EAS Journal of Radiology and Imaging Technology
Abbreviated Key Title: EAS J Radiol Imaging Technol
ISSN: 2663-1008 (Print) & ISSN: 2663-7340 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-8 | Issue-6 | Nov-Dec-2026 | DOI: https://doi.org/10.36349/easjrit.2026.v08i06.006

Original Research Article

A Comparative Study of the Utility of Ultrasonography (USG) And Elastography in Patient Presenting with Thyroid Nodules in Tertiary Care Hospital

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Article History
Received: 09.09.2026
Accepted: 05.11.2026
Published: 09.11.2026

Journal homepage:
https://www.easpublisher.com

Quick Response Code

Abstract: ***Background:*** Thyroid nodules are common clinical findings, and differentiating benign from malignant lesions is essential for appropriate management. Conventional ultrasonography (USG) is widely used, while strain elastography provides additional information regarding tissue stiffness. ***Aim:*** To compare the diagnostic performance of conventional USG, strain elastography, and their combined approach in differentiating benign from malignant thyroid nodules. ***Materials and Methods:*** This observational, cross-sectional study included 66 patients with thyroid nodules evaluated at a tertiary care hospital. Conventional USG assessed nodule morphology, echogenicity, margins, shape, echogenic foci, and vascularity, with classification according to ACR TI-RADS. Strain elastography was performed using Rago elasticity scores and strain-ratio measurements. Fine-needle aspiration cytology, supplemented by histopathology where available, served as the reference standard. Diagnostic performance was assessed using sensitivity, specificity, predictive values, accuracy, and receiver operating characteristic analysis. ***Results:*** Of the 66 patients, 54 (81.8%) had benign nodules and 12 (18.2%) had malignant nodules. Suspicious sonographic features and higher ACR TI-RADS categories were significantly associated with malignancy ($p < 0.001$). The mean strain ratio was significantly higher in malignant than benign nodules (4.92 ± 1.05 versus 1.82 ± 0.87; $p < 0.001$). The strain-ratio cut-off of 2.80 yielded an area under the curve of 0.982, with 100% sensitivity and 88.89% specificity. Diagnostic accuracy was 80.30% for USG, 89.39% for elastography, and 92.42% for the combined approach. ***Conclusion****:* Strain elastography improved diagnostic performance compared with conventional USG alone. Their combined assessment demonstrated the highest observed accuracy and specificity, suggesting complementary value in thyroid nodule characterization. Larger prospective studies are required to validate these findings.

Keywords: Thyroid nodules; ultrasonography; strain elastography; ACR TI-RADS; strain ratio; diagnostic accuracy.

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INTRODUCTION

Thyroid nodules are common clinical findings identified during physical examination or incidentally on imaging. Although most nodules are benign, differentiating benign from malignant lesions is essential for appropriate management and avoiding unnecessary invasive procedures. The initial evaluation includes clinical assessment, thyroid function testing and ultrasonography, with fine-needle aspiration (FNA) performed according to clinical and sonographic risk.[1,2] Conventional ultrasonography (USG) is the primary imaging modality for evaluating thyroid nodules because it is non-invasive, widely available and provides detailed information about composition, echogenicity, shape, margins and echogenic foci.[3] Suspicious features include marked hypoechogenicity, irregular margins, a taller-than-wide shape and punctate echogenic foci. However, individual features cannot reliably distinguish every benign nodule from malignancy. Standardized systems, including the American College of Radiology Thyroid Imaging, Reporting and Data System (ACR TI-RADS) and EU-

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TIRADS, improve risk stratification and help guide decisions regarding FNA. [4,5,6] Despite its clinical value, conventional USG remains operator-dependent and may produce indeterminate or overlapping findings. FNA cytology is an important diagnostic investigation, but inadequate or indeterminate samples can complicate management. [7,8] Therefore, complementary imaging techniques that provide additional information about tissue characteristics have been investigated. Ultrasound elastography assesses tissue stiffness by evaluating tissue deformation or mechanical responses to applied forces. Strain elastography estimates deformation following gentle compression, displaying tissue elasticity through colour-coded images or semiquantitative measurements. The Rago elasticity score grades nodules according to stiffness, while the strain ratio compares deformation in the nodule with that in a reference tissue. [9,10] These methods may provide information beyond the morphological characteristics assessed by conventional USG. Early studies reported promising results for elastography. Rago and colleagues demonstrated the potential of elasticity scoring to differentiate benign from malignant thyroid nodules.[9] A meta-analysis by Bojunga and colleagues also reported favourable diagnostic performance for real-time elastography.[11] However, findings have not been consistent across studies. Moon and colleagues found that elastography did not outperform grayscale USG in their assessment of solid thyroid nodules.[12] A prospective multicentre study by Friedrich-Rust and colleagues also reported variable sensitivity and specificity across elastography parameters.[13] Differences in scoring systems, acquisition techniques, operator experience and study populations may contribute to these variations.[14,15] Combining conventional USG with strain elastography may improve nodule characterization by integrating morphological features with tissue stiffness. Nevertheless, elastography should be considered complementary rather than a replacement for conventional USG, and its additional value requires evaluation against an appropriate cytological or histopathological reference standard. [5,14] The present study included 66 patients with thyroid nodules, comprising 54 benign and 12 malignant cases. It compared conventional USG, strain elastography and their combined diagnostic approach. It also assessed the relationship of sonographic features, ACR TI-RADS categories, Rago elasticity scores and strain ratios with the final diagnosis. Receiver operating characteristic analysis was used to evaluate the discriminatory ability of the strain ratio. The study aimed to determine whether combining conventional ultrasonography and strain elastography improves the differentiation of benign from malignant thyroid nodules in the study population.

OBJECTIVES

1. To evaluate and compare the sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of conventional ultrasonography, strain elastography, and their combined approach in differentiating benign from malignant thyroid nodules.
2. To assess the association of conventional sonographic features, ACR TI-RADS categories, Rago elasticity scores, and strain ratio with the final diagnosis of thyroid nodules.
3. To determine the diagnostic utility of strain ratio using receiver operating characteristic (ROC) curve analysis and to compare the agreement and diagnostic performance of the three approaches against the reference standard.

METHODOLOGY

This observational comparative study with a cross-sectional design was conducted in the Department of Radiodiagnosis at a tertiary care centre in Maharashtra, India, over 18 months. A total of 66 adult patients with palpable or incidentally detected thyroid nodules were enrolled using consecutive sampling. Patients aged 18 years or older who underwent conventional ultrasonography and strain elastography, provided written informed consent, and had cytological or histopathological confirmation were included. Patients with previous thyroid surgery, prior non-diagnostic thyroid biopsy, pregnancy, thyroiditis, known thyroid malignancy, inability to undergo imaging, or inability or refusal to consent were excluded. Clinical history, demographic details, thyroid function tests and imaging findings were recorded using a structured proforma. Conventional B-mode ultrasonography was performed using a high-resolution ultrasound machine with a 7.5–12 MHz linear-array transducer. Nodules were assessed for size, composition, echogenicity, shape, margins, echogenic foci and Doppler vascularity, and classified according to ACR TI-RADS. Strain elastography was subsequently performed using gentle, repetitive freehand compression. Each nodule was assigned a Rago elasticity score and strain ratio, followed by a combined USG–elastography assessment. Fine-needle aspiration cytology was reported using the Bethesda system. Where surgery was performed, histopathological examination was considered the reference standard; otherwise, the FNAC result served as the final diagnosis. Diagnostic performance was evaluated using sensitivity, specificity, positive and negative predictive values, and accuracy. Cohen's kappa, chi-square testing, Mann–Whitney U testing and receiver operating characteristic analysis were used as appropriate. Institutional Ethics Committee approval was obtained, and confidentiality was maintained throughout the study.

RESULTS AND OBSERVATIONS

A total of 66 patients presenting with thyroid nodules were evaluated in this study. Conventional ultrasonography (USG), strain elastography, and the combined USG–elastography approach were compared against the final diagnosis based on FNAC and/or

histopathology. The results are presented in three consolidated tables, accompanied by graphs illustrating the demographic distribution, association of imaging findings with malignancy, and comparative diagnostic performance. This format follows the journal-style presentation shown in your screenshots.

Baseline demographic and clinical characteristics

Table 1: Demographic, clinical, and final diagnostic profile of the study population (n = 66)

Characteristic	Category	n (%) or value
Age	Mean ± SD (years)	42.58 ± 10.43
	Median (years)	43
	Range (years)	22–62
Age group	18–30 years	10 (15.2%)
	31–40 years	18 (27.3%)
	41–50 years	21 (31.8%)
	51–60 years	15 (22.7%)
	>60 years	2 (3.0%)
Sex	Female	57 (86.4%)
	Male	9 (13.6%)
Presenting complaint	Neck swelling	54 (81.8%)
	Incidental detection	7 (10.6%)
	Incidental detection on USG	2 (3.0%)
	Slow-growing nodule	1 (1.5%)
	Long-standing multinodular goitre	1 (1.5%)
	Neck swelling with lymphadenopathy	1 (1.5%)
Duration of symptoms	Mean ± SD (months)	18.74 ± 16.30
	Median (months)	12
	Range (months)	0–60
Final diagnosis	Benign	54 (81.8%)
	Malignant	12 (18.2%)
Relevant clinical history	Family history of thyroid disease	1 (1.5%)
	Previous neck irradiation	0 (0%)
	Thyroid function tests	Within normal limits in all patients

Values are expressed as number (percentage), unless otherwise indicated. Percentages may not total 100 because of rounding.

A total of 66 patients were included, with a mean age of 42.58 ± 10.43 years. The largest proportion belonged to the 41–50-year age group (31.8%), followed by the 31–40-year group (27.3%). Females constituted 86.4% of the population, giving a female-to-male ratio of approximately 6.3:1. Neck swelling was the most frequent presenting complaint (81.8%). The final diagnosis was benign in 54 patients (81.8%) and malignant in 12 (18.2%).

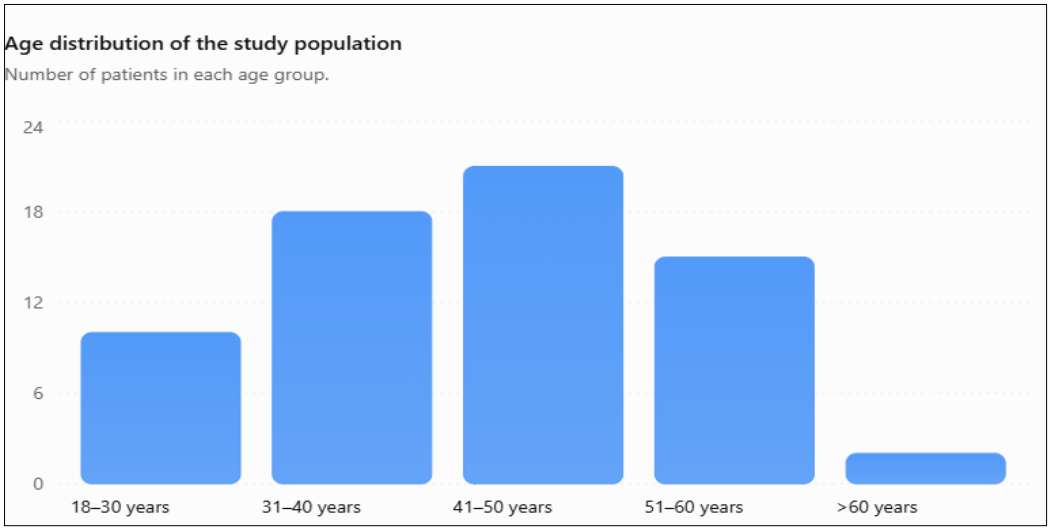


Figure 1: Age distribution of the study population

Age distribution of patients
Distribution of 66 patients according to age group.

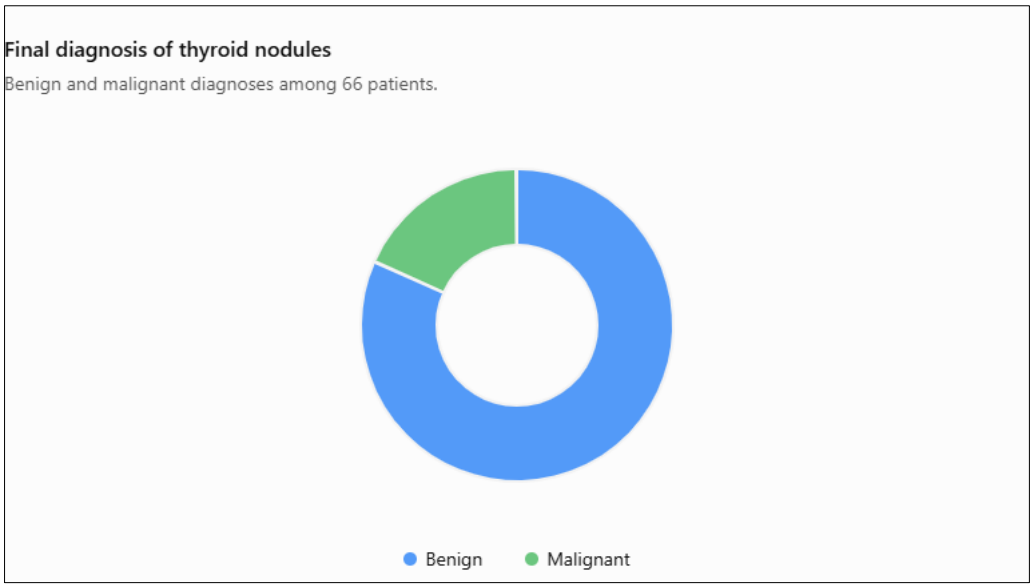


Figure 2: Distribution according to final diagnosis

Association of ultrasonographic and elastographic findings with malignancy

Table 2: Comparison of selected USG features, ACR TI-RADS categories, and Rago elasticity scores with final diagnosis

Parameter	Category	Benign (n = 54), n (%)	Malignant (n = 12), n (%)	Statistical result
Echogenicity	Hypoechoic	10 (18.5%)	6 (50.0%)	Overall $p < 0.001$
	Markedly hypoechoic	0 (0%)	3 (25.0%)	
Shape	Taller-than-wide	0 (0%)	8 (66.7%)	$p < 0.001$
	Wider-than-tall	54 (100%)	4 (33.3%)	
Margins	Irregular	0 (0%)	5 (41.7%)	Overall $p < 0.001$
	Lobulated	1 (1.9%)	2 (16.7%)	
	Microlobulated	2 (3.7%)	2 (16.7%)	
	Smooth	51 (94.4%)	3 (25.0%)	
Echogenic foci	Punctate echogenic foci	0 (0%)	4 (33.3%)	Overall $p < 0.001$
	Comet-tail artefact	22 (40.7%)	0 (0%)	
Doppler vascularity	Central	2 (3.7%)	6 (50.0%)	Overall $p < 0.001$
	Mixed	1 (1.9%)	3 (25.0%)	
	Peripheral	44 (81.5%)	3 (25.0%)	
ACR TI-RADS	TR1	8	0	$\chi^2 = 46.730$; $p < 0.001$
	TR2	34	0	
	TR3	2	3	
	TR4	10	2	
	TR5	0	7	
Rago elasticity score	Score 1	27	0	$\chi^2 = 47.667$; $p < 0.001$
	Score 2	21	0	
	Score 3	0	1	
	Score 4	6	5	
	Score 5	0	6	
Strain ratio	Mean ± SD	1.82 ± 0.87	4.92 ± 1.05	$U = 636.5$; $p < 0.001$
Nodule size	Mean ± SD (mm)	20.96 ± 7.25	19.08 ± 6.69	$p = 0.449$

For echogenicity, margins, echogenic foci, and Doppler vascularity, p-values refer to the overall association across the reported categories. The original dissertation should be consulted for the complete category-level distribution of echogenic foci.

The analysis demonstrated significant associations between malignancy and several sonographic features, including hypoechogenicity, taller-than-wide shape, irregular margins, echogenic foci, and central or mixed vascularity ($p < 0.001$). All seven TR5 nodules were malignant, whereas all TR1 and TR2 nodules were benign. Higher Rago elasticity scores were also associated with malignancy. The mean strain ratio was significantly higher in malignant nodules than in benign nodules (4.92 ± 1.05 versus 1.82 ± 0.87; $p < 0.001$). In contrast, the difference in mean nodule size was not statistically significant ($p = 0.449$).

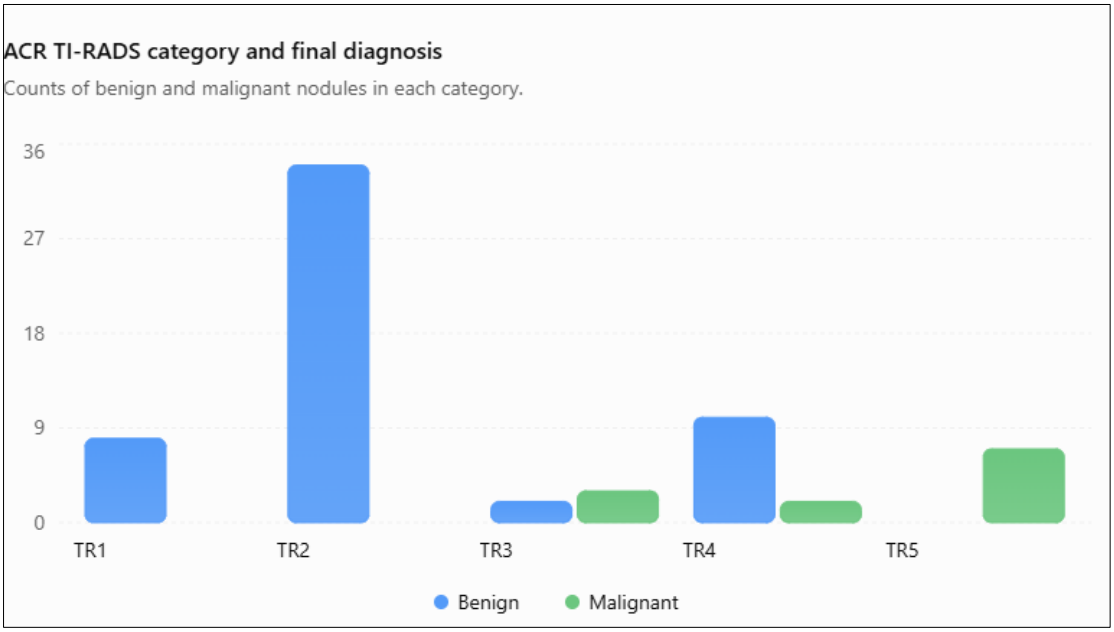


Figure 3: Distribution of malignant nodules according to ACR TI-RADS category

ACR TI-RADS category and final diagnosis

Comparative diagnostic performance of USG, elastography, and the combined approach

Table 3: Comparative diagnostic performance, agreement statistics, and ROC analysis

A. Diagnostic classification against the final diagnosis

Diagnostic approach	True positive	False negative	True negative	False positive
Conventional USG	9	3	44	10
Strain elastography	11	1	48	6
Combined USG + elastography	11	1	50	4

B. Diagnostic performance

Diagnostic parameter	Conventional USG, % (95% CI)	Strain elastography, % (95% CI)	Combined approach, % (95% CI)
Sensitivity	75.00 (46.8–91.1)	91.67 (64.6–98.5)	91.67 (64.6–98.5)
Specificity	81.48 (69.2–89.6)	88.89 (77.8–94.8)	92.59 (82.4–97.1)
Positive predictive value	47.37 (27.3–68.3)	64.71 (41.3–82.7)	73.33 (48.0–89.1)
Negative predictive value	93.62 (82.8–97.8)	97.96 (89.3–99.6)	98.04 (89.7–99.7)
Overall diagnostic accuracy	80.30 (69.2–88.1)	89.39 (79.7–94.8)	92.42 (83.5–96.7)
False-positive rate	18.52	11.11	7.41
False-negative rate	25.00	8.33	8.33

C. Agreement and ROC analysis

Parameter	Result
USG Cohen's kappa (95% CI)	0.460 (0.198–0.723)
Elastography Cohen's kappa (95% CI)	0.693 (0.478–0.908)
Combined approach Cohen's kappa (95% CI)	0.768 (0.572–0.963)
Strain-ratio ROC AUC (95% CI)	0.9823 (0.9504–1.0000)
Optimal strain-ratio cut-off	2.80
Sensitivity at ROC cut-off	100.00%

Parameter	Result
Specificity at ROC cut-off	88.89%
Youden index	0.8889
McNemar: USG vs. elastography	p = 0.146
McNemar: USG vs. combined approach	p = 0.0215
McNemar: elastography vs. combined approach	p = 0.500

CI: confidence interval; AUC: area under the receiver operating characteristic curve. Diagnostic estimates and agreement statistics are reproduced from the dissertation.

Conventional USG correctly identified 9 of the 12 malignant nodules, whereas strain elastography and the combined approach each identified 11. The combined approach correctly classified 50 of 54 benign nodules and produced four false-positive results, compared with ten for conventional USG. Overall diagnostic accuracy increased from 80.30% with conventional USG to 89.39% with elastography and 92.42% with the combined approach. The combined approach also demonstrated the highest specificity (92.59%) and positive predictive value (73.33%). Agreement with the reference diagnosis was strongest for the combined approach (κ = 0.768). The difference between conventional USG and the combined approach was statistically significant (p = 0.0215); the difference between elastography and the combined approach was not statistically significant (p = 0.500).

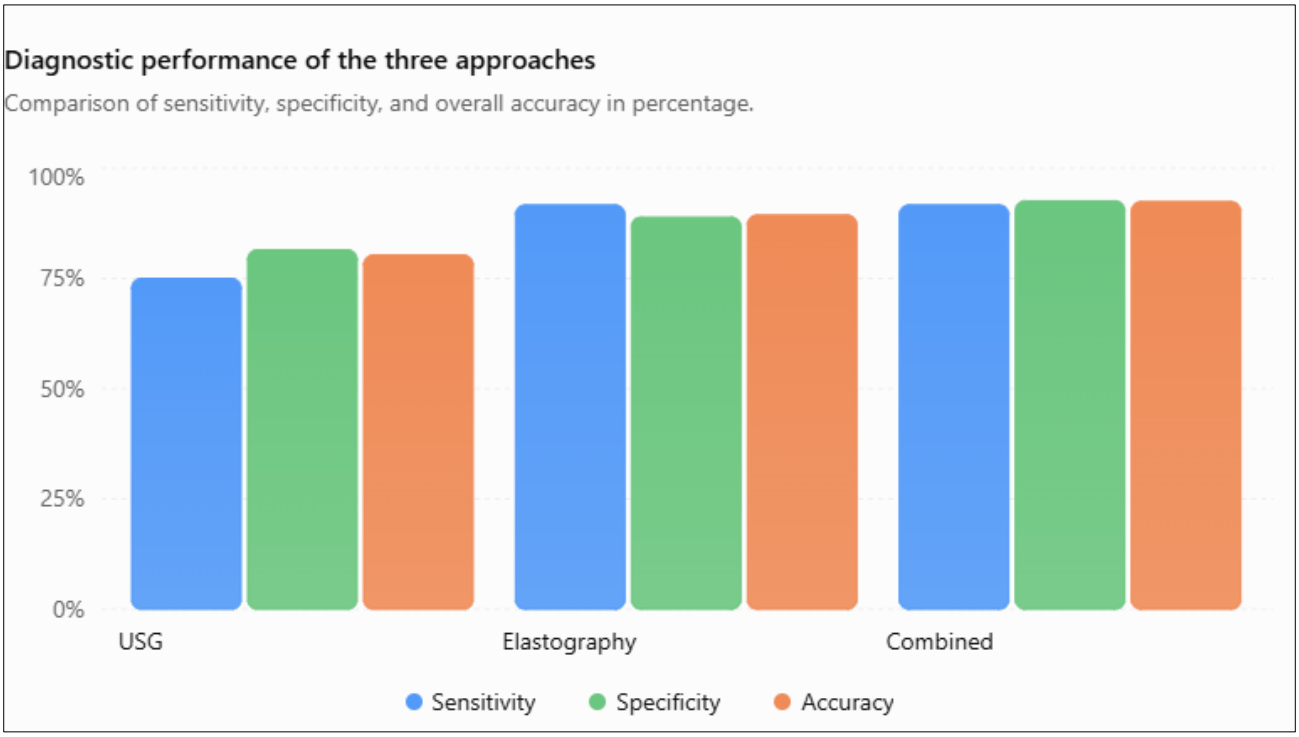


Figure 4: Comparison of diagnostic performance across the three approaches

Overall observations

The results demonstrate that strain elastography provided better sensitivity and overall diagnostic accuracy than conventional USG alone. Combining USG with elastography achieved the highest observed specificity, positive predictive value, and diagnostic accuracy. The strain ratio also showed excellent discrimination in ROC analysis. However, the study included only 12 malignant nodules, and the ROC cut-off performance should be distinguished from the categorical elastography results. These findings support the potential complementary role of elastography in thyroid nodule assessment but require validation in larger prospective studies.

DISCUSSION

The present study evaluated 66 patients with thyroid nodules, including 54 benign and 12 malignant lesions. Suspicious sonographic features, including hypoechogenicity, taller-than-wide shape, irregular margins, and echogenic foci, were significantly associated with malignancy. These findings support established ultrasound-based risk-stratification systems, including ACR TI-RADS and EU-TIRADS, which guide the assessment and management of thyroid nodules. [16,17] Strain elastography demonstrated promising diagnostic performance, with a significantly higher mean strain ratio in malignant than benign nodules (4.92 ± 1.05 vs. 1.82 ± 0.87; p < 0.001). The area under the receiver

operating characteristic curve was 0.982, and a cut-off of 2.80 yielded 100% sensitivity and 88.89% specificity. These findings are consistent with previous studies reporting the potential utility of elastography in differentiating benign and malignant thyroid nodules. [18,19] However, diagnostic performance may vary according to equipment, technique, and patient characteristics. Conventional ultrasonography achieved an accuracy of 80.30%, compared with 89.39% for strain elastography and 92.42% for the combined approach. The combined assessment demonstrated the highest specificity (92.59%) and negative predictive value (98.04%). Agreement with the reference diagnosis was also strongest for the combined approach ($\kappa = 0.768$). These results suggest that elastography may provide complementary information to conventional USG, although the difference between elastography alone and the combined approach was not statistically significant (McNemar $p = 0.500$). This is consistent with literature indicating that the additional diagnostic benefit of elastography may vary across study settings. [18,19] The study's limitations include its single-centre design, small sample size, and the inclusion of only 12 malignant nodules. Therefore, the diagnostic estimates and proposed strain-ratio threshold require validation in larger prospective studies.

CONCLUSION

Strain elastography showed better diagnostic performance than conventional USG alone, while their combined assessment achieved the highest observed accuracy and specificity. Integrating elastography with established sonographic assessment may improve thyroid nodule characterization. However, larger studies are needed to validate these findings before routine clinical adoption.

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Cite This Article: Meshram, M. D., & Pawar, S. S. (2026). A Comparative Study of the Utility of Ultrasonography (USG) And Elastography in Patient Presenting with Thyroid Nodules in Tertiary Care Hospital. *EAS J Radiol Imaging Technol, 8*(6), 186-193. https://doi.org/10.36349/easjrit.2026.v08i06.006