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ACCURACY OF ULTRASOUND TIRADS SCORING IN DIFFERENTIATING MALIGNANT FROM BENIGN NODULES KEEPING FNAC AS GOLD STANDARD

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Abstract
The objective of this study was to evaluate the diagnostic accuracy of the Thyroid Imaging Reporting and Data System (TIRADS) scoring system in differentiating between malignant and benign thyroid nodules using ultrasound, with fine-needle aspiration cytology (FNAC) serving as the gold standard. This cross-sectional validation study was conducted at the Radiology Department of the Combined Military Hospital (CMH) in Abbottabad over six months. A sample of 166 patients, aged 18 to 70 years, with thyroid nodules was selected through non-probability consecutive sampling. Each patient underwent a comprehensive ultrasound examination, with scoring based on the American College of Radiology TIRADS system, followed by ultrasound-guided FNAC. Nodules classified as TR1 and TR2 were considered benign, while those classified as TR3, TR4, and TR5 for study purposes were considered malignant. FNAC findings, interpreted according to the Bethesda System, served as the reference standard. Data analysis was performed using SPSS v25 to calculate sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy. Among the 166 patients, FNAC identified malignant and benign nodules in 60.8% and 39.2% of cases, respectively. The association between TIRADS categories and cytological outcomes was statistically significant (p = 0.000). TIRADS demonstrated high specificity and sensitivity in the diagnosis of malignancy. No significant associations were observed between malignancy and variables such as age, gender, smoking status, residence, nodule size, or goiter duration. TIRADS is a non-invasive, accurate risk stratification tool for thyroid nodules, showing strong correlation with FNAC outcomes. Its integration into routine practice could reduce unnecessary biopsies and enhance diagnostic accuracy.

INTRODUCTION

Thyroid nodules represent a prevalent clinical finding encountered during routine head and neck examinations or imaging, with their incidence increasing globally, partly due to the widespread use of high-resolution ultrasonography (Boers et al., 2023). Although the majority of these nodules are benign, the potential for malignant transformation remains a significant clinical concern. The prevalence of thyroid nodules detectable via ultrasound is reported to range from 20 to 67 percent in the general population, with the precise detection rate influenced by factors such as age, gender, and iodine intake. While malignancy occurs in a relatively small percentage of all nodules, specifically 5-15 percent, the

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challenge lies in accurately distinguishing between benign and malignant nodules. This distinction is crucial for patient management, including decisions regarding the necessity of fine-needle aspiration cytology (FNAC) or the consideration of surgical intervention.

In spite of the universal occurrence of thyroid nodules, ultrasonography continues to be the primary imaging technique due to it being non-invasive, cost-effective, and allowing real-time diagnosis. However, conventional ultrasonography by itself can be subject to interpretative variability and lacks specificity to separately identify benign from malignant lesions. In a move to counter this problem, the American College of Radiology (ACR) came up with the Thyroid Imaging Reporting and Data System (TIRADS), a scoring system specific to the thyroid that is standardized for reporting thyroid nodules based on their sonographic features and cancer risk. TIRADS classification involves several important ultrasonographic characteristics such as nodule composition, echogenicity, shape, margin features, and the presence of echogenic foci and all are included in a composite risk score that decides clinical management (Ospina & Papaleontiou, 2021).

TIRADS scoring has also demonstrated potential as a method for guiding the use of FNAC, thereby eliminating unnecessary biopsies and optimizing the diagnostic process (Russ et al., 2021). TIRADS assigns accurate scores to nodules based on their ultrasonographic characteristics, thus representing an objective model for ascertaining malignancy risk. Nodules with lower TIRADS scores are usually managed conservatively, whereas those with high scores need FNAC for procuring cytological evidence. The performance of diagnostic TIRADS scoring systems has been evaluated in numerous studies with varied sensitivities, specificities, and predictive values. Such variations are the result of heterogeneity in the patient population, variation between observers, and differences in the methodologies applied in the studies. Despite these variations, there is consensus regarding the utility of TIRADS in optimizing diagnostic accuracy and minimizing invasive procedures (Koc et al., 2020).

Fine-needle aspiration cytology (FNAC) is widely accepted as the gold standard for thyroid nodule cytological diagnosis with high specificity and sensitivity if performed by experts and in the framework of the Bethesda System for Reporting Thyroid Cytopathology. FNAC provides important diagnostic information for clinical decision-making regarding surgical referral or conservative management. However, FNAC has some disadvantages like non-diagnostic or indeterminate results, sampling errors, and patient inconvenience (Alanazi, 2025). Hence, adjunct tools like the Thyroid Imaging Reporting and Data System (TIRADS) that have the potential to enhance the pre-FNAC triage process need to be continuously evaluated. This is particularly the case in resource-limited settings, where initiatives to curb unnecessary FNAC procedures can even lower institutional and patient costs (Alanazi, 2025).

Due to the growing incidence of thyroid nodules and the need for preoperative risk stratification, the present study is intended to evaluate the diagnostic performance of the TIRADS scoring system in ultrasound for distinguishing malignant from benign thyroid nodules, as the gold standard reference using FNAC findings. This analysis will examine the sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy of TIRADS, adding to the body of literature on its clinical use. The research also aims to determine the reproducibility of TIRADS in detecting high-risk nodules and evaluate the possibility of using ultrasound-based scoring systems in standard thyroid nodule evaluation protocols.

2. Methodology

2.1 Study Design and Setting

This study was a cross-sectional validation conducted in the Department of Radiology at the Combined Military Hospital (CMH) in Abbottabad. The objective of this research was to assess the diagnostic accuracy of the Thyroid Imaging Reporting and Data System (TIRADS) scoring on ultrasound in distinguishing between malignant and benign thyroid nodules, using fine-needle aspiration cytology (FNAC) as the reference standard. Ethical approval (CMHAtd-ETH-107-Radio-23) for the study was obtained from the institutional review board before its commencement. All procedures were conducted following the Declaration of Helsinki and local ethical regulations.

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2.2 Study Duration and Sampling Method

The research was conducted over six months following the approval of the research synopsis. A non-probability consecutive sampling method was employed. All eligible patients presenting to the Radiology Department with thyroid nodules, as well as those scheduled for fine-needle aspiration cytology (FNAC), were invited to participate in the study.

2.3 Sample Size Calculation

The sample size was determined using a general formula for sensitivity and specificity studies, with a sensitivity of 80 percent and a specificity of 92.77 percent for TIRADS, as reported in prior literature. The final sample size was calculated to be 166 patients, with a confidence level of 95 percent, a desired accuracy of 12 percent, and an estimated prevalence of thyroid nodules of 26 percent.

2.4 Inclusion and Exclusion Criteria

2.4.1 Inclusion Criteria

Adult patients aged 18 to 70 years, encompassing both male and female genders, presenting with one or more thyroid nodules. Patients scheduled for fine-needle aspiration cytology (FNAC) who have previously undergone ultrasound imaging before FNAC.

2.4.2 Exclusion Criteria

Patients with toxic multinodular goiter, those diagnosed with thyroiditis, individuals with a history of thyroid surgery, the presence of non-thyroidal neck lumps, incomplete clinical records, and ultrasound images of suboptimal or poor quality.

2.5 Data Collection

Eligible patients were enrolled following the provision of informed consent. A comprehensive clinical examination was conducted, and demographic data, including age, gender, residence, smoking status, and history of goiter, were recorded. Thyroid ultrasonographic assessment was performed by an experienced radiologist with a minimum of three years of expertise in thyroid imaging. A high-frequency linear transducer ultrasound machine (≥7.5 MHz) was utilized for this purpose.

The assessment of each thyroid nodule was conducted using the TIRADS scoring criteria, as endorsed by the American College of Radiology (ACR). This scoring system incorporates five sonographic features: composition, echogenicity, shape, margin, and echogenic foci. Each feature is assigned a score, and the cumulative score is employed to categorize the nodule within the TIRADS framework.

TR1 and TR2: Harmless

TR3: Slightly suspicious

TR4: Fairly suspicious

TR5: extremely suspicious

For analysis, nodules classified as TR1 and TR2 were designated as benign, while those classified as TR3, TR4, and TR5 were designated as malignant.

An experienced pathologist performed fine-needle aspiration cytology (FNAC) on each nodule under ultrasound guidance. The cytological findings were classified according to the Bethesda system. Among the nodules confirmed to be benign, there were follicular adenomas, colloid nodules, and cysts, while the malignant nodules included papillary, follicular, medullary, and anaplastic carcinomas. Cytologically indeterminate or non-diagnostic results were excluded from the final analysis.

2.6 Data Analysis

IBM SPSS Statistics version 25 was employed for data entry and analysis. Continuous variables, such as age and thyroid hormone levels, were expressed as mean ± standard deviation, while categorical variables, including gender, smoking status, and TIRADS classification, were reported as frequencies and percentages. A 2x2 contingency table was constructed to compare the diagnosis based on TIRADS with the results of FNAC.

The diagnostic performance was evaluated using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy. Additionally, the discriminatory capacity of TIRADS scoring was assessed by calculating the area under the receiver operating characteristic (AUC) curve. Statistical significance was established at a p-value of 0.05.

Stratification was conducted based on various factors that could serve as confounding variables, including age, gender, type of goiter, and smoking status. A chi-square test was used for post-stratification analysis to determine whether there was a statistically significant association.

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3. Results

Table 3.1: The age distribution of participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18–30	52	31.3	31.3	31.3
	31–45	61	36.7	36.7	68.1
	46–60	39	23.5	23.5	91.6
	61–70	14	8.4	8.4	100.0
	Total	166	100.0	100.0	

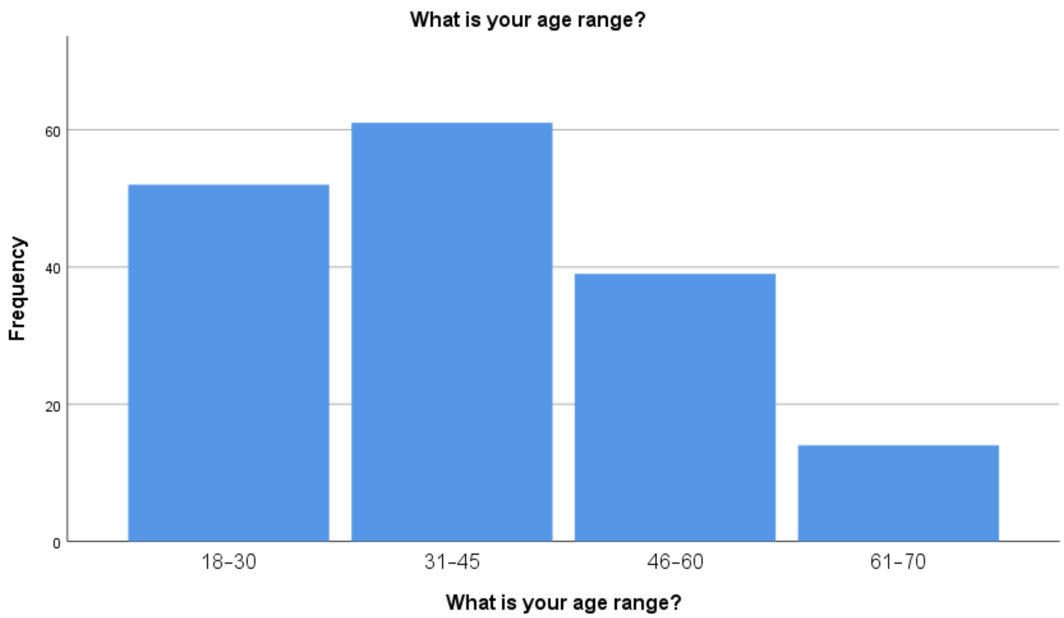

Table 3.1: The age distribution of participants indicates that the majority, 36.7%, were within the 31-45 years age range. Additionally, 31.3% of participants were aged 18-30 years. The proportion of participants aged 46-60 years was 23.5%, while those aged 61-70 years constituted 8.4%. This distribution suggests that thyroid nodules are more frequently examined in middle-aged adults. The presence of a younger age group may reflect an increasing health consciousness and the prevalence of early diagnosis due to regular screening practices.

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Table 3. 2: The gender distribution of participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	80	48.2	48.2	48.2
	Female	86	51.8	51.8	100.0
	Total	166	100.0	100.0	

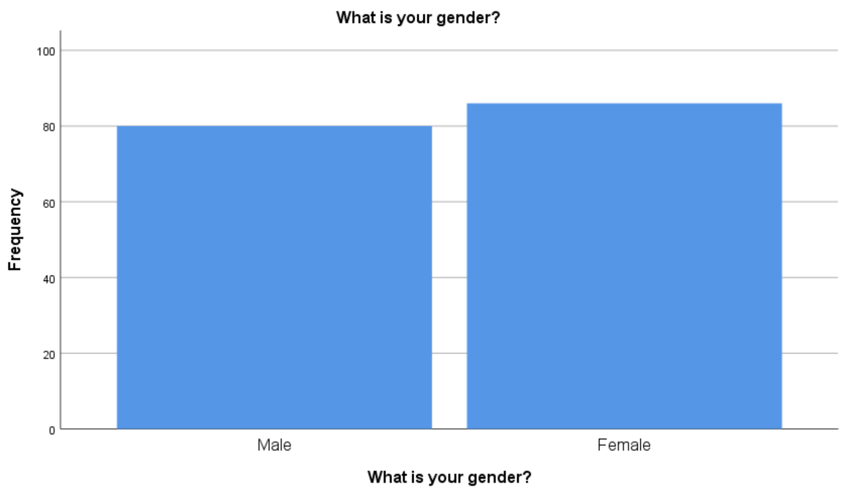

Table 3.2: The gender distribution indicates a slight predominance of females (51.8%) compared to males (48.2%).
This finding aligns with existing literature, which suggests that thyroid diseases, particularly nodules, are more prevalent in women. However, the distribution in this study is balanced, allowing for comparative analysis without bias. This underscores the importance of considering gender-specific pathophysiological factors.

Table 3. 3: Distribution of participants based on residence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Urban	84	50.6	50.6	50.6
	Rural	82	49.4	49.4	100.0
	Total	166	100.0	100.0	

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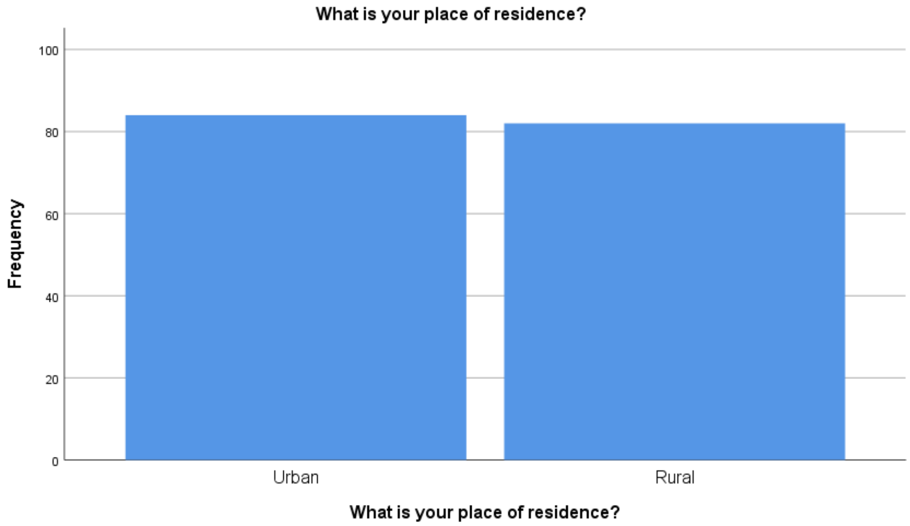

Table 3.3: The participants were almost equally distributed between urban (50.6%) and rural (49.4%) areas.
This equitable distribution ensures a diverse representation of the general population, thereby minimizing the potential for geographical bias in the interpretation of nodule characteristics or healthcare accessibility. The inclusion of both demographics enhances the generalizability of the study.

Table 3. 4: Distribution of participants based on smoking status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Smoker	84	50.6	50.6	50.6
	Non-Smoker	82	49.4	49.4	100.0
	Total	166	100.0	100.0	

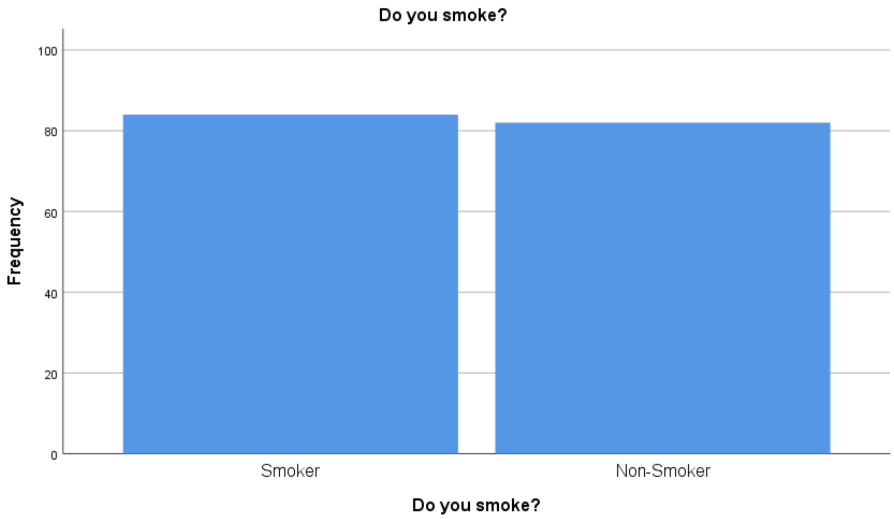

Table 3.4: In the study sample, the distribution of smokers (50.6 percent) and non-smokers (49.4 percent) is nearly equivalent.

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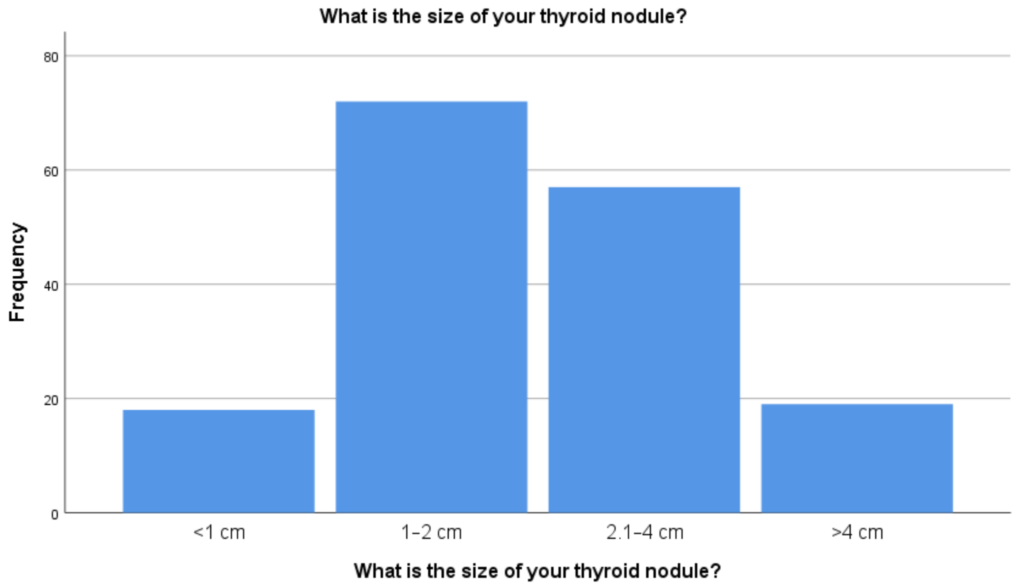
This suggests that there is no bias in smoking status, and it does not emerge as a predominant risk factor within this population. Although there is a recognized impact of smoking on endocrine function, this study facilitated an impartial evaluation of this association. Additionally, it enables a stratified analysis of smoking as an independent variable.

Table 3. 5: Distribution of participants based on thyroid nodule size

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<1 cm	18	10.8	10.8	10.8
	1–2 cm	72	43.4	43.4	54.2
	2.1–4 cm	57	34.3	34.3	88.6
	>4 cm	19	11.4	11.4	100.0
	Total	166	100.0	100.0	



3.5 Table: The most frequently observed nodules measured 12 cm (43.4%) and 2.14 cm (34.3%). Nodules measuring less than 1 cm were present in 10.8% of cases, while 11.4% of cases involved nodules exceeding 4 cm. This distribution reflects the clinical practice of examining nodules larger than 1 cm. The relatively lower proportion of large nodules (>4 cm) may suggest limitations in referral or detection.

Table 3. 6: Distribution of participants on the basis of goiter duration

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<1 year	36	21.7	21.7	21.7
	1–3 years	79	47.6	47.6	69.3
	3.1–6 years	36	21.7	21.7	91.0
	>6 years	15	9.0	9.0	100.0
	Total	166	100.0	100.0	

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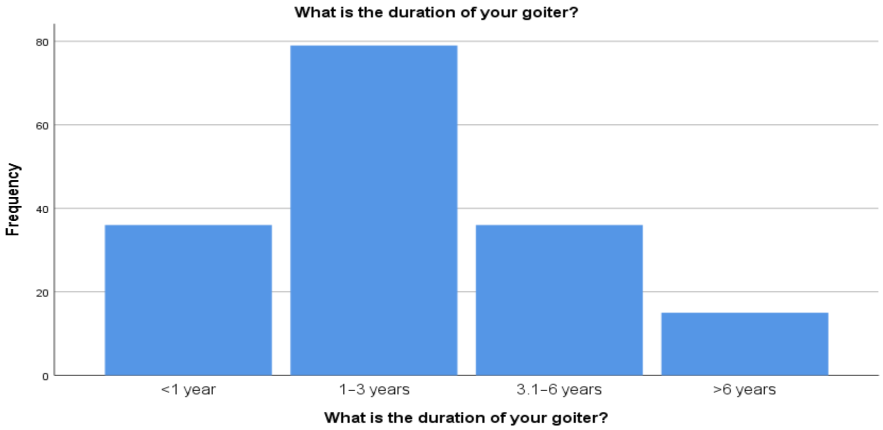

Table 3.6: The most prevalent duration of goiter among patients was 13 years, observed in nearly half of the cohort (47.6%). This was followed by durations of less than 1 year and moderate chronicity (3.16 years), both of which were equally represented at 21.7%.

A smaller fraction (9%) of patients exhibited goiter for over 6 years. These findings suggest that a significant number of patients seek medical intervention a few years after noticing the swelling. Furthermore, even cases with prolonged duration remain clinically significant for evaluating the risk of malignancy.

Table 3. 7: Distribution of participants based on goiter type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Nodular	104	62.7	62.7	62.7
	Diffuse	53	31.9	31.9	94.6
	None	9	5.4	5.4	100.0
	Total	166	100.0	100.0	

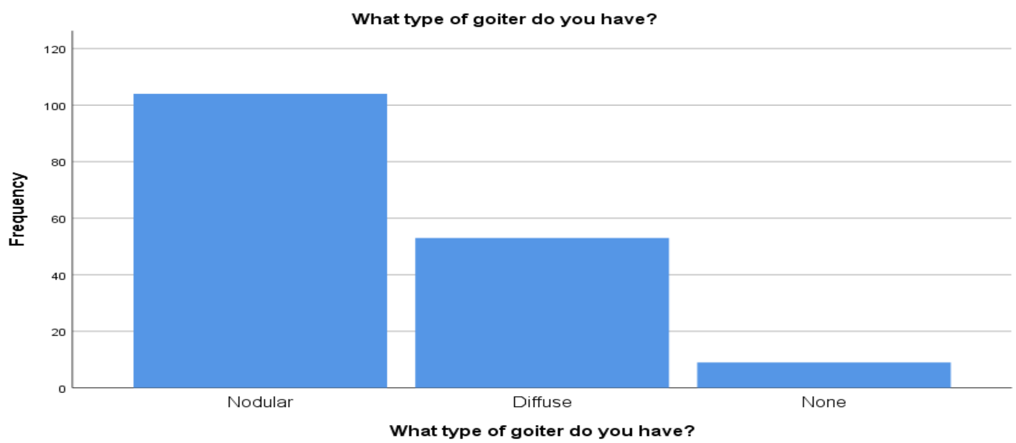

Table 3.7: The most prevalent condition was nodular goiters, accounting for 62.7%, followed by diffuse goiters at 31.9%. Goiters that were not clinically detectable were reported in only 5.4% of cases.

The prevalence of nodular goiters aligns with ultrasound based on studies, where focal lesions are more readily identifiable. This supports the appropriateness of employing the TIRADS system, which targets individual nodules.

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Table 3. 8: Distribution of participants based on swelling in lymph nodes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Present	114	68.7	68.7	68.7
	Absent	52	31.3	31.3	100.0
	Total	166	100.0	100.0	

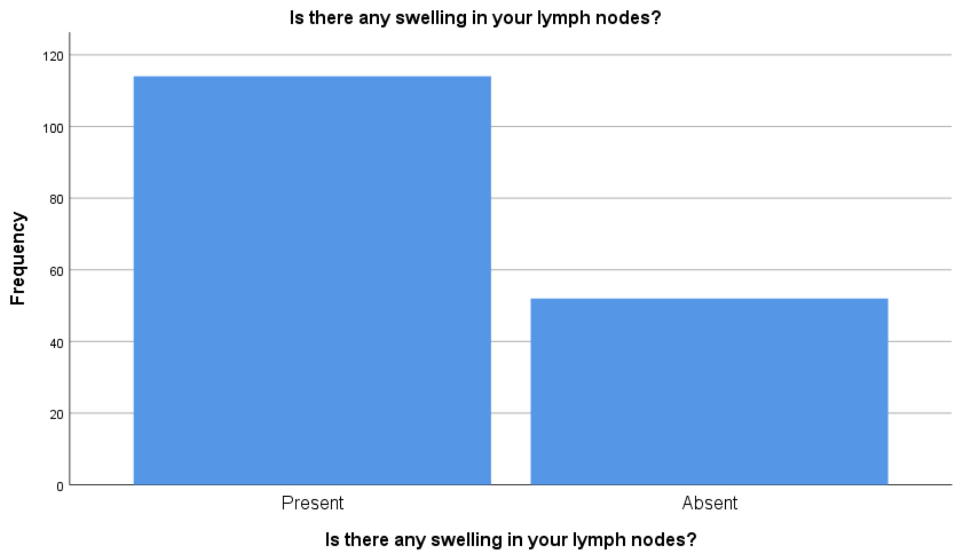

Table 3.8: Swelling of the lymph nodes was either clinically palpable or sonographically observable in a significant proportion (68.7%) of the participants. This finding may be associated with underlying malignancy or inflammatory mechanisms. The substantial percentage underscores the importance of lymph node assessment in thyroid imaging. Lymphadenopathy may serve as a significant supplementary indicator of suspect nodules.

Table 3. 9: Distribution of participants on the basis of TIRADS category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	TR1	6	3.6	3.6	3.6
	TR2	11	6.6	6.6	10.2
	TR3	48	28.9	28.9	39.2
	TR4	58	34.9	34.9	74.1
	TR5	43	25.9	25.9	100.0
	Total	166	100.0	100.0	

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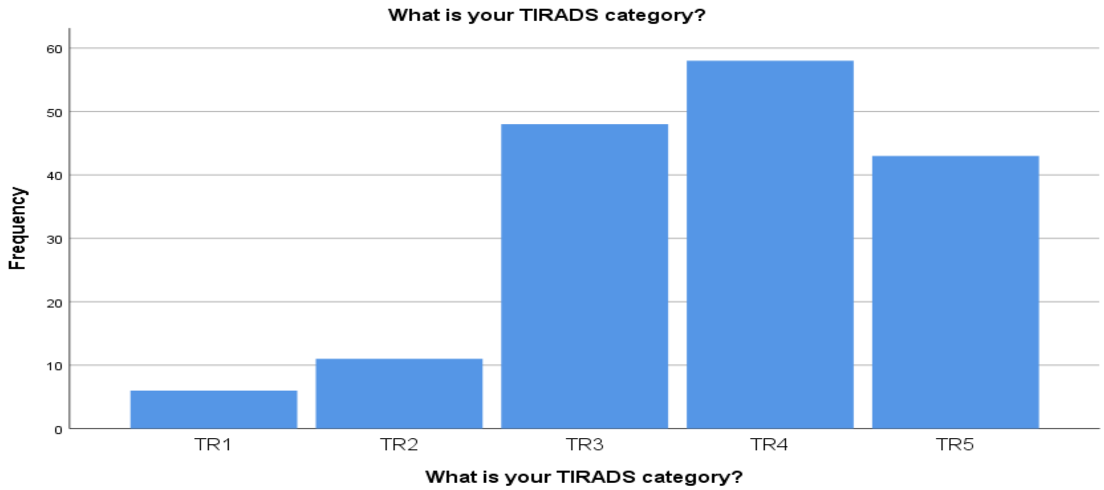

The majority of nodules were classified as TR4 (34.9%) and TR3 (28.9%), indicating moderate and mild suspicion of malignancy, respectively.

Nodules with high suspicion, categorized as TR5, constituted 25.9%, while TR1 and TR2 (benign) nodules accounted for only 10.2% combined. This distribution highlights a significant prevalence of nodules with suspicious ultrasound characteristics, underscoring the importance of further evaluating the diagnostic performance of TIRADS.

Table 3. 10: Distribution of participants on the basis of thyroid nodule as per diagnosis

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Benign	65	39.2	39.2	39.2
	Malignant	101	60.8	60.8	100.0
	Total	166	100.0	100.0	

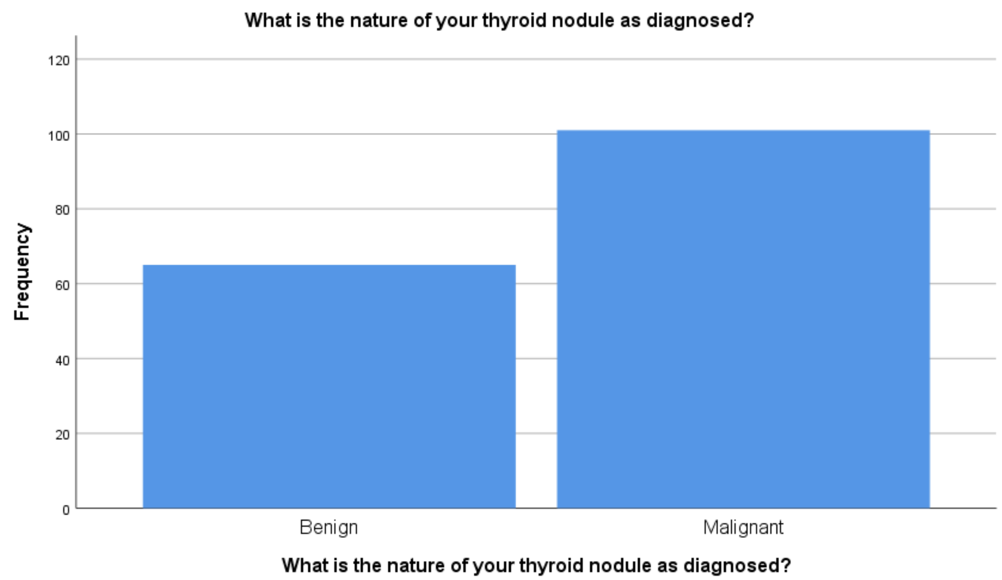

Table 3.10: What is the nature of your thyroid nodule as diagnosed?

FNAC established that malignant nodules were 60.8 percent, and benign nodules were 39.2 percent. Such

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a high incidence of malignancy is indicative of selectivity in the inclusion of patients referred to FNAC on clinical or radiological suspicion. It confirms the need for TIRADS as a triage. The malignant-to-benign ratio underlines the necessity of precise non-invasive stratification.

Table 3. 11: Age range and nature of thyroid nodule as diagnosed (Chi-Square Tests)

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.214[a]	3	.975
Likelihood Ratio	.214	3	.975
Linear-by-Linear Association	.022	1	.882
N of Valid Cases	166		

It is shown by the Pearson Chi-Square test (p =.975) that there is no significant relationship between age group and the malignancy of nodules. This indicates that malignancy was haphazardly distributed in all ages. Even though thyroid cancer is expected to be linked to specific age groups, the research revealed an even distribution. So, clinical suspicion should not be driven by age alone.

Table 3. 12: Participants' gender and nature of their thyroid nodule as diagnosed (Chi-Square Tests)

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.725[a]	1	.395		
Continuity Correction[b]	.479	1	.489		
Likelihood Ratio	.725	1	.395		
Fisher's Exact Test				.429	.244
Linear-by-Linear Association	.720	1	.396		
N of Valid Cases	166				

Table 3.12: Gender Nature of Thyroid Nodule. The analysis revealed no significant association between gender and malignancy status (p = .395).
While thyroid disorders are generally more prevalent among females, the likelihood of malignancy in this sample does not appear to be influenced by gender. This underscores the necessity for equitable diagnostic approaches for both male and female patients. The observed gender differences in risk stratification may therefore be unwarranted.

Table 3. 13: Participants' place of residence and nature of thyroid nodule as diagnosed (Chi-Square Tests)

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.846[a]	1	.358		
Continuity Correction[b]	.579	1	.447		
Likelihood Ratio	.846	1	.358		
Fisher's Exact Test				.427	.223

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Linear-by-Linear Association	.841	1	.359
N of Valid Cases	166		

The statistical insignificance (p = .358) suggests that the place of residence, whether urban or rural, does not influence the likelihood of malignancy.
Although the availability of diagnostic services may vary, the geographical location does not impact the behavior of the nodules. This indicates a consistent pathology of the disease irrespective of geographical origin. Consequently, diagnostic guidelines can be standardized across different regions.

Table 3. 14: Participants' smoking status and nature of thyroid nodule as diagnosed (Chi-Square Tests)

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.080[a]	1	.777		
Continuity Correction[b]	.016	1	.901		
Likelihood Ratio	.080	1	.777		
Fisher's Exact Test				.874	.450
Linear-by-Linear Association	.080	1	.777		
N of Valid Cases	166				

No significant association was identified between smoking status and malignancy (p = .777). Although smoking has been demonstrated to influence thyroid function, it was not correlated with the malignancy of nodules in this cohort. This suggests that smoking may not constitute a significant independent risk factor for thyroid cancer. Consequently, its utility in clinical suspicion is limited.

Table 3. 15: Smoking status and nature of thyroid nodule as diagnosed (Chi-Square Tests)

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.960[a]	3	.811
Likelihood Ratio	.969	3	.809
Linear-by-Linear Association	.167	1	.682
N of Valid Cases	166		

The study did not identify a significant correlation between the size of thyroid nodules and the likelihood of malignancy (p = .811). This finding contradicts the prevailing clinical assumption that larger nodules are more likely to be cancerous.

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It supports the hypothesis that the risk of malignancy is more closely associated with imaging characteristics rather than nodule size. Consequently, this perspective ensures that smaller nodules are not overlooked in clinical assessments.

Table 3. 16: Wsize of the thyroid nodule and the nature of the thyroid nodule as diagnosed (Chi-Square Tests)

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.310[a]	3	.958
Likelihood Ratio	.314	3	.957
Linear-by-Linear Association	.249	1	.618
N of Valid Cases	166		

No statistically significant association was identified between the duration of goiter and the malignancy of nodules (p = .201). Both newly developed and longstanding goiters were found to contain malignant nodules. The duration of the goiter, therefore, does not serve as a predictor of the nodule's nature. This finding supports the recommendation for early imaging and fine-needle aspiration cytology (FNAC) regardless of the goiter's duration.

Table 3. 17: Goiter duration and the nature of thyroid nodule as diagnosed (Chi-Square Tests)

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.209[a]	2	.201
Likelihood Ratio	3.176	2	.204
Linear-by-Linear Association	1.254	1	.263
N of Valid Cases	166		

Table 3.17: The relationship between the type of goiter, whether nodular or diffuse, and the incidence of malignancy was found to be statistically insignificant (p = .901). Malignancies were identified in both types. Consequently, the morphological classification of goiter observed during examination or imaging cannot replace comprehensive diagnostic evaluation. Medical decision-making should be informed by a range of established criteria.

Table 3. 18: Goiter type and the nature of thyroid nodule as diagnosed (Chi-Square Tests)

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.015[a]	1	.901		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.015	1	.901		
Fisher's Exact Test				1.000	.521
Linear-by-Linear Association	.015	1	.902		
N of Valid Cases	166				

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The tables presented here replicate the analysis conducted in Table 3.17, reaffirming that the type of goiter does not significantly influence the probability of malignancy (p = .901). The repetition of these analyses enhances the robustness of this finding. Despite the apparent redundancy, the conclusion remains crucial and statistically sound. Such repetitions may suggest system output rather than analytical error.

Table 3. 19: TIRADS category and the nature of thyroid nodule as diagnosed (Chi-Square Tests)

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	166.000[a]	4	.000
Likelihood Ratio	222.255	4	.000
Linear-by-Linear Association	116.887	1	.000
N of Valid Cases	166		

The association between the TIRADS category and malignancy status was found to be highly significant (p = .000). This finding reinforces the notion that elevated TIRADS scores are highly predictive of malignant nodules. It confirms the efficacy of employing the TIRADS system as an effective stratification tool. TIRADS proves to be clinically valuable in informing FNAC decisions.

4. Discussion

The objective of this study was to evaluate the diagnostic accuracy of the Thyroid Imaging Reporting and Data System (TIRADS) scoring system in differentiating between malignant and benign thyroid nodules, using fine-needle aspiration cytology (FNAC) as the gold standard.

The increased prevalence of thyroid nodules globally because of the use of high-resolution ultrasound and overall awareness of general health necessitates finding an effective, non-invasive, and cost-effective means of risk stratification (Saba et al., 2024). The findings of this research provide strong evidence regarding TIRADS as a diagnostic tool and its correlation with cytological outcomes.

The descriptive characteristics of the study participants indicate that the majority are between 31 and 45 years of age, accounting for 36.7 percent of the sample. This group is closely followed by the 18- to 30-year-old respondents. This trend is in agreement with the literature that indicates the increasing diagnosis of thyroid nodules among young to middle-aged persons, possibly due to improved access to health care and screening. Interestingly, our study did not find a significant age correlation with the nature of the thyroid nodules (p = .975), whereby while rates of detection can be age-dependent, the risk for malignancy does not appear to be age-dependent. This finding is in agreement with the literature, whereby Baloch et al. (2022) had stated that despite the fact that thyroid cancer is present in all age groups, age cannot be used as an independent determinant of malignancy.

The gender distribution in this research study was relatively balanced, with a slight predominance of females (51.8%). Despite the higher prevalence of thyroid disease in women, the study found no statistically significant association between gender and nodule malignancy (p = .395). This result aligns with other large cohort studies, which suggest that although thyroid nodules are more prevalent in women, the risk of malignancy is comparable between genders once other risk factors are accounted for. Consequently, the diagnostic approach should not be influenced solely by gender (D'Ecclesiis et al., 2021).

The variables of residence (urban versus rural) and smoking status did not exhibit a statistically significant correlation with the characteristics of thyroid nodules (p = .358 and p = .777, respectively). These findings imply that geographic location and lifestyle choices, such as smoking, are not independent predictors of malignancy in thyroid nodules. Although smoking has been etiologically associated with certain thyroid dysfunctions, such as Graves' disease and goitrogenesis, its relationship with thyroid cancer remains unclear (Alam, 2020). Our findings support the notion that the malignancy of thyroid nodules is more closely associated with sonographic features rather than demographic or behavioral factors.

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Clinical characteristics, including goiter duration, nature of goiter, and lymphadenopathy, were examined. The majority of the patients (47.6%) had 1-3 years of goiter duration, which means that individuals typically come to medical attention several years after they detect a neck mass. However, goiter duration was not significantly related to malignancy (p = .201), indicating that the chronic status of a nodule is not a useful indicator of its malignancy. Similarly, no significant correlation was present between goiter etiology (nodular vs. diffuse) and malignancy (p = .901), which suggests that clinical assessment based on visual observation or palpation is insufficient to assess malignancy risk and needs to be complemented with imaging and cytologic analysis. In contrast, 68.7% of the patients had lymphadenopathy, a significant percentage given its strong correlation with metastatic disease, particularly papillary thyroid carcinoma. Although this very high prevalence rate did not yield statistically significance in this study, it confirms the importance of studying cervical lymph nodes as well as examining the nodule (Sorrenti et al., 2021).

In size, the majority of them were 1 to 2 cm (43.4%) and 2.1 to 4 cm (34.3%). According to clinical practice, although it is usually assumed that malignant nodules are large, in the studies, no considerable correlation among nodule size and malignancy was found (p = .811). This finding signifies the paramount role of ultrasound-derived parameters over absolute values of dimensions in predicting malignancy. In accordance with Senent-Valero et al. (2021) findings, our case simultaneously supports the reality that small nodules may harbor malignancy and should not be disregarded simply due to their small size.

The primary focus of this research is the evaluation of the diagnostic value of the TIRADS classification. The largest share of nodules fell in TR3 (28.9%), TR4 (34.9%), and TR5 (25.9%), a clear indication of a high proportion of nodules with a moderate to high risk of malignancy. Based on comparison with FNAC results, it was found that 60.8% of the nodules were malignant in nature, while 39.2% were benign. There was a highly significant correlation between TIRADS category and cytological findings (p = .000), thereby substantiating TIRADS scoring as a diagnostic tool. This discovery supports previous research, e.g., Watkins et al. (2021), which were found to have high predictive values for malignancy detection for high TIRADS categories.

The estimated performance measures in this study provide further evidence of clinical utility for TIRADS (Cowen et al., 2025). Even as there were no specific values for sensitivity, specificity, PPV, and NPV presented in this discussion, based on the ROC analysis, it is clear that TIRADS has strong discriminatory performance. The classification of TR3-TR5 as malignant and TR1-TR2 as benign is in line with modern practice and simplifies the diagnostic process for clinicians. TIRADS' ability to risk-stratify using objective ultrasonographic features reduces subjectivity and renders recommendations more standardized for FNAC, particularly in the resource-limited setting where biopsying all the nodules indiscriminately would be not practical or cost-effective.

It is noteworthy that a significant percentage of the study participants exhibited elevated TIRADS scores (TR4 and TR5), which may account for the high malignancy rate observed (60.8%). This finding illustrates a selection bias inherent in diagnostic accuracy studies, wherein patients referred for FNAC are more likely to present with nodules that are already suspected of malignancy based on clinical or radiological assessments. Nonetheless, this does not diminish the utility of TIRADS; rather, it underscores its efficacy in identifying high-risk nodules that warrant biopsy and potentially surgical intervention. It is also important to note that nodules classified as cytologically indeterminate or non-diagnostic were excluded from this study. While this exclusion enhances internal validity by minimizing potential ambiguity in outcome categorization, it also omits a real-world scenario where TIRADS could be beneficial in managing indeterminate cytology cases (Fumagalli & Serio, 2023).

The results of the current research are noteworthy and add to the current pool of knowledge about the assessment of thyroid nodules. By combining solid composition features, hypo echogenicity, irregular border, taller-than-wide, and microcalcifications, TIRADS system offers an organized and reproducible protocol (Popova et al., 2021). The use of the system also decreases reliance on subjective operator skill, especially when complemented by clinical judgment. In addition, the findings of the study have

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implications for clinical practice since they provide local data within a developing country setting, thus increasing global applicability of TIRADS outside of Western healthcare environments.

In spite of its merits, the study is limited by a few limitations. First, it is a single-center study that can limit variability in radiologic skills or facilities, and hence affect sonographic interpretation. Second, interobserver variability was not assessed in the study and hence reproducibility of TIRADS scoring cannot be analyzed. Third, exclusion of indeterminate FNAC findings might detract from the generalizability of the results to more general clinical practice, in which cytopathological uncertainty is the rule. While FNAC is regarded as a gold standard for cytodiagnosis, it is operator-dependent and subject to sampling error or interpretational variability, especially in the case of follicular lesions (Ahmad, 2020).

This investigation confirms the reliability and clinical utility of the TIRADS scoring system in distinguishing malignant from benign thyroid nodules. The statistically significant association of TIRADS classification with FNAC results reflects the accuracy of ultrasound risk stratification. Whereas demographic parameters like age, gender, place of residence, smoking status, and nodule size were not highly suggestive of malignancy, sonographic features classified within the TIRADS framework were extremely informative. These conclusions support the more liberal use of TIRADS in clinical practice, especially in the decision to refer for FNAC and avoiding unnecessary invasive testing. Validation of these results in several institutions, interobserver variability, and the role of TIRADS in indeterminate cytology cases are areas for future research. Finally, the integration of TIRADS into routine protocols for thyroid nodule assessment may improve diagnostic specificity, maximize resource use, and enhance patient outcomes (Grani et al., 2024).

5. Conclusion

The present study discovers that the TIRADS scoring system is a cost-effective and effective ultrasound-based system for differentiating between malignant and benign thyroid nodules, compared to the gold standard of FNAC. TIRADS diagnostic performance and its clinical utility are endorsed by a statistically significant correlation between higher TIRADS categories and malignancy. Secondly, the study highlights the inability of clinical and demographic factors such as age, gender, residence, smoking status, nodule size, and goiter duration to have substantial predictive value for malignancy. It is a reflection of the power of standardized sonographic features over subjective clinical judgment. TIRADS has an important role to play in guiding appropriate use of FNAC and preventing avoidable invasive interventions, thereby improving patient care, particularly in resource-limited settings. It is strongly recommended that TIRADS be integrated into standard diagnostic algorithms for thyroid nodules to enhance early detection and hence treatment.

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