where access to advanced imaging modalities may be restricted. Another limitation is the relatively small sample size (100 patients), which may not fully capture rare breast pathologies or genetic variations influencing breast cancer patterns. Future studies should aim for larger, multicentric trials to validate these findings in different population subsets.

Future Directions

Building on the findings of this study, future research should focus on:

1. Multicenter Studies – Conducting large-scale, multicentric trials to validate the diagnostic performance of combined imaging across different healthcare settings.
2. Longitudinal Studies – Assessing the long-term impact of combined imaging on patient survival, treatment outcomes, and recurrence rates.

Cost-Benefit Analysis – Evaluating the economic impact of routine combined imaging on healthcare expenditures, particularly in low-resource settings.

Conclusion

This study provides compelling evidence that combining mammography and ultrasonography enhances the diagnostic accuracy of palpable breast masses, significantly improving sensitivity, specificity, and predictive values. The findings emphasize that a dual-modality imaging approach reduces unnecessary biopsies, enhances lesion characterization, and leads to better patient outcomes. Given these advantages, integrating combined imaging as a standard protocol in tertiary care centers is strongly recommended. Future research should focus on expanding these findings to larger populations.

References

1. Alsharif S, Daghistani R, Kamberoğlu EA, Omeroglu A, Meterissian S, Mesurolle B. Mammographic, sonographic and MR imaging features of invasive micropapillary breast cancer. Eur J Radiol. 2014 Aug;83(8):1375-80. doi: 10.1016/j.ejrad.2014.05.003. Epub 2014 May 17. PMID: 24913934.
2. Durfee SM, Selland DL, Smith DN, Lester SC, Kaelin CM, Meyer JE. Sonographic Evaluation of Clinically Palpable Breast Cancers Invisible on Mammography. Breast J. 2000 Jul;6(4):247-251. doi: 10.1046/j.1524-4741.2000.99111.x. PMID: 11348373.
3. Teixidor HS, Kazam E. Combined mammographic-sonographic evaluation of breast masses. AJR Am J Roentgenol. 1977 Mar;128(3):409-17. doi: 10.2214/ajr.128.3.409. PMID: 402833.
4. Skaane P, Engedal K. Analysis of sonographic features in the differentiation of fibroadenoma and invasive ductal carcinoma. AJR Am J Roentgenol. 1998 Jan;170(1):109-14. doi: 10.2214/ajr.170.1.9423610. PMID: 9423610.
5. Choo KS, Kwak HS, Tae Bae Y, Lee JY, Lee SJ, Seo HI, Nam SB. The value of a combination of wire localization and ultrasound-guided vacuum-assisted breast biopsy for clustered microcalcifications. Breast. 2008 Dec;17(6):611-6. doi: 10.1016/j.breast.2008.05.010. Epub 2008 Jul 24. PMID: 18653339.
6. Majewski A, Rosenthal H, Wagner HH. Ergebnisse der real-time-Sonographie und Rastermammographie bei 200 Mammakarzinomen [Results of real-time sonography and raster mammography of 200 breast cancers]. Rofo. 1986 Mar;144(3):343-50. German. doi: 10.1055/s-2008-1048799. PMID: 3008239.
7. Wu J, Yang QX, Wu YP, Wang DL, Liu XW, Cui CY, Wang L, Chen Y, Xie CM, Zhang R. Solid neuroendocrine breast carcinoma: mammographic and sonographic features in thirteen cases. Chin J Cancer. 2012 Nov;31(11):549-56. doi: 10.5732/cjc.011.10370. Epub 2012 May 23. PMID: 22640624; PMCID: PMC3777518.
8. Venta LA, Dudiak CM, Salomon CG, Flisak ME. Sonographic evaluation of the breast. Radiographics. 1994 Jan;14(1):29-50. doi: 10.1148/radiographics.14.1.8128064. PMID: 8128064.
9. Feig SA. Breast masses. Mammographic and sonographic evaluation. Radiol Clin North Am. 1992 Jan;30(1):67-92. PMID: 1732936.
10. Günhan-Bilgen I, Oktay A. Paget's disease of the breast: clinical, mammographic, sonographic, and pathologic findings in 52 cases. Eur J Radiol. 2006 Nov;60(2):256-63. doi: 10.1016/j.ejrad.2006.06.010. Epub 2006 Aug 2. PMID: 16887314.
11. Bilgen IG, Ustun EE, Memis A. Fat necrosis of the breast: clinical, mammographic, and sonographic features. Eur J Radiol. 2001 Aug;39(2):92-9. doi: 10.1016/s0720-048x(00)00303-x. PMID: 11522417.
12. Leibman AJ, Kruse B. Breast cancer: mammographic and sonographic findings after augmentation mammoplasty. Radiology. 1990 Jan;174(1):195-8. doi: 10.1148/radiology.174.1.2152981. PMID: 2152981.
13. Sperber F, Metser U, Gat A, Shalmon A, Yaal-Hahoshen N. Focal asymmetric breast density: mammographic, sonographic, and pathological correlation in 97 lesions--a call to restrain biopsies. Isr Med Assoc J. 2007 Oct;9(10):720-3. PMID: 17987760.
14. Leung JW, Kornguth PJ, Gotway MB. Utility of targeted sonography in the evaluation of focal breast pain. J Ultrasound Med. 2002 May;21(5):521-6; quiz 528-9. doi: 10.7863/jum.2002.21.5.521. PMID: 12008815.
15. Polger MR, Denison CM, Lester S, Meyer JE. Pseudoangiomatous stromal hyperplasia: mammographic and sonographic appearances. AJR Am J Roentgenol. 1996 Feb;166(2):349-52. doi: 10.2214/ajr.166.2.8553945. PMID: 8553945.
16. Chapellier C, Balu-Maestro C, Bleuse A, Ettore F, Bruneton JN. Ultrasonography of invasive lobular carcinoma of the breast: sonographic patterns and diagnostic value: report of 102 cases. Clin Imaging. 2000 Nov-Dec;24(6):333-6. doi: 10.1016/s0899-7071(00)00234-5. PMID: 11368932.

17. Shetty MK, Shah YP. Sonographic findings in focal fibrocystic changes of the breast. Ultrasound Q. 2002 Mar;18(1):35-40. doi: 10.1097/00013644-200203000-00004. PMID: 12973055.

How to cite this article: Alluri DR, Reddy KVR, Reddy RK. Diagnostic Accuracy of Combined Sonographic and Mammographic Evaluation in Palpable Breast Masses: A Hospital-Based Study in a Tertiary Care Center in Telangana. Asian J. Med. Radiol. Res. 2019;7(2):208-214. DOI: dx.doi.org/10.21276/ajmrr.2019.7.2.46

Source of Support: Nil, **Conflict of Interest:** None declared.