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A Study of Correlation between Clinical, Pathological and Radiological Spectrum of Thyroid Swellings

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Abstract

Thyroid swellings constitute one of the most frequently encountered endocrine disorders in clinical practice and encompass a wide spectrum of benign and malignant lesions. Early and accurate differentiation between benign and malignant thyroid nodules is essential for timely intervention and appropriate management. Clinical examination alone is often inadequate in determining the exact nature of thyroid lesions, thereby necessitating the use of radiological and pathological investigations. Ultrasonography of the thyroid using the Thyroid Imaging Reporting and Data System (TIRADS) has emerged as a valuable modality for risk stratification of thyroid nodules, while Fine Needle Aspiration Cytology (FNAC), reported according to the Bethesda system, remains the cornerstone of preoperative cytological diagnosis. Correlation among clinical, radiological, cytological, and histopathological findings can substantially enhance diagnostic precision and optimize patient outcomes.

Objective: To evaluate the correlation between clinical findings, ultrasonographic characteristics based on TIRADS grading, cytological diagnosis using the Bethesda system, and histopathological findings in patients presenting with thyroid swellings.

Methods: A prospective observational study was conducted in the Department of Otorhinolaryngology at K.D. Medical College, Hospital and Research Centre, Mathura, Uttar Pradesh, over a duration of 18 months from May 2024 to November 2025. A total of 60 patients presenting with clinically detectable thyroid swelling were enrolled in the study. Detailed clinical history and examination were performed for all patients. Investigations included thyroid function tests, ultrasonography of the neck with TIRADS grading, and Fine Needle Aspiration Cytology (FNAC) categorized according to the Bethesda system. Histopathological examination of postoperative specimens was considered the gold standard for definitive diagnosis. Statistical analysis was performed using descriptive statistics and appropriate inferential tests, with a p-value of <0.05 considered statistically significant.

Results: The majority of patients belonged to the 31–40 years age group (45%), with a marked female predominance (83.33%). Multinodular thyroid swellings were more common (63.33%) than solitary nodules (36.67%), and most patients were euthyroid (63.33%). Ultrasonographic evaluation demonstrated that TIRADS 3 lesions were the most prevalent (48.33%), followed by TIRADS 2 lesions (26.67%), whereas 16.67% of nodules were categorized as TIRADS 5, indicating high suspicion for malignancy. FNAC findings revealed Bethesda II lesions in 48.33% of cases, Bethesda III in 31.67%, and Bethesda VI in 15% of patients. Histopathological examination identified colloid goiter (26.67%) and multinodular goitre (16.67%) as the most common benign lesions, while papillary thyroid carcinoma (15%) was the predominant malignant pathology. A strong positive correlation was observed between TIRADS grading and Bethesda cytology categories ($r = 0.86$, $p < 0.001$). Significant concordance was also noted between FNAC and histopathological findings ($p < 0.001$). Clinical parameters such as hard consistency, fixation of swelling, pressure symptoms, and nodules larger than 4 cm showed significant association with malignancy. FNAC demonstrated a diagnostic sensitivity of 91.11% with an overall diagnostic accuracy of 81.67%.

Conclusion: The present study highlights the importance of an integrated clinical–radiological–pathological approach in the evaluation of thyroid swellings. TIRADS grading exhibited strong correlation with FNAC and histopathological diagnosis, thereby aiding in the early identification of malignant thyroid nodules. FNAC continues to be a reliable, minimally invasive, and highly sensitive diagnostic modality for preoperative assessment. The combined use of clinical examination, ultrasonography, and cytological evaluation significantly improves diagnostic accuracy and facilitates effective management of thyroid nodules**.**

Keywords: Thyroid swelling; TIRADS; FNAC; Bethesda system; Histopathology; Thyroid nodules.

Introduction

Thyroid swellings are among the most frequently encountered endocrine disorders in clinical practice and include a broad spectrum of benign and malignant conditions. The thyroid gland, a highly vascular butterfly-shaped endocrine organ situated in the anterior neck, is responsible for the synthesis of thyroxine (T4) and triiodothyronine (T3), hormones essential for metabolic regulation, growth, and development.[1–5] Thyroid enlargement may arise from physiological, inflammatory, autoimmune, or neoplastic processes and is more commonly observed in females and in iodine-deficient regions. While palpable nodules are identified in nearly 4–7% of adults, high-resolution ultrasonography can detect nodules in up to 70% of the population.[6,7]

Clinically, thyroid swellings may present as diffuse or nodular enlargements and can be solitary or multinodular, cystic or solid, with or without associated thyroid dysfunction. The major clinical challenge lies in distinguishing benign lesions from malignant ones, as both often share overlapping presentations. Careful clinical examination remains the cornerstone of initial evaluation, providing information regarding the size, consistency, mobility, tenderness, and presence of cervical lymphadenopathy.[8,9] Features such as hard consistency, fixation to surrounding structures, rapid enlargement, compressive symptoms, and nodal involvement may raise suspicion for malignancy.[10] Additional signs including Pemberton's sign, retrosternal dullness, or thyroid bruit may further aid diagnosis in selected cases.[11] However, clinical examination alone

lacks sufficient specificity, particularly in deep-seated or small nodules, and is often limited by subjective interpretation and overlapping findings between benign and malignant conditions.[12–14]

Radiological assessment, particularly ultrasonography (USG), has therefore become indispensable in the evaluation of thyroid nodules. USG provides detailed characterization of nodules based on echogenicity, margins, internal composition, calcifications, and vascularity.[15,16] Suspicious features such as hypo echogenicity, irregular margins, microcalcifications, and taller-than-wide configuration are strongly associated with malignancy. The introduction of Thyroid Imaging Reporting and Data System (TI-RADS) classifications, including the ACR TI-RADS, has improved standardization and risk stratification of thyroid nodules.[17] These systems help reduce unnecessary interventions while ensuring timely evaluation of high-risk lesions. Color Doppler imaging further complements assessment by evaluating vascular flow patterns, with central intramodular vascularity being more suggestive of malignancy.[18]

Pathological evaluation remains the definitive component in thyroid nodule assessment. Fine Needle Aspiration Cytology (FNAC) is widely regarded as the most reliable initial pathological investigation because of its simplicity, safety, and cost-effectiveness.[19] The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC) has standardized cytological interpretation into six diagnostic categories, thereby improving communication between pathologists and clinicians and guiding management strategies.[20] Histopathological examination (HPE) of excised thyroid tissue remains the gold standard for definitive diagnosis, allowing accurate identification of benign and malignant lesions along with their histological subtypes.[21] Correlation of FNAC findings with histopathology enhances diagnostic reliability and helps identify false-negative and indeterminate cases.[22]

Despite advances in individual diagnostic modalities, none is independently conclusive. Clinical findings may be subjective, ultrasonographic interpretation may vary with expertise, and FNAC may occasionally yield indeterminate results, particularly in follicular-pattern lesions. Hence, an integrated clinicoradiological and pathological approach is essential for improving diagnostic accuracy and optimizing patient management.

The incidence of thyroid malignancies, especially papillary thyroid carcinoma, has shown a steady rise in recent years, largely due to increased awareness and improved imaging techniques. Understanding regional disease patterns and evaluating the effectiveness of combined diagnostic modalities are therefore important for improving early detection and guiding treatment decisions. This study was undertaken to assess the correlation between clinical findings, radiological evaluation, and pathological diagnosis in patients presenting with thyroid swellings, while also identifying the strengths and limitations of each modality individually and collectively**.** Thyroid swellings are common endocrine disorders ranging from benign goiters to malignant thyroid neoplasms. Although clinical examination remains the first step in evaluation, it is often insufficient to reliably differentiate benign from malignant lesions because of overlapping clinical features. Careful assessment of nodule size, consistency, fixation, compressive symptoms, and cervical lymphadenopathy may raise suspicion for malignancy, but definitive diagnosis requires radiological and pathological correlation.[13,14]

Ultrasonography (USG) is the primary imaging modality for thyroid evaluation because of its high sensitivity, non-invasive nature, and ability to characterize nodules based

on echogenicity, margins, calcifications, composition, and vascularity. Suspicious sonographic features such as hypo echogenicity, irregular margins, microcalcifications, and taller-than-wide shape are associated with increased malignancy risk. TI-RADS classification systems have further improved standardized reporting, risk stratification, and selection of nodules requiring FNAC.[14,23]

Fine Needle Aspiration Cytology (FNAC), reported using the Bethesda System, remains the cornerstone of preoperative diagnosis. It effectively distinguishes benign from malignant lesions and significantly reduces unnecessary surgeries.[24-28] Histopathological examination remains the gold standard for definitive diagnosis and prognostic assessment.

An integrated clinical–radiological–pathological approach improves diagnostic accuracy, facilitates early detection of thyroid malignancies, and guides appropriate management while minimizing unnecessary interventions.

Material and Methods

This prospective observational study was conducted in the Department of Otorhinolaryngology (ENT) at K.D. Medical College, Hospital and Research Centre, Mathura, Uttar Pradesh, over a period of 18 months from May 2024 to November 2025. The study included 60 patients presenting with clinically detectable thyroid swellings in the ENT outpatient and inpatient departments. Patients lost to follow-up were excluded from the study.

A detailed clinical history was recorded, including symptoms such as neck swelling, dysphagia, dyspnea, voice change, pain, and features suggestive of thyroid dysfunction. General, systemic, and local examinations of the thyroid swelling were performed to assess characteristics such as size, consistency, nodularity, mobility, pressure effects, and cervical lymphadenopathy.

All patients underwent thyroid function tests and ultrasonography (USG) of the neck with TIRADS grading to evaluate nodule characteristics and malignancy risk. Fine Needle Aspiration Cytology (FNAC) was performed under aseptic precautions, and cytological findings were categorized according to the Bethesda System for Reporting Thyroid Cytopathology (TBSRTC). Patients requiring surgery underwent appropriate thyroidectomy procedures, and excised specimens were subjected to histopathological examination, which was considered the gold standard for definitive diagnosis. All clinical, radiological, cytological, and histopathological findings were systematically recorded and analyzed to establish clinicoradiological and pathological correlation in thyroid swellings using SPSS 30.0.0.0.

Observations

Table 1: Sex Distribution (n = 60)

Sex	Number (n)	Percentage (%)
Male	10	16.67
Female	50	83.33
Total	**60**	**100**

The study population showed a clear female predominance. Females constituted 83.33% of cases, whereas males accounted for only 16.67%. This suggests the condition was markedly more common among females in the present study.

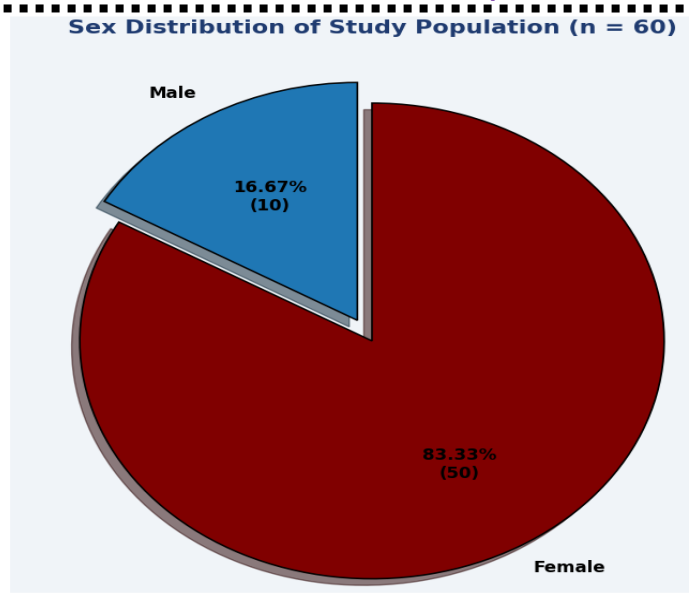

Figure 1: Sex Distribution amongst the study population

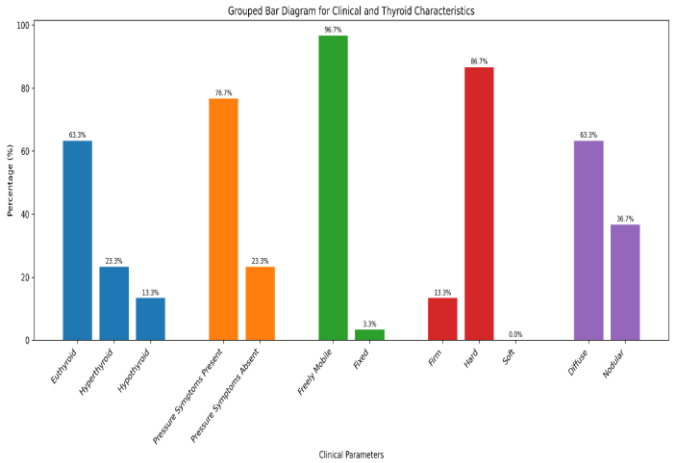

Figure 2: Clinical parameters in different Thyroid swelling patients of the study

The majority of patients were Euthyroid (63.3%), while hyperthyroid (23%) and hypothyroid (13.3%) states less common. Pressure symptoms were present in 76.7%, indicating significant compressive manifestations in most cases. On clinical examination, 96.7% swelling were freely mobile, 86.7% were hard and 63.3% had diffuse enlargement, suggestive of predominantly benign but clinically significant thyroid swelling.

Table 2: TIRADS Grade vs FNAC (Bethesda Category) (n = 60)

TIRADS Grade	II	III	IV	V	VI	Total
TR2	13	3	0	0	0	16
TR3	15	12	2	0	0	29
TR4	1	4	0	0	0	5
TR5	0	0	0	1	9	10
Total	**29**	**19**	**2**	**1**	**9**	**60**
p-value: < 0.001						

Coefficient of correlation (r) = 0.86

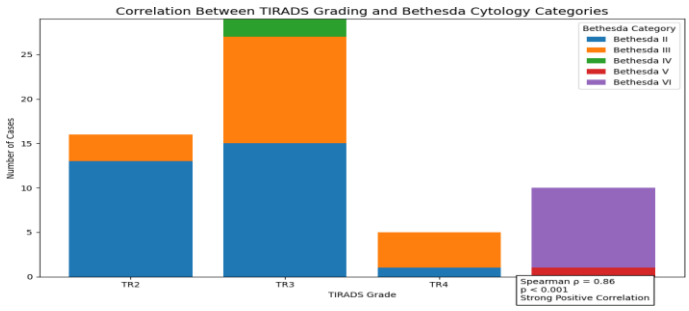

Figure 3: A stacked correlation bar chart showing the relationship between TIRADS grading and Bethesda cytology categories.

This representation clearly demonstrates the increasing malignancy trend with higher TIRADS grades and supports the strong positive Spearman correlation ($\rho = 0.86$, $p < 0.001$). Hence, increasing TIRADS grade and higher-risk Bethesda Cytology categories are highly co related. Therefore, higher ultrasonographic suspicion strongly corelates with cytological evidence of malignancy.

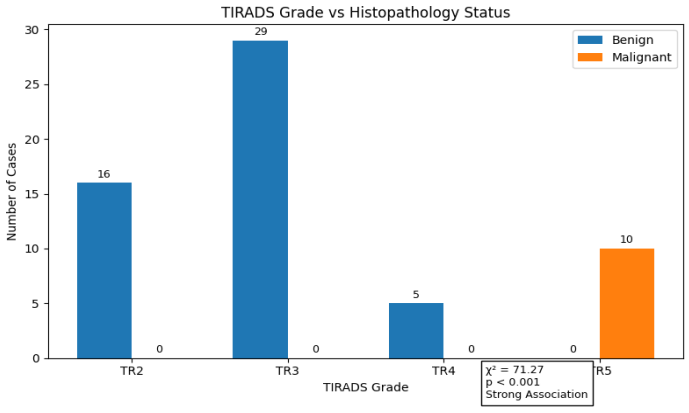

Figure 4: TIRADS Grade vs Histopathology status

This bar diagram demonstrates the strong association between higher TIRADS grades and malignancy (χ^2 = 71.27, p < 0.001). Lower the TIRADS (TIRADS I, II) were predominantly benign, whereas TIRADS V lesions showed the highest malignancy yield. The association was highly significant, confirming TIRADS are reliable predictor of malignancy.

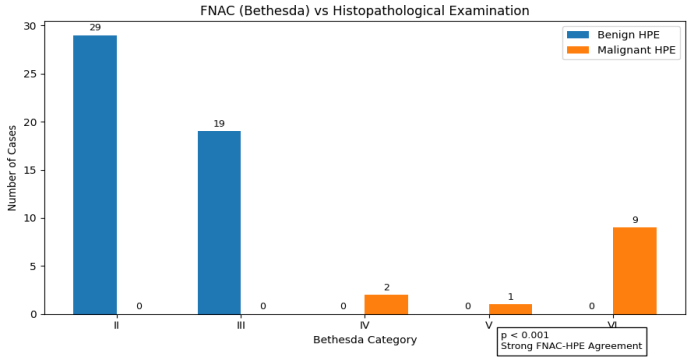

Figure 5: FNAC (Bethesda) vs Histopathological Examination

The Bar Diagram Shows the increasing malignancy risk with higher Bethesda categories and strong FNAC-HPE agreement with p<0.001 with benign lesions largely corresponding to Bethesda II, while malignant cases clustered in Bethesda IV-VI. Higher Bethesda category were associated with progressively increased malignancy risk. This supports FNAC as an effective preoperative diagnostic tool for thyroid nodules.

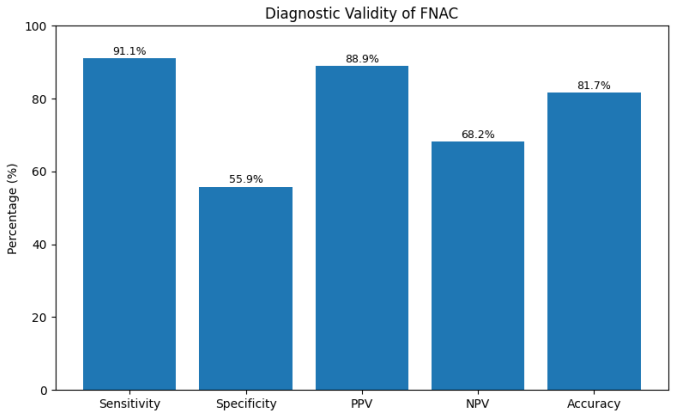

Figure 6: Diagnostic validity of FNAC with Histopathological Finding taken as Gold Standard

FNAC demonstrated high diagnostic performance with sensitivity of 91.1%, specificity of 55.6%, PPV of 88.9%, NPV of 82.7%. The higher yield of sensitivity and PPV indicate ability to detect malignancy, while moderate specificity suggests occasional false positive diagnostics.

Discussion

The present study evaluates the contemporary diagnostic approach to thyroid nodules through integrated clinical, ultrasonographic, cytological, and histopathological assessment. Thyroid swellings remain among the most common endocrine disorders, with the primary clinical challenge being the accurate differentiation of benign from malignant lesions while minimizing unnecessary surgical intervention and associated morbidity.

The majority of patients were in the 31–50-year age group, consistent with findings reported by Chaudhary et al., Raniwala et al., and Rajan et al., which demonstrated a peak incidence in middle-aged individuals. A marked female predominance (83.33%) was observed, comparable to previous studies reporting female representation between 80–93%, supporting the recognized hormonal and autoimmune predisposition among women.

Multinodular goiter was the most common presentation (63.33%), reflecting the predominantly benign nature of thyroid disease. In contrast, malignant lesions were significantly associated with solitary nodules (χ^2 = 20.91, p < 0.001), corroborating observations by Kumar et al. and Rajan et al. that solitary thyroid nodules warrant heightened clinical suspicion. Although right-lobe involvement was more frequent, laterality alone did not predict malignancy. Bilateral swellings were largely benign, whereas malignant lesions were confined to unilateral nodules. Discrete nodules also demonstrated significantly greater malignant potential than diffuse thyroid enlargement.

Several clinical characteristics showed strong associations with malignancy. Hard consistency, fixation to surrounding structures, pressure symptoms, and nodule size >4 cm were significantly correlated with malignant histopathology. All fixed nodules and most hard nodules were malignant, while symptoms such as dysphagia, dyspnea, and voice change demonstrated a particularly strong association with malignancy ($\chi^2 = 60.0$, $p < 0.001$). These findings are consistent with reports by Raniwala et al., Chauhan et al., and Shilli et al.

Most patients were euthyroid despite structural thyroid abnormalities, and no significant association was observed between thyroid functional status and histopathological outcome. This finding reinforces existing evidence that biochemical euthyroidism does not exclude neoplastic disease.

Ultrasonographic risk stratification using TIRADS proved highly effective. Although TR3 lesions constituted the largest group, all histopathologically confirmed malignant lesions were classified as TIRADS 5, demonstrating a highly significant association with malignancy ($\chi^2 = 71.27$, $p < 0.001$). These results are comparable to those reported by Alshaikh et al., Rajyakodi et al., and Ziani et al., highlighting the value of standardized ultrasonographic assessment.

Bethesda cytology similarly provided excellent risk stratification. Bethesda II was the most common category, whereas malignant lesions were predominantly concentrated in Bethesda V and VI. Papillary thyroid carcinoma was the most frequent malignant subtype on histopathology. FNAC demonstrated high sensitivity (91.11%) and overall diagnostic accuracy (81.67%), with strong cytology–histopathology agreement ($\kappa = 0.82$, $p < 0.001$), confirming its reliability as a preoperative diagnostic tool.

The findings underscore the value of an integrated diagnostic approach. High-risk clinical features, combined with higher TIRADS and Bethesda categories, showed strong concordance with malignant histopathology, improving diagnostic precision and facilitating appropriate surgical decision-making. Overall, the study confirms that thyroid swellings are predominantly benign and more common in middle-aged women; however, specific clinical, radiological, and cytological parameters reliably predict malignant potential. The strong agreement between TIRADS, Bethesda classification, and histopathology supports the adoption of a structured multidisciplinary protocol for evidence-based management of thyroid nodules.

Conclusion

The present study demonstrates that thyroid swellings predominantly affect middle-aged women and are largely benign in nature. The observed demographic profile is consistent with established epidemiological evidence showing a higher prevalence of thyroid disorders among females, likely due to hormonal influences and the greater incidence of autoimmune thyroid disease. Although benign lesions constituted the majority of cases, the primary clinical challenge remains the identification of malignant nodules requiring timely intervention.

Multinodular goiter was the most common presentation, reflecting the predominantly benign pathology of thyroid disease. However, solitary thyroid nodules showed a significantly greater association with malignancy, reinforcing the well-recognized principle that isolated nodules warrant careful evaluation because of their higher oncological risk. These findings emphasize the need for heightened clinical vigilance in patients presenting with solitary thyroid lesions.

Clinical examination remained a valuable component of initial risk assessment. Hard consistency, fixation to surrounding structures, compressive symptoms such as dysphagia, dyspnea, and voice change, as well as nodule size greater than 4 cm, were significantly associated with malignant histopathology. These observations highlight that, despite advances in imaging and cytopathology, meticulous clinical assessment continues to provide important diagnostic information. Careful evaluation of nodular characteristics, mobility, cervical lymphadenopathy, and local compressive effects remains essential for identifying patients at increased risk of malignancy and guiding subsequent investigations.

Ultrasonography using the TIRADS classification system proved to be a highly reliable non-invasive tool for malignancy prediction. Higher TIRADS categories demonstrated a strong correlation with malignant histopathological outcomes, supporting the effectiveness of standardized ultrasound-based risk stratification. Sonographic features such as marked hypo echogenicity, irregular margins, microcalcifications, and taller-than-wide morphology contributed significantly to high-risk categorization. In addition to improving diagnostic accuracy, TIRADS enhances reporting consistency and assists in selecting nodules that require cytological evaluation.

Fine-needle aspiration cytology (FNAC) demonstrated high sensitivity and satisfactory overall diagnostic performance, reaffirming its role as a cornerstone investigation in thyroid nodule assessment. While its ability to identify malignant lesions was excellent, limitations remain in indeterminate Bethesda categories, particularly in differentiating follicular adenoma from follicular carcinoma, where assessment of capsular and vascular invasion requires histopathological examination. Nevertheless, FNAC remains a minimally invasive, cost-effective, and highly informative diagnostic modality that substantially reduces unnecessary surgery when interpreted in conjunction with clinical and radiological findings.

The study further highlights the value of integrating clinical evaluation, TIRADS-based ultrasonographic risk stratification, and FNAC to improve diagnostic accuracy and guide management. Concordance among these modalities allows confident clinical decision-making, whereas discordant or indeterminate findings can be selectively directed toward surgical excision and definitive histopathological assessment. As the diagnostic gold standard, histopathology remains indispensable for confirming malignancy and characterizing lesions with equivocal cytological features.

In conclusion, a structured and multidisciplinary approach combining careful clinical examination, ultrasonography, and cytological assessment provides the most effective framework for the evaluation of thyroid nodules. Such an approach facilitates early detection of high-risk lesions, minimizes unnecessary surgical interventions in benign disease, and supports evidence-based, individualized patient management, ultimately improving clinical outcomes and surgical decision-making.

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