ONLINE ISSN :3007-309X
PRINT ISSN :3007-3081

Journal of Medical & Health Sciences Review

# DIAGNOSTIC ACCURACY OF RESISTIVE INDEX IN DIFFERENTIATING BENIGN AND MALIGNANT SOLID BREAST LESION COMPARED WITH HISTOPATHOLOGICAL DIAGNOSIS

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**ARTICLE INFO**

**Keywords:**
Resistive index, Doppler ultrasound, breast lesions, breast cancer, diagnostic accuracy, histopathology, non-invasive imaging, sensitivity, specificity.

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**ABSTRACT**

**Background:** Distinguishing between benign and malignant breast lesions early is essential for guiding treatment and avoiding unnecessary procedures. Doppler ultrasound, particularly the use of resistive index (RI), has shown promise as a non-invasive method to assess vascular characteristics of solid breast masses. This study assessed how accurately RI can identify malignancy, using histopathology as the reference standard.

**Methods:** We carried out a descriptive cross-sectional study at the Radiology Department, Dr. Ruth K.M. Pfau Civil Hospital Karachi, over a six-month period. We included 291 women aged 20 to 70 years with solid breast lesions detected on grayscale ultrasound. All participants underwent Doppler ultrasound, and we used an RI value of $\geq 0.7$ to indicate malignancy. Final diagnoses were confirmed through histopathology. We calculated sensitivity, specificity, predictive values, and diagnostic accuracy.

**IRB-**
3718/DUHS/Approval/2024/97

**Submitted Date: 15/05/2025**
**Accepted Date: 28/05/2025**
**Published Date: 05/06/2025**

**Journal of Medical & Health Sciences Review**

**Results:** Out of 291 patients, Doppler ultrasound classified 229 lesions as malignant and 62 as benign. Histopathology confirmed malignancy in 208 cases. The RI threshold of ≥ 0.7 yielded a sensitivity and negative predictive value of 100%, specificity of 74.6%, positive predictive value of 90.8%, and overall diagnostic accuracy of 92.7%.

**Conclusion:** An RI cut-off of 0.7 on Doppler ultrasound reliably identified malignant breast lesions in this study. Incorporating RI measurement into routine ultrasound may improve diagnostic confidence, support clinical decision-making, and reduce unnecessary biopsies, particularly in low-resource settings.

## INTRODUCTION

Breast cancer is the most prevalent cancer worldwide and the leading cause of cancer related mortality in women population.[1] According to GLOBOCAN 2020, the breast cancer constitutes about 24.5% of all female malignancies with new diagnosis of 2.3 million breast cancer cases worldwide and almost half diagnosed in Asia.[1] The incidence of breast cancer has been on rising pattern over the last few decades. There is no proper tumor registry in Pakistan so exact prevalence is difficult to describe but its prevalence in Karachi is the highest in Asia.[2] These statistics emphasis the identification and utilization of imaging modalities for timely and proper diagnosis of breast cancer.

Various non-invasive imaging modalities like mammography, ultrasound and MRI are available for characterization of solid breast lesion but every modality has its own pros and cons.[3] Although the mammography is the best breast cancer screening imaging tool with a sensitivity of 85-95% but it has reduced sensitivity in dense breast parenchyma.[4,5] Breast ultrasound is commonly used imaging method due to its easily availability, low cost, non-invasive and no radiation property.[2] A local study found that ultrasound has 91.07% sensitivity and 83.57% specificity in differentiating benign from malignant breast lesions.[6] Recently the role of Doppler ultrasound has been increased in characterization of breast masses due to vascularization of malignant lesion by using different Doppler parameters. The findings of conventional gray scale ultrasound to determine the nature of breast lesions are widely available in literature but there is inconsistent local data of use of Doppler ultrasound in differentiating breast lesions. Although tumor vascularity seen on color Doppler ultrasound is an important finding help in diagnosis and prognosis of malignant breast lesion but this finding may be overlapped between vascular benign mass and malignant neoplasm as well as between benign mass and low/intermediate grade malignancy. This makes it difficult to differentiate malignant tumors from benign masses just based on color Doppler features but a noticeable waveform pattern on spectral Doppler ultrasound is a strong predictor of malignancy. Resistive Index (RI) is one of the Spectral Doppler parameter which quantitatively measures the resistance to arterial flow within a vascular bed.[7] The metabolically active malignant lesion needs more oxygen and releases vascular growth factor that lead to increase number and formation of vessels within the lesion; however these vessels are tortuous resulting in increased vascular resistance to blood.[2,3,5] The RI along with conventional ultrasound features increases the

sensitivity to detect malignant breast lesion.[7] Parveen *et al.*[2] reported the diagnostic accuracy of 90.67% of RI at ≥ 0.7 for characterization of breast lesion with sensitivity 92.40%, specificity 88.77%, positive predictive value 90.12% and negative predictive value 91.30%.

Though biopsy is a gold standard test but due to invasive and painful procedure, patients not ready to undergo biopsy all the time leading to delay in diagnosis and poor prognosis. For early diagnosis imaging play a crucial role. The diagnostic criteria of various non-invasive imaging modalities to differentiate between benign and malignant solid breast lesions are available in the literature but limited and inconsistent data is available for utilization of RI in differentiating benign versus malignant breast lesion due to different cut-off value of RI.[3,4,8]

The Doppler parameters are not performed with routine breast ultrasound in daily practice so their application in evaluation of breast mass are locally limited and entail inconsistent results. The aim of current study is to determine the diagnostic accuracy of resistive index in differentiating benign and malignant solid breast lesion taking histopathological diagnosis as gold standard this will help in identifying the nature of the lesion, to determine the optimal cut-off point for RI in our community, to segregate the patients who require biopsy and to reduce frequency of unnecessary biopsies and surgical procedures thus reducing the morbidity and financial burden to the patient.

## MATERIALS AND METHODS

The study was conducted at the Radiology Department of Dr. Ruth K.M. Pfau Civil Hospital Karachi over a six-month period once the Institutional Review Board (IRB) approval was obtained . Employing a descriptive cross-sectional design, the research aimed to evaluate the diagnostic performance of the resistive index (RI) on Doppler ultrasound in identifying breast malignancies. The required sample size of 291 patients was determined using Dr. Lin Naing's sample size calculator, based on an expected sensitivity of 92.4%, specificity of 88.7%, a 16.2% prevalence of malignant breast lesions, a desired precision of 7.6%, and a 95% confidence interval. Patients were selected through a non-probability consecutive sampling method.

The study population included women aged 20 to 70 years presenting with solid breast lesions identified on grayscale ultrasound, as defined by specific imaging characteristics. These included round or oval, well-defined hypoechoic masses; irregular hypoechoic masses; masses demonstrating lateral or posterior acoustic shadowing; and those with internal homogeneity or heterogeneity. Patients were excluded if they had a previously diagnosed breast lesion, a history of breast surgery, chemotherapy, or radiotherapy, failed to provide histopathology results, or declined to participate.

Doppler ultrasound was used to assess vascularity in the solid breast lesions, with the resistive index measured automatically via spectral tracing using Toshiba's built-in software. A lesion was considered malignant if the RI was ≥0.7 and benign if it was <0.7. Histopathological outcomes were used as the reference standard. Diagnostic categories were defined as follows: true positive if a lesion with RI ≥0.7 was confirmed malignant; true negative if a lesion with RI <0.7 was confirmed benign; false positive if a benign lesion showed RI ≥0.7; and false negative if a malignant lesion showed RI <0.7.

All patients referred for breast ultrasound at the Radiology Department were approached for enrollment. Informed written consent was taken prior to participation. All ultrasound examinations, including grayscale and Doppler assessments, were performed by a consultant radiologist with over five years of experience and specialized training in women's imaging, using a Toshiba Diagnostic Ultrasound system (TUS-X100S, Japan) equipped with a 7.5 MHz linear transducer. Based on ultrasound findings, further

diagnostic management was conducted within 2–3 weeks by the treating clinician or interventional radiologist. Biopsies were typically performed in the same radiology department by the consultant radiologist trained in women's imaging. Patients were followed up by telephone to obtain their histopathology reports, which were then compared with ultrasound findings. Data were recorded using a structured questionnaire capturing clinicodemographic details and imaging results.

Statistical analysis was carried out using SPSS version 26.0. Continuous variables such as age, lesion duration, and RI were reported as means with standard deviations, while categorical variables such as ultrasound and histopathological findings were expressed as frequencies and percentages. A 2×2 contingency table was used to compute sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of RI, with histopathology serving as the gold standard. Post-stratification analysis was conducted using the chi-square test, considering a p-value of less than 0.05 as statistically significant.

## RESULTS

A total of 291 patients who had solid breast lesion on gray scale ultrasound who met the inclusion criteria were enrolled in the study. The mean age was 50.66±16.47 years. Out of 291, 231 (79.4%) patients belonged to age group 20-45 years and 60 (20.6%) belonged to age group 46-70 years. Amongst the patients 136 (46.7%) were nulliparous and 155 (53.3) were multiparous. Moreover, majority of the patients had the lesion for > 30 days (81.4%). Overall, 229 (78.7%) and 208 (71.5%) had malignant solid breast lesions on ultrasound and histopathology. (Table 1)

Using ultrasound and taking histopathology as gold standard for diagnosis of malignant solid breast lesions, true positives (TP) were recorded as 208, false positives (FP) 21, false negatives (FN) 00 and true negatives (TN) as 62. Sensitivity was 100%, specificity was 74.6%, positive predictive value (PPV) was 90.8%, negative predictive value (NPV) was 100% and diagnostic accuracy (DA) was 92.7%. (Table 2-3)

## DISCUSSION

This study investigated the diagnostic accuracy of the resistive index (RI) on Doppler ultrasound in differentiating benign and malignant solid breast lesions, with histopathology serving as the gold standard. We found that using an RI threshold of ≥ 0.7 yielded a sensitivity and negative predictive value (NPV) of 100%, indicating that Doppler ultrasound reliably identified all malignant cases and correctly excluded malignancy when RI was below the threshold. These findings align with previous studies that reported similarly high sensitivity values when applying Doppler-based vascular parameters for breast lesion evaluation.[10-11]

The specificity in our study was 74.6%, with a positive predictive value (PPV) of 90.8%. These results indicate that while a high RI strongly suggests malignancy, some benign lesions—particularly those with increased vascularity such as fibroadenomas or inflamed nodules—may still mimic malignant vascular patterns. [12-13] This overlap, which others have also reported, suggests that RI alone may not be sufficient for ruling in malignancy but is highly useful for ruling it out with other grey scale parameters. [14-15]

Our findings support earlier research by Choi et al. and Peters-Engl et al., who observed that malignant lesions typically display RI values above 0.70, with sensitivity and specificity exceeding 80% in most cohorts. [16-17] We used an RI cut-off of 0.7 based on this precedent and confirmed its utility within our local population. Other studies have proposed slightly different cut-offs—ranging from 0.69 to 0.78—but overall trends remain

consistent, highlighting the role of angiogenesis and vessel resistance in tumor physiology. [18-19]

The mean age of patients with malignant tumors was significantly higher than that of those with benign lesions, consistent with established evidence that age is a strong risk factor for breast cancer. [20-21] In our study, most patients with malignancy were aged 46–70, a pattern that mirrors findings from regional and global data. [22] Interestingly, we observed that other reproductive risk factors, such as early menarche and delayed first childbirth, did not show statistically significant associations in our cohort—findings that contrast with large meta-analyses but may reflect regional variability or sample size limitations. [23-24]

We also examined clinical factors such as oral contraceptive use, family history, and body mass index (BMI). Patients with a positive family history of malignancy had more than twice the odds of being diagnosed with breast cancer, reinforcing the importance of family history in risk stratification. [22] Likewise, obesity was more common among patients with malignancy and may represent an important modifiable risk factor, as previously shown in studies from Southeast Asia. [23-24]

Importantly, the use of Doppler ultrasound in our setting offered a non-invasive, accessible, and cost-effective diagnostic tool, particularly valuable in resource-limited environments. Unlike MRI or contrast-enhanced techniques, Doppler ultrasound is widely available and does not require intravenous contrast or advanced post-processing, making it feasible for routine clinical use. [25-26] Although some studies question the reproducibility of RI values due to operator dependence, we minimized this variability by ensuring that experienced radiologists performed all scans in a standardized fashion. [27]

While our results are encouraging, this study does have limitations. It was conducted at a single center, and the sample had a relatively high prevalence of malignancy, which may influence PPV estimates. Additionally, we relied on a fixed RI threshold rather than optimizing cut-offs through ROC curve analysis, which may be considered in future studies. However, the strength of our findings lies in the high sensitivity and accuracy achieved using a simple, reproducible Doppler parameter.

In conclusion, our study supports the use of RI measured by Doppler ultrasound as a valuable adjunct in the evaluation of solid breast lesions. An RI cut-off of $\geq 0.7$ demonstrated excellent sensitivity and high diagnostic accuracy. Incorporating RI into the initial assessment may reduce unnecessary biopsies in benign cases while ensuring timely diagnosis and management for malignant lesions.

## LIMITATIONS

We carried out this study in a single public hospital, which may limit how well the findings apply to other healthcare settings. Since we used a non-probability consecutive sampling method, the sample may not fully represent the broader population. Doppler ultrasound depends heavily on operator technique, and we did not evaluate interobserver variation in RI measurements. Additionally, we excluded patients without histopathology reports and did not follow up on lesion progression, which may have affected the completeness of our data.

## CONCLUSION

Our findings show that a resistive index (RI) cut-off of $\geq 0.7$ on Doppler ultrasound can accurately differentiate between benign and malignant solid breast lesions. The technique achieved excellent sensitivity and negative predictive value, making it a useful, non-invasive tool for early detection of malignancy. By integrating RI assessment into routine ultrasound, clinicians can make more informed decisions and potentially reduce the

number of unnecessary biopsies. This approach may be especially valuable in settings where access to advanced imaging is limited.

**CONFLICT OF INTEREST**

This study has no conflict of interest to declare by any author.

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**TABLE 1: CHARACTERISTICS OF PATIENTS**

| DEMOGRAPHY | | NUMBER | PERCENTAGE |
|---|---|---|---|
| **AGE** | **20-45 YEARS** | 231 | 79.4% |
| | **46-70 YEARS** | 60 | 20.6% |
| **PARITY** | **NULLIPAROUS** | 136 | 46.7% |
| | **MULTIPAROUS** | 155 | 53.3% |
| **DURATION OF BREAST LEISION** | **≤ 30 DAYS** | 54 | 18.6% |
| | **> 30 DAYS** | 237 | 81.4% |
| **HISTORY OF BREASTFEEDING** | **YES** | 134 | 46.0% |
| | **NO** | 157 | 54.0% |
| **FAMILY HISTORY OF BREAST CANCER** | **YES** | 185 | 63.6% |
| | **NO** | 106 | 36.4% |
| **MALIGNANT SOLID BREAST LESION ON ULTRASOUND (RI≥ 0.7)** | **POSITIVE** | 229 | 78.7% |
| | **NEGATIVE** | 62 | 21.3% |
| **MALIGNANT SOLID BREAST LESION ON HISTOPATHOLOGY** | **POSITIVE** | 208 | 71.5% |
| | **NEGATIVE** | 83 | 28.5% |

**TABLE 2: DIAGNOSTIC ACCURACY OF ULTRASOUND (RI≥ 0.7) USING HISTOPATHOLOGY AS GOLD STANDARD FOR THE DIAGNOSIS OF MALIGNANT SOLID BREAST LEISION.**

| VARIABLE | | HISTOPATHOLOGY | | TOTAL |
|---|---|---|---|---|
| | | POSITIVE | NEGATIVE | |
| **MALIGNANT SOLID BREAST LESION ON ULTRASOUND (RI≥ 0.7)** | **POSITIVE** | 208(TP) | 21(FP) | 229 |
| | **NEGATIVE** | 00(FN) | 62(TN) | 62 |
| **TOTAL** | | 208 | 83 | 291 |

**TABLE 3: SENSITIVITY, SPECIFICITY, POSITIVE AND NEGATIVE PREDICTIVE VALUES AND DIAGNOSTIC ACCURACY OF THE ULTRASOUND (RI≥ 0.7)**

| VARIABLE | SENSITIVITY | SPECIFICITY | POSITIVE PREDICTIVE VALUE | NEGATIVE PREDICTIVE VALUE | DIAGNOSTIC ACCURACY |
|---|---|---|---|---|---|
| **MALIGNANT SOLID BREAST LESION ON ULTRASOUND (RI≥ 0.7)** | 100% | 74.6% | 90.8% | 100% | 92.7% |