Original Article
Running Title: Multi-Modality Imaging of Papillary Lesions
Received: March 4, 2025; Accepted: December 7, 2025

Differentiating Benign from Malignant Papillary Breast Lesions: Insights from a Multi-Modality Imaging Approach

Syarifah Muna-Izzati Sayed Abul Khair[*], MD, Teoh Kean Hooi[**], MD, Farhana Fadzil[*], MD, Ouzreiah Nawawi[*], MD, Norlisah Mohd Ramli[*], MD, Faizatul Izza Rozalli[*], MD, See Mee Hoong[***], MD, Marlina Tanty Ramli Hamid[****♦], MD, Kartini Rahmat[*], MD

[*]*Department of Biomedical Imaging, University Malaya Research Imaging Centre, Kuala Lumpur, Malaysia*
[**]*Department of Pathology, University Malaya Medical Centre, Kuala Lumpur, Malaysia*
[***]*Department of Surgery, University Malaya Medical Centre, Kuala Lumpur, Malaysia*
[****]*Department of Radiology, Faculty of Medicine University Teknologi MARA, Selangor, Malaysia*

♦Corresponding Author
Marlina Tanty Ramli Hamid, MD
Department of Radiology,
Faculty of Medicine University Teknologi MARA,
Selangor, Malaysia
Email: marlina352@uitm.edu.my

Abstract

Background: Papillary breast lesions are a heterogeneous group of breast lesions with overlapping benign and malignant imaging features, often posing diagnostic and management challenges. The present study aimed to evaluate the imaging characteristics of papillary breast lesions using ultrasound (US), mammography, and magnetic resonance imaging (MRI), and to correlate these findings with histopathological results to identify features predictive of malignancy.

Method: In this retrospective observational study, we reviewed clinical, imaging, and pathological data from 168 women with 188 histologically confirmed papillary breast lesions treated at a tertiary center from 2009 to 2019. Imaging features were assessed using the American College of Radiology Breast Imaging Reporting and Data System (ACR BI-RADS) lexicon. Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY). Mann–Whitney U test and Pearson chi-squared test were used to investigate group differences, and binary logistic regression was applied to evaluate associations. A P <0.05 was considered statistically significant.

Results: Malignant lesions were significantly larger in size (median >10 mm, $P < 0.001$), and more likely to exhibit non-circumscribed margins, internal vascularity, posterior acoustic features, and non-parallel orientation on US. Mammographic features significantly associated with malignancy included irregular shape and non-circumscribed margins ($P < 0.05$). MRI features predictive of malignancy included irregular shape, non-circumscribed margins, heterogeneous enhancement, and non-mass enhancement, although the small MRI sample size limits the generalizability of the study results.

Conclusion: Specific imaging features on US, mammography, and MRI may help distinguish malignant from benign papillary breast lesions. Given the notable upgrade rate upon excision, surgical removal is recommended for lesions with atypical or indeterminate features.

Keywords: Breast neoplasms, Biopsy, Diagnostic imaging, Magnetic resonance imaging, Mammography

Introduction

Papillary lesions of the breast represent an uncommon and heterogeneous group of epithelial proliferations, ranging from benign intraductal papillomas without atypia to malignant forms, such as invasive papillary carcinoma. These lesions pose diagnostic challenges due to their diverse clinical presentations and overlapping radiological and histopathological features.[1-3]

Clinically, patients may present with abnormal nipple discharge or palpable masses, while many remain asymptomatic.[1,4] The World Health Organization (WHO) classification highlights the wide histological spectrum of papillary lesions, encompassing benign, atypical, and malignant subtypes.[5]

Historically, the assessment of papillary lesions has relied on conventional imaging modalities such as ultrasound (US) and mammography.[6-8] However, the advent of magnetic resonance imaging (MRI) has enhanced the detection and characterization of these lesions, particularly in complex or multifocal presentations.[9-11]

Despite advances in imaging technology, accurately distinguishing benign from malignant papillary lesions remains difficult. Prior studies have reported variable sensitivities and specificities across modalities, and no single imaging feature is consistently diagnostic.[1,8,12,13] This diagnostic uncertainty complicates clinical decision-making, especially regarding the need for surgical excision.

Therefore, the present study aimed to analyse and compare the imaging characteristics of benign and malignant papillary breast lesions using US, mammography, and MRI, and to correlate these findings with histopathological results. Our goal is to identify reliable imaging predictors of malignancy and to provide radiological insights that support more informed management strategies.

Methodology

This retrospective observational study was conducted at the Department of Biomedical Imaging, University Malaya Medical Centre (UMMC), Malaysia.

Ethical approval and consent to participate

Ethical approval was obtained from the Medical Research Ethics Committee of UMMC in 2018 (MECID No: 20171025-5705). Due to the retrospective nature of the study, the requirement for informed consent was waived.

We reviewed records from January 2009 to December 2019, identifying 168 women who underwent breast imaging and were diagnosed with 188 histologically confirmed papillary breast lesions. The patients were selected from routine breast screening and diagnostic follow-ups. Data collected included age, presenting symptoms, histopathology results, and imaging findings from US, mammography, and MRI.

Inclusion and exclusion criteria

The inclusion criteria were: complete clinical, radiological, and histopathological records confirming papillary breast lesions. The exclusion criteria were: (i) co-existing invasive breast cancers of other subtypes, (ii) inadequate clinical follow-up at UMMC, (iii) incomplete imaging datasets, or (iv) prior breast surgery or reconstruction affecting imaging interpretation.

Imaging protocols

US

Examinations were performed using a Philips IU22 US system (Philips Healthcare, Bothell, WA, USA) equipped with a 12.5 MHz linear transducer. Sonographic features were retrospectively analyzed using the American College of Radiology Breast Imaging Reporting and Data System (ACR BI-RADS) lexicon.

Mammography

Full-field digital mammography was

conducted using the Selenia Dimensions system (Hologic Inc., Bedford, MA, USA). Standard craniocaudal (CC) and mediolateral oblique (MLO) views were acquired, supplemented by digital breast tomosynthesis when necessary. Features were assessed using the ACR BI-RADS descriptors.

MRI

MRI was performed using 3.0 Tesla scanners (Signa HDx, GE Healthcare, and MAGNETOM Prisma, Siemens Healthcare) with dedicated eight-channel breast coils. A standardized contrast-enhanced protocol was used with intravenous gadolinium-based contrast agents. Sequences included T1-weighted, T2-weighted, short tau inversion recovery (STIR), and dynamic contrast-enhanced (DCE) imaging.

Biopsy procedures

Core needle biopsies were performed with 14-gauge needles using the Bard Magnum biopsy system. Lesion targeting was based on mammographic or US visibility. Vacuum-assisted biopsy was conducted using either Mammotome or EnCore Enspire systems, guided by appropriate imaging modalities.

Data collection and analysis

Demographic and clinical data were extracted from the hospital information system (i-Pesakit), and imaging data were retrieved from the Picture Archiving and Communication System (PACS, GE Centricity RIS-I Version 5.0). All imaging features were reviewed retrospectively and anonymized prior to analysis.

Statistical analysis

Statistical analysis was conducted using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics summarized patient characteristics. The Mann–Whitney U test was used for non-parametric continuous variables, and Pearson's chi-squared test was used for categorical comparisons. Binary logistic regression was performed to assess predictors of malignancy. A *P*-value <0.05 was considered statistically significant.

Results

Demographic data

A total of 168 women with 188 histologically confirmed papillary breast lesions were included. Detailed demographic data are presented in Table 1. The patients' age ranged from 25 to 87 years, with a mean age of 54 years. A bimodal age distribution was observed, with the majority of patients (36.7%, n = 69) in the 41–50 year age group. The patients with malignant lesions were significantly older (mean age: 59.8 ± 12.3 years) than those with benign lesions (mean age: 51.6 ± 12.1 years).

Ethnically, the majority of the patients were Chinese (41.7% benign, 62.3% malignant), followed by Malay (35.4% benign, 27.9% malignant) and Indian (20.5% benign, 8.2% malignant). Other ethnic groups made up the remainder.

Most patients presented with symptoms (73.2% benign, 80.3% malignant), the most common being a palpable breast lump (37.0% benign, 57.4% malignant). A notable proportion were asymptomatic at presentation (26.0% benign, 19.7% malignant). Nipple discharge was reported in 23.6% of benign and 18.0% of malignant cases. The difference in clinical presentation between benign and malignant lesions was not statistically significant (*P* = 0.086).

General lesion characteristics

Lesion characteristics are summarized in Table 2. Lesions were more frequently located in the left breast (47.2% benign, 54.1% malignant). Central location was more common for benign lesions (55.1%), whereas peripheral location predominated in malignant lesions (55.7%). However, differences in lesion laterality and location were not statistically significant.

US findings

US characteristics are detailed in Table 3. Most lesions appeared as masses (90.6% benign, 95.1% malignant). Malignant

lesions had significantly larger median sizes (1.7 cm vs. 1.0 cm, $P < 0.001$), and were more likely to exhibit non-circumscribed margins, internal vascularity, non-parallel orientation, and posterior acoustic features (Figure 1).

Binary logistic regression analysis identified lesion size and posterior features as independent predictors of malignancy, with a negative predictive value (NPV) of 96.5%, positive predictive value (PPV) of 75.9%, sensitivity of 91.7%, specificity of 88.8%, and overall diagnostic accuracy of 89.6%.

Mammographic findings

Mammographic features are summarized in Table 4. Malignant lesions were more frequently visualized as masses with irregular shapes and non-circumscribed margins ($P < 0.05$). They also tended to be of high density and associated with architectural distortion and microcalcifications (Figure 2).

According to the results of logistic regression, lesion shape and density were significant predictors of malignancy on mammography, yielding an NPV of 80.6%, PPV of 83.3%, sensitivity of 78.1%, specificity of 85.3%, and overall accuracy of 81.8%.

MRI findings

MRI was performed in 37 patients: 21 with benign lesions and 16 with malignant lesions (Table 5). Malignant lesions commonly demonstrated irregular shape, non-circumscribed margins, heterogeneous enhancement, and associated non-mass enhancement (NME) (Figure 3). High PPVs were observed for irregular or spiculated margins, heterogeneous enhancement, and NME. However, due to the limited sample size, these findings should be interpreted with caution.

Histopathological analysis from core needle biopsy (CNB)

CNB identified 143 benign and 45 malignant lesions (Table 6). Among the benign group, 69.7% were classified as intraductal papillomas without atypia. Other benign findings included flat epithelial atypia (FEA), lobular carcinoma in situ, and atypical ductal hyperplasia (ADH).

Surgical interventions

Surgical procedures are summarized in Table 7. Hook-wire localization was the most common technique for lesion excision (41.7% of benign cases). The choice of surgical intervention was based on lesion characteristics and radiologic-pathologic correlation.

Final histopathological examination (HPE) from surgical excision

Final surgical histopathology classified 67.6% of lesions as benign and 32.4% as malignant (Table 6). Most benign lesions remained intraductal papillomas without atypia. Malignant diagnoses included ductal carcinoma in situ, invasive papillary carcinoma, and encapsulated papillary carcinoma.

Upgrade rate following surgical excision

The overall upgrade rate from benign diagnosis on CNB to malignancy on final HPE was 10.7% (Table 8). Among the CNB-diagnosed benign lesions, 9.9% were found to be malignant upon excision. A detailed comparison of CNB and final surgical diagnoses in upgraded lesions is shown in Table 9.

Discussion

Our study highlights the role of multi-modality imaging in distinguishing benign from malignant papillary breast lesions and demonstrates a substantial rate of upgrade upon surgical excision in lesions initially diagnosed as benign on CNB. Overall, we found that malignant lesions were associated with older patient age, larger lesion size, and distinct imaging features across US, mammography, and MRI.

Consistent with previous literature, increasing age was a significant predictor of malignancy in papillary lesions.[2,8,14] While nipple discharge has been commonly reported as a hallmark symptom in malignant cases, our cohort revealed breast lumps to be the most frequent presenting complaint, particularly in malignant

lesions, emphasizing the variability in clinical presentation.[6,8]

Histopathological evaluation remains the gold standard for diagnosis; however, interpretation of papillary lesions from limited tissue samples, such as CNB, presents inherent challenges. [3,5,15] A key histological feature distinguishing benign from malignant papillary lesions is the presence or absence of a continuous myoepithelial cell layer, which often requires careful immunohistochemical assessment.[8,16] In our study, a subset of CNB specimens did not undergo surgical excision. While some of these were cases with radiologic-pathologic concordance and benign imaging features, others represented discordant or atypical cases. This discrepancy underscores the importance of multidisciplinary review and cautious interpretation of CNB results, especially in lesions lacking definitive benign features.

US demonstrated the highest sensitivity in identifying features associated with malignancy. Notably, lesion size, non-circumscribed margins, internal vascularity, non-parallel orientation, and posterior acoustic features were strongly associated with malignancy—findings corroborated by previous studies.[10,17] Mammography, though less sensitive, provided valuable complementary information, particularly regarding lesion shape, margin characteristics, and associated calcifications.[8,18]

MRI contributed additional diagnostic insights, especially in ambiguous or complex cases. Malignant lesions commonly exhibited irregular or spiculated margins, heterogeneous enhancement, and NME—parameters associated with high PPV.[11,12,13,18] Nevertheless, the small sample size for MRI in our study limits statistical power, and interpretation of MRI findings should be made cautiously, ideally in conjunction with other modalities.

A clinically important finding was the malignant upgrade rate of 10.7% in lesions initially diagnosed as benign on CNB. This finding aligns with other reports advocating surgical excision in cases with atypia, imaging-pathology discordance, or radiological suspicion despite benign biopsy results.[14,15,19,20] Radiologists should maintain a high index of suspicion for lesions exhibiting such features and advocate for surgical management where appropriate.

Our findings reinforce the importance of a multimodal approach combining clinical examination, imaging features, and histological correlation to guide management of papillary breast lesions. Future studies should incorporate advanced imaging biomarkers, including radiomics and diffusion-weighted imaging, to improve diagnostic accuracy. Additionally, cross-institutional collaborations and multicentric trials are essential for validating these findings across broader populations and enhancing the generalizability of imaging criteria.

The present study has certain limitations. The retrospective single-center design of the studymay limit external validity. Data loss during institutional PACS migration also restricted access to some imaging records. Moreover, the small number of cases with MRI limited the ability to establish robust MRI-based criteria. Despite these limitations, our findings offer significant insights into the radiologic evaluation and clinical management of papillary breast lesions.

Conclusion

The present study identifies critical imaging features that aid in differentiating benign from malignant papillary breast lesions. US demonstrated high sensitivity and diagnostic accuracy, with lesion size, posterior acoustic features, and vascularity serving as reliable indicators of malignancy. Mammography and MRI contributed complementary findings, particularly in complex or ambiguous cases. A noteworthy proportion of lesions initially classified as benign on CNB were found to be malignant upon surgical

excision, emphasizing the need for caution in conservative management. Surgical excision should be considered in lesions with atypical features or radiology-pathology discordance. Continued research, particularly incorporating advanced imaging techniques and larger MRI cohorts, is essential to refine diagnostic strategies and improve patient outcomes.

Human and Animal Rights

All procedures were performed in accordance with the ethical standards of the institutional research committee and the 1964 Declaration of Helsinki and its later amendments.

Availability of Data and Materials

The datasets generated or analysed during the present study are available from the corresponding author upon reasonable request.

Acknowledgements

The authors thank the radiology and pathology departments at University Malaya Medical Centre for their support and contributions.

Authors' Contribution

S.M.I.S.A.K. and M.T.R.H. contributed substantially to data acquisition, imaging analysis, and the initial drafting of the manuscript. T.K.H. provided expert pathological input, participated in data interpretation, and critically revised the manuscript for important intellectual content. F.F., O.N., N.M.R., and F.I.R. were involved in imaging analysis, data interpretation, and contributed to critical manuscript revisions. S.M.H. provided clinical and surgical insights, particularly in correlating radiological findings with surgical outcomes. K.R. conceptualized and designed the study, supervised the project, critically reviewed the manuscript, and approved the final version for submission.

All authors have read and approved the final manuscript and agreed to be accountable for all aspects of the work.

Funding

The authors received no financial support for the research, authorship, or publication of this article.

Conflict of Interest

None declared.

References

1. Nuñez DL, González FC, Ibargüengoitia MC, Fuentes Corona RE, Hernández Villegas AC, Zubiate ML, et al. Papillary lesions of the breast: a review. *Breast Cancer Manag.* 2020;9(8):BCM45. doi:10.2217/bmt-2020-0028.
2. Kulka J, Madaras L, Floris G, Lax SF. Papillary lesions of the breast. *Virchows Arch.* 2022;480(1):65-84. doi: 10.1007/s00428-021-03182-7. PMID: 34734332; PMCID: PMC8983543.
3. Rakha EA, Ellis IO. Diagnostic challenges in papillary lesions of the breast. *Pathology.* 2018;50(1):100-10. doi: 10.1016/j.pathol.2017.10.005. PMID: 29179906.
4. Jo Y, Kim SH, Kang BJ, Choi BG. MR findings of papillary neoplasms of the breast. *J Korean Soc Magn Reson Med.* 2014;18(1):43-51. doi:10.13104/jksmrm.2014.18.1.43.
5. Wei S. Papillary lesions of the breast: an update. *Arch Pathol Lab Med.* 2016;140(7):628-43. doi:10.5858/arpa.2015-0092-RA. PMID:27362568.
6. Li X, Wang H, Sun Z, Fan C, Jin F, Mao X. A retrospective observational study of intraductal breast papilloma and its coexisting lesions: a real-world experience. *Cancer Med.* 2020;9(20):7751-62.
7. Sinn HP, Kreipe H. A brief overview of the WHO classification of breast tumors, 4th edition, focusing on issues and updates from the 3rd edition. *Breast Care (Basel).* 2013;8(2):149-54.

doi:10.1159/000350774. PMID:24415964; PMCID:PMC3683948.
8. Oh J, Park JY. Clinicopathological and imaging features of breast papillary lesions and their association with pathologic nipple discharge. *Diagnostics (Basel).* 2023;13(5):878. doi: 10.3390/diagnostics13050878. PMID: 36900021; PMCID: PMC10000596.
9. Kurtoğlu Özçağlayan Tİ, Öznur M. Digital mammography, ultrasound and magnetic resonance imaging characteristics in differential diagnosis of papillary carcinoma subtypes of the breast and diagnostic challenges. *Eur J Breast Health.* 2022;18(2):172-81. doi: 10.4274/ejbh.galenos.2022.2021-9-4. PMID: 35445176; PMCID: PMC8987858.
10. Fadzli F, Rahmat K, Ramli MT, Rozalli FI, Hooi TK, Fadzli AN, et al. Spectrum of imaging findings of papillary breast disease: A radiopathological review in a tertiary center. *Medicine (Baltimore).* 2021;100(16):e25297. doi: 10.1097/MD.0000000000025297. PMID: 33879660; PMCID: PMC8078345.
11. Zhou J, Li M, Liu D, Sheng F, Cai J. Differential diagnosis of benign and malignant breast papillary neoplasms on MRI with non-mass enhancement. *Acad Radiol.* 2023;30 Suppl 2:S127-S132. doi: 10.1016/j.acra.2023.02.010. PMID: 36906443.
12. Wang LJ, Wu P, Li XX, Luo R, Wang DB, Guan WB. Magnetic resonance imaging features for differentiating breast papilloma with high-risk or malignant lesions from benign papilloma: a retrospective study on 158 patients. *World J Surg Oncol.* 2018;16(1):234. doi: 10.1186/s12957-018-1537-9. PMID: 30558621; PMCID: PMC6298003.
13. Hao N, Yuan X, Wang Q, Zhu J, Zheng Y, Zhang Y, et al. The role of magnetic resonance imaging in detection and surgical treatment of breast intraductal papillomas. *Transl Cancer Res.* 2019;8(2):635-46. doi: 10.21037/tcr.2019.03.27. PMID: 35116796; PMCID: PMC8798582.
14. Rizzo M, Linebarger J, Lowe MC, Pan L, Gabram SG, Vasquez L, et al. Management of papillary breast lesions diagnosed on core-needle biopsy: clinical pathologic and radiologic analysis of 276 cases with surgical follow-up. *J Am Coll Surg.* 2012;214(3):280-7. doi: 10.1016/j.jamcollsurg.2011.12.005. PMID: 22244207.
15. Qiu L, Mais DD, Nicolas M, Nanyes J, Kist K, Nazarullah A. Diagnosis of papillary breast lesions on core needle biopsy: Upgrade rates and interobserver variability. *Int J Surg Pathol.* 2019;27(7):736-43. doi: 10.1177/1066896919854543. PMID: 31187678.
16. Pathmanathan N, Albertini AF, Provan PJ, Milliken JS, Salisbury EL, Bilous AM, et al. Diagnostic evaluation of papillary lesions of the breast on core biopsy. *Mod Pathol.* 2010;23(7):1021-8. doi:10.1038/modpathol.2010.81. PMID:20473278.
17. Gao L, Lai X, Zhang J, Jiang Y, Li J. Sonographic prediction of intraductal papillary carcinoma with partially cystic breast lesions. *BMC Med Imaging.* 2023;23(1):3. doi: 10.1186/s12880-022-00934-y. PMID: 36609236; PMCID: PMC9817258.
18. Catanzariti F, Avendano D, Cicero G, Garza-Montemayor M, Sofia C, Venanzi Rullo E, et al. High-risk lesions of the breast: concurrent diagnostic tools and management recommendations. *Insights Imaging.* 2021;12(1):63. doi: 10.1186/s13244-021-01005-6. PMID: 34037876; PMCID: PMC8155169.
19. Han SH, Kim M, Chung YR, Yun B, Jang M, Kim SM, et al. Benign intraductal papilloma without atypia on core needle biopsy has a low rate of upgrading to malignancy after excision. *J Breast Cancer.* 2018;21(1):80-6. doi: 10.4048/jbc.2018.21.1.80. PMID: 29628987; PMCID: PMC5880969.
20. Ünal Özdemir Z. Rates of upgrade to malignancy in surgical excision of intraductal papillomas: a retrospective

cohort study. *J Surg Med.* 2023;7(10):690-3.

Table 1. Demographic characteristics of patients with papillary breast lesions (n = 188) (Groups are defined by final histopathological diagnosis into benign (n = 127) and malignant (n = 61) categories. Data include age distribution, ethnicity, and presenting symptoms.)

	Total cases (*n*=188)	
General characteristics	***n* (%) / mean ± SD**	
	Benign (*n* = 127)	**Malignant (*n* = 61)**
Age, years	51.57 ± 12.14	59.84 ± 12.27
Ethnicity		
Malay	45 (35.40)	17 (27.90)
Chinese	53 (41.70)	38 (62.30)
Indian	26 (20.50)	5 (8.20)
Others	3 (2.40)	1 (1.60)
Family history of breast carcinoma		
Yes	18 (14.20)	6 (9.80)
No	109 (85.80)	55 (90.20)
Initial presentation		
Screening	34 (26.80)	12 (19.70)
Diagnostic	93 (73.20)	49 (80.30)
Initial symptoms		
Breast lump	47 (37.00)	35 (57.40)
Nipple discharge	30 (23.60)	11 (18.00)
Breast pain	3 (2.40)	0 (0.00)
Mixed symptoms	13 (10.20)	3 (4.90)
Asymptomatic	34 (26.80)	12 (19.70)

n: Number; SD: Standard deviation

Table 2. Lesion distribution based on anatomical location including laterality (left vs. right breast) and quadrant location (central vs. peripheral) stratified by benign and malignant groups

Characteristics	**Total cases (*n*= 188) *n* (%)**		
	Benign (*n*=127)	**Malignant (*n*=61)**	***p* value (<0.05)**
Side of breast			
Right	54 (42.50)	22 (36.10)	
Left	60 (47.20)	33 (54.10)	
Bilateral	13 (10.20)	6 (9.80)	0.66
Location from nipple			
Central	70 (55.10)	27 (44.30)	0.16
Peripheral	57 (44.90)	34 (55.70)	
Location by quadrant			
Upper inner	9 (7.10)	9 (14.80)	
Upper outer	21 (16.50)	14 (23.00)	
Central/mid	70 (55.10)	27 (44.30)	0.27
Lower inner	11 (8.70)	6 (9.80)	
Lower outer	16 (12.60)	5 (8.20)	

n: Number

Table 3. Ultrasound characteristics of papillary breast lesions, classified using the ACR BI-RADS lexicon. Features including lesion type, size, shape, orientation, margins, echotexture, posterior acoustic features, and vascularity

US appearances	**Total cases (*n*= 188)**	
	***Median, n* (Interquartile range, %)**	
	Benign (*n*=127)	**Malignant (*n*=61)**	***p* value (<0.05)**
Size (cm)	1.0 (0.70)	1.7(1.70)	**<0.00**
Presence of mass			
Yes	115 (90.60)	58 (95.10)	0.28
No	12 (9.40)	3 (4.90)	
No of lesions			
Single	85 (73.90)	37 (63.80)	0.17
Multiple	30 (26.10)	21 (36.20)	
Orientation			
Parallel	114 (99.10)	36 (62.10)	**<0.00**
Non-parallel	1 (0.90)	22 (37.90)	
Margins			
Circumscribed	64 (55.70)	15 (25.90)	**<0.00**
Non-circumscribed	51 (44.30)	43 (74.10)	
Echogenicity			
Hyperechoic	6 (5.20)	2 (3.40)	
Hypoechoic	94 (81.70)	53 (91.40)	0.38
Isoechoic	8 (7.00)	2 (3.40)	
Heterogenous	7 (6.10)	1 (1.70)	
Solid cystic appearance			
Yes	17 (14.80)	9 (15.50)	0.90
No	98 (85.20)	49 (84.50)	
Posterior features			
No posterior features	100 (87.00)	18 (31.00)	
Enhancement	14 (12.20)	30 (51.70)	**<0.00**
Shadowing	1 (0.90)	7 (12.10)	
Combined pattern	0 (0.00)	3 (5.20)	
Calcifications			
Calcification in a mass	3 (2.60)	3 (5.30)	0.37
None	112 (97.40)	54 (94.70)	
Intraductal appearance			
Yes	49 (38.60)	8 (13.10)	**<0.00**
No	78 (61.40)	53 (86.90)	
Vascularity			
Yes	32 (25.20)	30 (49.20)	**0.00**
No	95 (74.80)	31 (50.80)	
Dilated ducts			
Yes	37 (29.10)	9 (14.80)	
No	76 (59.80)	47 (77.00)	0.06
Prominent	14 (11.00)	5 (8.20)	

n: Number; BI-RADS: Breast imaging reporting and data system

Table 4. Mammographic characteristics of papillary lesions based on the ACR BI-RADS lexicon including lesion shape, margins, density, presence of architectural distortion, and calcifications

Mammographic appearances	**Total cases (*n*= 188)**		
	***n* (%)**		
	Benign (*n*=127)	**Malignant (*n*=61)**	***p* value (<0.05)**
BIRADS density			
BIRADS A	6 (5.70)	2 (3.70)	0.56
BIRADS B	45 (42.50)	25 (46.30)	
BIRADS C	35 (33.00)	21 (38.90)	
BIRADS D	20 (18.90)	6 (11.10)	
Presence of mass			
Yes	36 (34.00)	30 (55.60)	**0.01**
No	70 (66.00)	24 (44.40)	
Shapes			
Oval	22 (61.10)	3 (10.00)	
Round	3 (8.30)	5 (16.70)	**<0.00**
Irregular	11 (30.60)	22 (73.30)	
Margins			
Circumscribed	28 (77.80)	8 (26.70)	**<0.00**
Non-circumscribed	8 (22.20)	22 (73.30)	
Density			
High density	13 (36.10)	25 (83.30)	
Equal density	11 (30.60)	2 (6.70)	**0.00**
Low density	12 (33.30)	3 (10.00)	
Architectural distortion			
Yes	2 (1.90)	7 (13.00)	**0.00**
No	104 (98.10)	47 (87.00)	
Calcifications			
Yes	12 (11.30)	16 (29.60)	**0.00**
No	94 (88.70)	38 (70.40)	

n: Number; BI-RADS: Breast imaging reporting and data system

Table 5. MRI features of papillary breast lesions assessed with contrast-enhanced sequences; Characteristics include lesion shape, margins, internal enhancement, NME, and kinetic curve types.

MRI Features	**Total cases (*n*= 37) (*n* (%))**			
	Benign (*n*=21)	**Malignant (*n*=16)**	***p*-value (<0.05)**	***PPV (%)***
Amount of fibroglandular tissues	0 (0.00)	0 (0.00		
Almost entirely fat	7 (33.30)	7 (43.80)		
Scattered	8 (38.10)	6 (37.40)	0.73	
Heterogenous	6 (28.60)	3 (18.80)		
Extreme				
BPE Level	1 (4.00)	4 (25.00)		
Minimal	4 (19.00)	3 (18.80)	0.09	
Mild	11 (52.40)	9 (56.20)		
Moderate	5 (23.80)	0 (0.00)		
Marked				
BPE Symmetry	21 (100.00)	15 (93.80)	0.43	
Symmetrical	0 (0.00)	1 (6.20)		
Asymmetrical				
Mass	20 (95.20)	10 (62.50)		33.30
Yes	1 (4.80)	6 (37.50)	**0.01**	85.70
No				
No of lesions	7 (33.30)	7 (43.80)		50.00
Single	13 (61.90)	3 (18.80)	**0.01**	18.80
Multiple	1 (4.80)	6 (37.40)		85.70
None				
Locations	10 (47.60)	4 (25.00)		28.60
Right	5 (23.80)	12 (75.00)	**0.00**	70.60
Left	6 (28.60)	0 (0.00)		0.00
Bilateral				
Margins	20 (100)	3 (30.00)		13.00
Circumscribed	0 (0.0)	3 (30.00)	**<0.00**	100.00
Irregular	0 (0.0)	4 (40.00)		100.00
Spiculated				
Shapes	20 (100)	2 (20.00)		9.00
Oval	0 (0.0)	0 (0.00)	**<0.00**	0.00
Round	0 (0.0)	8 (80.00)		100.00
Irregular				
Internal enhancement of mass	16 (80.00)	3 (30.00)		15.80
Homogenous	4 (20.00)	6 (60.00)	**0.02**	60.00
Heterogenous	0 (0.00)	1 (10.00)		100.00
Rim				
Associated NME	1 (4.80)	13 (81.20)		
Yes	20 (95.20)	3 (18.80)	**<0.00**	92.90
No				13.00
NME Distribution				
Focal	0 (0.00)	1 (6.30)		100.00
Linear	0 (0.00)	6 (37.50)		100.00

Segmental	0 (0.00)	4 (25.00)		100.00
Regional	1 (4.80)	2 (12.50)	**<0.00**	66.70
Multiple regions	0 (0.00)	0 (0.00)		0.00
Diffuse	0 (0.00)	0 (0.00)		0.00
None	20 (95.20)	3 (18.80)		13.00
Mixed mass-NME				
Yes	0 (0.00)	7 (43.80)	**0.00**	100.00
No	21 (100.00)	9 (56.20)		30.00
Architectural distortion				
Yes	0 (0.00)	5 (31.20)	**0.01**	100.00
No	21 (100.00)	11 (68.80)		34.30
Kinetic curve assessment				
Type 1	10 (47.60)	5 (31.30)		
Type 2	6 (28.60)	5 (31.30)	0.55	
Type 3	5 (23.80)	6 (37.40)		
ADC value ($x10^{-3}mm/s^2$)	1.53±0.27	1.11±0.23	**0.01**	

n: Number; MRI: Magnetic resonance imaging; NME: Non-mass enhancement; BPE: Background parenchymal enhancement; PPV: Positive predictive value; ADC: Apparent diffusion coefficient

Table 6. CNB and final surgical histopathology results; Lesions are classified into benign and malignant subtypes based on CNB and excised specimens.

HPE	**Total cases (*n* = 188) (*n (%)*)**	
	CNB	**Surgical excision**
Benign	143 (76.10)	127 (67.60)
Malignant	45 (23.90)	61 (32.40)
No surgical intervention:		
Benign	-	17 (13.40)
Malignant	-	3 (4.90)
HPE categories on CNB:		
Benign without atypia	131(69.70)	98 (58.30)
Benign with atypia		
ADH	9 (4.80)	10 (5.90)
LCIS	0.00	0.00
FEA	3 (1.60)	2 (1.20)
Malignant		
Non-invasive:		
DCIS within papilloma	19 (10.10)	24 (14.30)
Intraductal papillary carcinoma	5 (2.70)	3 (1.80)
Encapsulated papillary carcinoma	4 (2.10)	6 (1.20)
Solid papillary carcinoma	0.00	2 (1.20)
Micropapillary DCIS	0.00	0.00
Invasive	17 (9.00)	23 (13.70)

n: Number; HPE: Histopathological examination; CNB: Core needle biopsy; ADH: Atypical ductal hyperplasia; LCIS: Lobular carcinoma in situ; FEA: Flat epithelial atypia; DCIS: Ductal carcinoma in situ.

Table 7. Types of surgical interventions performed for papillary lesions and corresponding histopathological outcomes

Surgical intervention	**Total cases (*n* = 188) *n* (%)**	
	Benign(*n* = 127)	**Malignant(*n* = 61)**
Excisional biopsy	13 (10.20)	1 (1.60)
HWLB	53 (41.70)	5 (8.20)
VAB	7 (5.50)	0 (0.00)
Microdochectomy	9 (7.10)	0 (0.00)
WLE/BCS	13 (10.20)	22 (36.10)
Mastectomy	15 (11.80)	30 (49.20)
None	17 (13.40)	3 (4.90)

n: Number; HWLB: Hook-wire localization biopsy; VAB: Vacuum-assisted biopsy; WLE: Wide local excision; BCS: Breast-conserving surgery

Table 8. Upgrade rate of papillary breast lesions from benign diagnosis on CNB to malignancy on final surgical excision

Presence of upgrade from benign to malignant in final surgical excision	**Total (n = 168) n/total, %**
Overall upgrade	18/168 (10.70)
- Benign without atypia (n = 131) to malignant	13/131 (9.90)
- Benign with atypia (n = 12) to malignant	5/12 (41.70)
Similar	150/168 (89.30)
No surgical intervention	20/188 (10.6)

n: Number; CNB: Core needle biopsy

Table 9. Detailed comparison between CNB and final surgical histopathology findings in lesions that were upgraded including initial CNB diagnosis and final confirmed malignant subtype

CNB HPE	**Final surgical HPE**				
	DCIS	IPC	EPC	SPC	Invasive
Benign IP	8	1	1	1	2
ADH			1		1
FEA	2				1

CNB: Core needle biopsy; HPE: Histopathological examination; DCIS: Ductal carcinoma in situ; IPC: Intraductal papillary carcinoma; EPC: Encapsulated papillary carcinoma; SPC: Solid papillary carcinoma; IP: Intraductal papilloma; ADH: Atypical ductal hyperplasia; FEA: Flat epithelial atypia

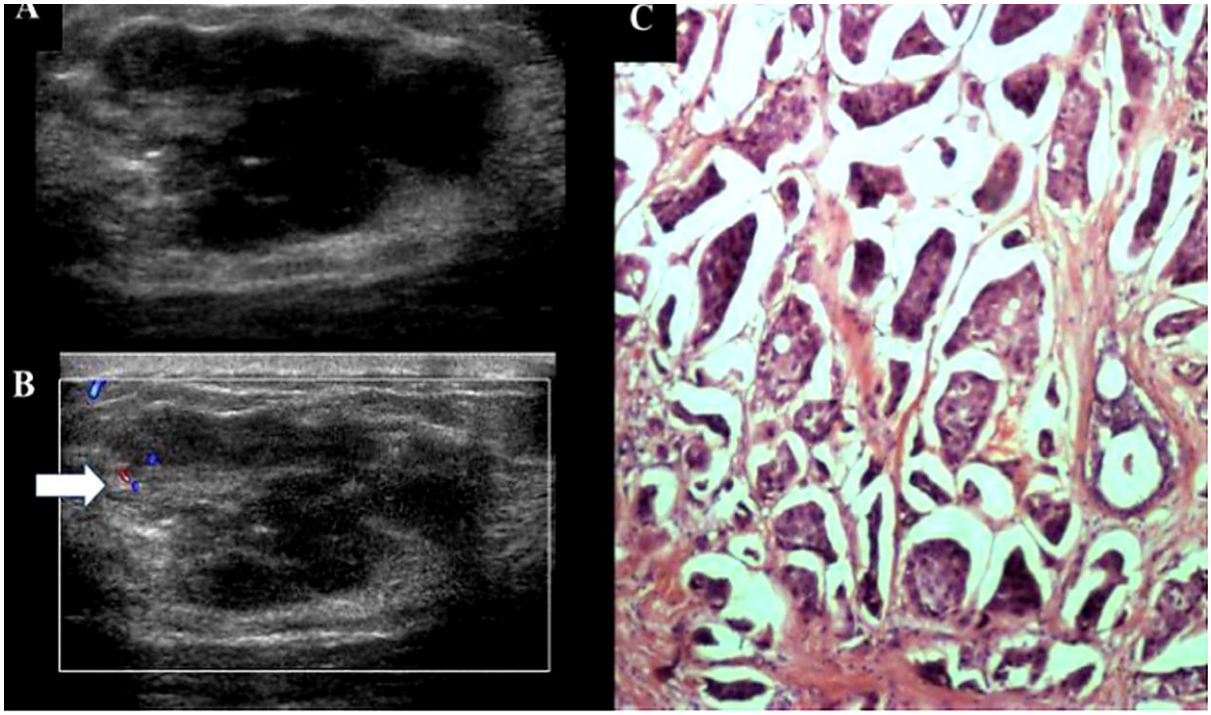

Figure 1. US and histopathological correlation in a 45-year-old woman with invasive micropapillary carcinoma. (A–B) US images show an irregular, lobulated hypoechoic lesion in the right retroareolar region with posterior enhancement and minimal peripheral vascularity (white arrow). (C) Photomicrograph (hematoxylin and eosin stain, 40× magnification) shows malignant epithelial cells arranged in micropapillary structures within clear stromal spaces.
US: Ultrasound

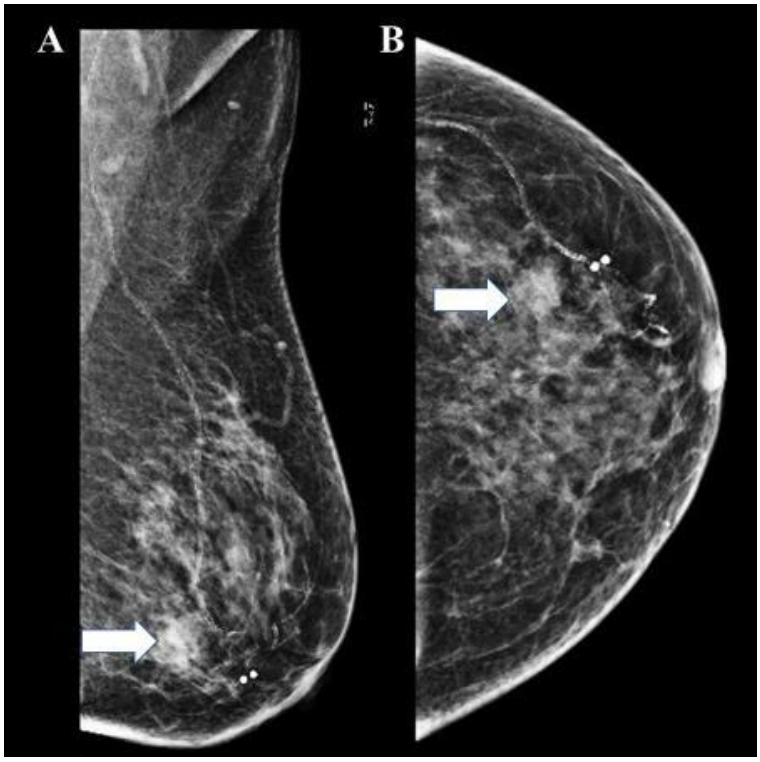

Figure 2. Mammographic findings in a 72-year-old woman with malignant solid papillary carcinoma of the left breast. (A) Mediolateral and (B) Craniocaudal views demonstrate an irregular, spiculated, high-density mass in the lower outer quadrant (white arrow).

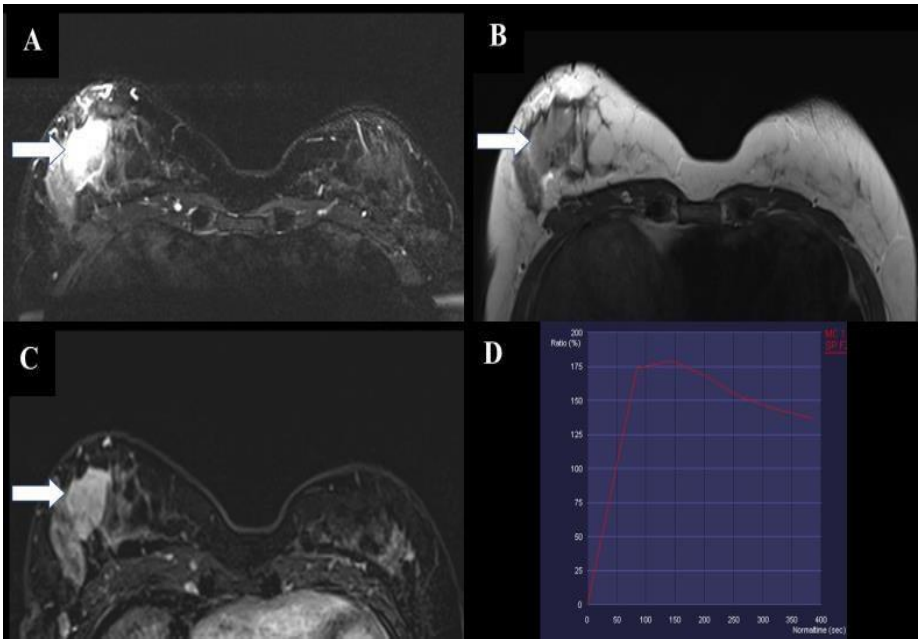

Figure 3. MRI features of invasive papillary carcinoma in a 44-year-old woman presenting with a right breast lump. (A) Axial STIR image shows TIRM hyperintensity. (B) Axial T2-weighted image demonstrates hypointensity of the lesion. (C) Subtracted dynamic contrast-enhanced image reveals a large irregular lesion with heterogeneous internal enhancement at the 6–8 o'clock position (white arrow). (D) Kinetic curve shows a type 3 (washout) enhancement pattern.

MRI: Magnetic resonance imaging; STIR: Short tau inversion recovery; TIRM: Turbo inversion recovery magnitude