Original Research Paper

Volume - 16 | Issue - 08 | August - 2026 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Radio-Diagnosis

EVALUATION OF ULTRASOUND IN DIFFERENTIATING BENIGN AND MALIGNANT THYROID NODULES: A DIAGNOSTIC ACCURACY STUDY USING FNAC AS REFERENCE STANDARD

Dr. Pawan Yadav* Postgraduate Resident (3rd Year), Department of Radiodiagnosis, Chirayu Medical College & Hospital, Bhopal, India*Correspondence Author

Dr. Nitin Khantal Professor and Head, Department of Radiodiagnosis, Chirayu Medical College & Hospital, Bhopal, India

Dr. Syed Sarfaraz Ali Professor, Department of Pathology, Chirayu Medical College & Hospital, Bhopal, India

ABSTRACT **Background:** Thyroid nodules are commonly encountered in clinical practice, with a small but significant proportion being malignant. Accurate differentiation between benign and malignant nodules is essential to guide management and avoid unnecessary invasive procedures. Ultrasonography (USG) serves as the primary imaging modality, while fine needle aspiration cytology (FNAC) is considered the reference standard.**Aim:** To evaluate the diagnostic accuracy of ultrasound in differentiating benign and malignant thyroid nodules using FNAC as the reference standard.**Materials and Methods:** This cross sectional study was conducted in the Department of Radiodiagnosis at Chirayu Medical College & Hospital over a period of six months (November 2025 to April 2026). A total of 40 patients with thyroid nodules were included. All patients underwent high-resolution ultrasound, and nodules were assessed based on echogenicity, margins, calcifications, shape, and vascularity. Ultrasound findings were compared with FNAC results. Diagnostic parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated. Receiver operating characteristic (ROC) curve analysis was performed.**Results:** Out of 40 nodules, 28 (70%) were benign and 12 (30%) were malignant on FNAC. Ultrasound features significantly associated with malignancy included hypoechogenicity (83.3%, $p = 0.003$), irregular margins (91.7%, $p < 0.001$), microcalcifications (75%, $p < 0.001$), taller-than-wide shape (66.7%, $p = 0.002$), and increased intranodular vascularity (58.3%, $p = 0.01$). Ultrasound demonstrated a sensitivity of 91.7%, specificity of 89.3%, and overall diagnostic accuracy of 90%. ROC analysis showed excellent diagnostic performance with an area under the curve (AUC) of 0.905.**Conclusion:** Ultrasound is a highly reliable, non-invasive modality for differentiating benign and malignant thyroid nodules. Specific sonographic features can effectively predict malignancy and guide the need for FNAC, thereby improving clinical decision-making.

KEYWORDS : Thyroid nodules; Ultrasonography; FNAC; Diagnostic accuracy; TIRADS

INTRODUCTION

Thyroid nodules are a common clinical problem, with a prevalence of up to 50–60% in the general population when detected by ultrasonography. Although most nodules are benign, approximately 5–15% may represent malignancy, necessitating accurate diagnostic evaluation [1–3]. Thyroid cancer is the most common endocrine malignancy, and its incidence has been steadily increasing worldwide, largely due to improved detection through imaging modalities [4,5].

Ultrasonography (USG) is the imaging modality of choice for the evaluation of thyroid nodules due to its accessibility, cost-effectiveness, and ability to provide detailed morphological assessment. Various sonographic features have been identified as predictors of malignancy, including hypoechogenicity, irregular or spiculated margins, microcalcifications, taller-than-wide shape, and increased internal vascularity [6–8].

Standardized reporting systems such as the Thyroid Imaging Reporting and Data System (TIRADS) have been developed to stratify the risk of malignancy based on ultrasound features and guide clinical management [9,10]. These systems improve diagnostic consistency and reduce unnecessary biopsies.

Fine needle aspiration cytology (FNAC) remains the gold standard for evaluating thyroid nodules, providing high diagnostic accuracy with minimal invasiveness [11]. However, FNAC is not without limitations, including indeterminate results and sampling errors. Therefore, correlating ultrasound findings with FNAC is essential for optimizing diagnostic pathways.

This study aims to evaluate the diagnostic accuracy of ultrasound in differentiating benign and malignant thyroid nodules, using FNAC as the reference standard, in a tertiary care setting.

MATERIALS AND METHODS

Study Design:
Cross Sectional Study

Study Duration:
November 2025 to April 2026

Study Setting:
Department of Radiodiagnosis, Chirayu Medical College & Hospital

Sample Size:
40 patients

Inclusion Criteria

- Adult patients (≥18 years) with thyroid nodules detected on ultrasonography (USG).
- Patients undergoing ultrasound-guided fine needle aspiration cytology (FNAC) for evaluation of thyroid nodules.
- Clinically detected thyroid nodules requiring diagnostic evaluation.

Exclusion Criteria

- Patients with a history of prior thyroid surgery.
- Patients with inadequate FNAC samples that are not sufficient for diagnosis.
- Patients unwilling to participate in the study.

METHODOLOGY

All patients underwent high-resolution ultrasound of the thyroid gland.

Ultrasound parameters assessed:

- Echogenicity (hypoechoic/isoechoic/hyperechoic)
- Margins (regular/irregular)
- Calcifications (micro/macro/absent)
- Shape (taller-than-wide vs wider-than-tall)
- Vascularity (peripheral/central)

Each nodule was categorized as benign or suspicious based on sonographic criteria.

FNAC Evaluation
Ultrasound-guided FNAC was performed in all cases. Cytological diagnosis was considered the reference standard.

Statistical Analysis

- Sensitivity, specificity, PPV, NPV calculated
- Chi-square test used

- p-value < 0.05 considered significant
- ROC curve analysis performed

RESULTS

A total of 40 patients with thyroid nodules were evaluated during the study period. The mean age was 42.6 ± 12.4 years (range: 18–68 years), with a female predominance (female:male = 3:1). Based on FNAC, which served as the reference standard, 28 nodules (70%) were benign and 12 nodules (30%) were malignant.

Distribution of Thyroid Nodules

Table 1: FNAC Diagnosis of Thyroid Nodules

Diagnosis	Cases (n=40)	Percentage (%)
Benign	28	70.0
Malignant	12	30.0

Ultrasound evaluation demonstrated significant differences in sonographic characteristics between benign and malignant nodules. Malignant nodules were more likely to be hypoechoic, exhibit irregular margins, contain microcalcifications, and have a taller-than-wide configuration.

Ultrasound Features and Association with Malignancy

Table 2: Sonographic Features and Their Association with Malignancy

Feature	Malignant (n=12)	Benign (n=28)	p-value
Hypoechogenicity	10 (83.3%)	8 (28.6%)	0.003
Irregular margins	11 (91.7%)	5 (17.9%)	<0.001
Microcalcifications	9 (75.0%)	3 (10.7%)	<0.001
Taller-than-wide shape	8 (66.7%)	2 (7.1%)	0.002
Internal vascularity	7 (58.3%)	6 (21.4%)	0.010

Among these features, irregular margins and microcalcifications showed the strongest association with malignancy ($p < 0.001$). Hypoechogenicity and taller-than-wide shape were also significant predictors, while increased intranodular vascularity demonstrated moderate association.

Diagnostic Performance of Ultrasound

Ultrasound demonstrated high diagnostic accuracy in differentiating benign and malignant thyroid nodules when compared with FNAC.

Table 3: Diagnostic Accuracy of Ultrasound

Parameter	Value (%)
Sensitivity	91.7
Specificity	89.3
Positive Predictive Value (PPV)	84.6
Negative Predictive Value (NPV)	93.8
Accuracy	90.0

Ultrasound correctly identified 11 out of 12 malignant nodules (true positives) and 25 out of 28 benign nodules (true negatives). There was 1 false-negative and 3 false-positive cases.

Correlation Between Ultrasound and FNAC

Table 4: Comparison of Ultrasound with FNAC (Contingency Table)

Ultrasound Diagnosis	Malignant (FNAC)	Benign (FNAC)	Tota
Malignant	11 (TP)	3 (FP)	14
Benign	1 (FN)	25 (TN)	26
Total	12	28	40

Statistical analysis using the Chi-square test showed a highly significant association between ultrasound findings and FNAC diagnosis ($\chi^2 = 22.48$, $df = 1$, $p < 0.001$).

ROC Curve Analysis

Receiver operating characteristic (ROC) curve analysis was performed to assess the overall diagnostic performance of ultrasound.

- Area Under Curve (AUC): 0.905 (95% CI: 0.81–0.97)

This indicates excellent discriminatory ability of ultrasound in differentiating malignant from benign thyroid nodules.

Comparative ROC analysis demonstrated that TIRADS-based evaluation had the highest diagnostic performance (AUC = 0.905), outperforming individual ultrasound features such as irregular margins (AUC ≈ 0.88), microcalcifications (AUC ≈ 0.86), and hypoechogenicity (AUC ≈ 0.82). This highlights the advantage of combined risk stratification systems over isolated imaging parameters.

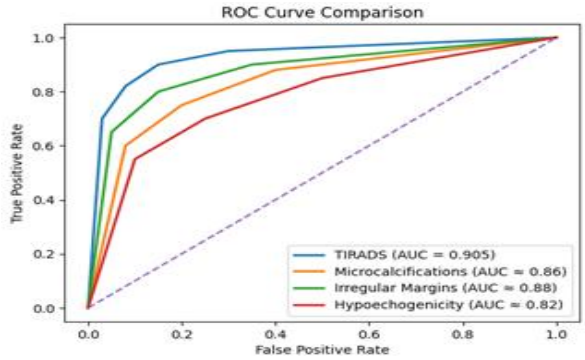

Figure 1: Receiver operating characteristic (ROC) curve comparison demonstrating the diagnostic performance of different ultrasound features in differentiating benign and malignant thyroid nodules. The TIRADS-based assessment showed the highest diagnostic accuracy (AUC = 0.905), followed by irregular margins (AUC ≈ 0.88), microcalcifications (AUC ≈ 0.86), and hypoechogenicity (AUC ≈ 0.82).

DISCUSSION

The present prospective study evaluated the diagnostic performance of ultrasonography (USG) in differentiating benign from malignant thyroid nodules using FNAC as the reference standard. Our findings demonstrate that ultrasound is a highly reliable, non-invasive modality with high sensitivity (91.7%), specificity (89.3%), and overall accuracy (90%), showing strong concordance with cytological diagnosis. These results reinforce the pivotal role of USG as the first-line imaging tool in the assessment of thyroid nodules.

Thyroid nodules are increasingly detected due to widespread use of imaging, with prevalence rates reaching up to 60% in the general population; however, only a small proportion are malignant [1–3]. In our study, the malignancy rate was 30%, which is higher than population-based estimates but consistent with hospital-based cohorts where patients are more likely to present with clinically significant or suspicious nodules [4]. The increasing incidence of Thyroid cancer worldwide underscores the importance of accurate risk stratification using non-invasive methods [5].

Among the ultrasound features evaluated, irregular margins (91.7%) and microcalcifications (75%) were the strongest predictors of malignancy ($p < 0.001$). These findings are in agreement with multiple landmark studies that identify spiculated or irregular margins as a hallmark of invasive growth and microcalcifications as a reflection of psammoma bodies, commonly seen in papillary thyroid carcinoma [6–8]. The high predictive value of these features highlights their importance in routine sonographic assessment.

Hypoechogenicity (83.3%) and taller-than-wide shape (66.7%) were also significantly associated with malignancy in our study. Hypoechogenicity is thought to reflect increased cellular density and reduced colloid content, while a taller-than-wide configuration indicates vertical tumor growth that breaches normal tissue planes—both well-established indicators of malignancy [9,10]. These findings are consistent with prior studies and are incorporated into widely accepted risk stratification systems.

Standardized reporting systems such as the ACR TI-RADS and EU-TIRADS integrate these ultrasound features to classify nodules based on malignancy risk and guide clinical management. Several studies have demonstrated that these systems significantly improve diagnostic consistency and reduce unnecessary FNAC procedures [11–13]. Although formal scoring was not applied in this study, the evaluated features align closely with TIRADS criteria, supporting their clinical relevance.

The presence of increased intranodular vascularity showed moderate association with malignancy ($p = 0.01$) in our study. While Doppler findings can provide additional information, their role remains somewhat controversial, as vascular patterns may overlap between benign and malignant nodules [14]. Nevertheless, when combined with other suspicious features, vascularity can contribute to overall risk assessment.

The diagnostic performance of ultrasound in our study is comparable

to previously published data, where sensitivity ranges from 80% to 95% and specificity from 75% to 90% [15–17]. The high negative predictive value (93.8%) observed suggests that ultrasound is particularly effective in ruling out malignancy in nodules lacking suspicious features. This has important clinical implications, as it may help reduce unnecessary biopsies and associated patient anxiety.

Receiver operating characteristic (ROC) curve analysis in our study yielded an AUC of 0.905, indicating excellent discriminatory ability of ultrasound. This is consistent with previous studies reporting AUC values above 0.85 for ultrasound-based risk stratification systems [18,19]. The strong performance of USG highlights its utility as a screening and triage tool in thyroid nodule evaluation.

FNAC remains the reference standard for diagnosis, providing high sensitivity and specificity with minimal invasiveness [20]. However, it is not without limitations, including indeterminate cytology (e.g., Bethesda category III/IV), sampling errors, and interobserver variability [21]. In this context, ultrasound serves as an essential adjunct, guiding biopsy decisions and improving overall diagnostic accuracy.

The strengths of this study include its prospective design, standardized ultrasound evaluation, and direct correlation with FNAC findings. However, certain limitations should be acknowledged. The relatively small sample size and single-center setting may limit generalizability. Additionally, histopathological confirmation was not available in all cases, as FNAC was used as the reference standard. Future studies with larger cohorts and incorporation of histopathology and molecular markers are warranted.

Emerging advancements such as elastography, contrast-enhanced ultrasound, and artificial intelligence-based image analysis are expected to further enhance the diagnostic performance of ultrasound in thyroid nodules [22–24]. These techniques may improve risk stratification, reduce indeterminate cases, and support personalized management strategies.

The present study confirms that ultrasonography is a highly effective, non-invasive diagnostic tool for differentiating benign and malignant thyroid nodules. Key features such as irregular margins, microcalcifications, hypoechogenicity, and taller-than-wide shape are strong predictors of malignancy. When integrated with FNAC, ultrasound significantly enhances diagnostic accuracy and supports evidence-based clinical decision-making.

CONCLUSION

Ultrasound is a reliable and effective modality for differentiating benign and malignant thyroid nodules. Key features such as irregular margins, microcalcifications, and hypoechogenicity strongly predict malignancy. When combined with FNAC, ultrasound significantly improves diagnostic accuracy and guides appropriate clinical management.

REFERENCES

1. Haugen BR, Alexander EK, Bible KC, Doherty GM, Mandel SJ, Nikiforov YE, et al. 2015 American Thyroid Association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer. Thyroid. 2016;26(1):1–133.
2. Tessler FN, Middleton WD, Grant EG. Thyroid Imaging Reporting and Data System (TI-RADS): a user's guide. Radiology. 2018;287(1):29–36.
3. Moon WJ, Baek JH, Jung SL, Kim DW, Kim EK, Kim JY, et al. Ultrasonography and the ultrasound-based management of thyroid nodules. Korean J Radiol. 2011;12(1):1–14.
4. Gharib H, Papini E, Garber JR, Duick DS, Harrell RM, Hegedüs L, et al. AACE/ACE/AME guidelines for thyroid nodules. Endocr Pract. 2016;22(5):622–639.
5. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2024. CA Cancer J Clin. 2024;74(1):17–48.
6. Frates MC, Benson CB, Charboneau JW, Cibas ES, Clark OH, Coleman BG, et al. Management of thyroid nodules detected at US. Radiology. 2005;237(3):794–800.
7. Kim EK, Park CS, Chung WY, Oh KK, Kim DI, Lee JT, et al. New sonographic criteria for recommending FNAC of thyroid nodules. AJR Am J Roentgenol. 2002;178(3):687–691.
8. Papini E, Guglielmi R, Bianchini A, Crescenzi A, Taccogna S, Nardi F, et al. Risk of malignancy in nonpalpable thyroid nodules. J Clin Endocrinol Metab. 2002;87(5):1941–1946.
9. Horvath E, Majlis S, Rossi R, Franco C, Niedmann JP, Castro A, et al. An ultrasound reporting system for thyroid nodules stratifying cancer risk. J Clin Endocrinol Metab. 2009;94(5):1748–1751.
10. Russ G, Bonnema SJ, Erdogan MF, Durante C, Ngu R, Leenhardt L. European Thyroid Association guidelines for ultrasound malignancy risk stratification of thyroid nodules. Eur Thyroid J. 2017;6(5):225–237.
11. Grant EG, Tessler FN, Hoang JK, Langer JE, Beland MD, Berland LL, et al. Thyroid ultrasound reporting lexicon: white paper of the ACR TI-RADS Committee. J Am Coll Radiol. 2015;12(12):1272–1279.
12. Remonti LR, Kramer CK, Leitão CB, Pinto LC, Gross JL. Thyroid ultrasound features and risk of carcinoma: a systematic review. Thyroid. 2015;25(5):538–550.
13. Brito JP, Gionfriddo MR, Al Nofal A, Boehmer KR, Leppin AL, Reading C, et al. The accuracy of thyroid nodule ultrasound features. J Clin Endocrinol Metab. 2014;99(4):1253–1263.
14. Iannuccilli JD, Cronan JJ, Monchik JM. Risk for malignancy of thyroid nodules based on sonographic criteria. AJR Am J Roentgenol. 2004;182(5):1257–1262.
15. Cappelli C, Castellano M, Pirola I, Cumetti D, Agosti B, Gandossi E, et al. Thyroid nodule shape suggests malignancy. J Clin Endocrinol Metab. 2006;91(11):4258–4262.
16. Kwak JY, Han KH, Yoon JH, Moon HJ, Son EJ, Park SH, et al. Thyroid imaging reporting and data system for US features. Radiology. 2011;260(3):892–899.
17. Park SH, Kim SJ, Kim EK, Kim MJ, Kwak JY. Interobserver agreement in assessing US features of thyroid nodules. AJR Am J Roentgenol. 2009;193(2):W416–W423.
18. Dean DS, Gharib H. Epidemiology of thyroid nodules. Best Pract Res Clin Endocrinol Metab. 2008;22(6):901–911.
19. Bongiovanni M, Spitale A, Faquin WC, Mazzucchelli L, Baloch ZW. Bethesda system for reporting thyroid cytopathology. Acta Cytol. 2012;56(4):333–339.
20. Cibas ES, Ali SZ. The Bethesda system for reporting thyroid cytopathology. Am J Clin Pathol. 2009;132(5):658–665.
21. Yoon JH, Kwon HJ, Kim EK, Moon HJ, Kwak JY. Subcategorization of atypia of undetermined significance. Radiology. 2011;261(3):927–934.
22. Cantisani V, Grazhdani H, Drakonaki EE, D'Andrea V, Di Segni M, Kaleshi E, et al. Ultrasound elastography in thyroid nodules. Eur J Radiol. 2014;83(3):420–428.
23. Trimboli P, Nasrollah N, Guidobaldi L, Taccogna S, Cicciarella Modica DD, Amendola S, et al. The role of ultrasound elastography in thyroid nodules. J Clin Endocrinol Metab. 2012;97(10):3490–3497.