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Diagnostic Accuracy of ACR Ti-Rads in The Diagnosis of Thyroid Carcinoma in Solitary Thyroid Nodule Taking FNAC as Gold Standard

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ABSTRACT

Background: Thyroid carcinoma is a common malignancy with the solitary thyroid nodule (STN) being a significant risk factor. The American College of Radiology (ACR) Thyroid Imaging Reporting and Data System (Ti-RADS) is widely used for thyroid nodule risk stratification. It is essential that its performance against the gold standard fine needle aspiration cytology (FNAC) is evaluated further. **Objective:** To assess Diagnostic accuracy of ACR Ti-Rads in the diagnosis of thyroid carcinoma in solitary thyroid nodule taking FNAC as gold standard. **Study Design:** Cross-sectional validation study. **Duration and Place of Study:** The study was conducted from February 2025 to May 2025 at the Department of Diagnostic Radiology, Shifa International Hospital, Islamabad. **Methodology:** We enrolled 423 patients aged between 18-65 with suspicious thyroid nodules. ACR Ti-RADS ultrasound and FNAC for all of them were performed. Sensitivity, specificity, positive predictive value (PPV), the negative predictive value (NPV), and diagnostic accuracy of ACR Ti-RADS were determined. A stratified analysis by age and sex was performed as well. **Results:** The study found that ACR Ti-RADS demonstrated high sensitivity (87.50%) and NPV (93.60%), with moderate specificity (59.20%) and diagnostic accuracy (66.20%). The study also showed differences in diagnostic performance based on age and gender, with younger patients and males exhibiting better specificity and diagnostic accuracy. **Conclusion:** ACR Ti-RADS is a reliable, non-invasive diagnostic tool for the detection of thyroid carcinoma in patients with solitary thyroid nodules, especially when used in combination with FNAC.

INTRODUCTION

A solitary thyroid nodule (STN) is a single distinct growth of the thyroid gland.[1] A common and frequently found occurrence that is identified accidentally on neck imaging, the incidence of the nodules is age-dependent.[2] Most of the STNs being benign in nature, a few percent of them tend to have the potential of being malignant.[3] Clinical significance of a solitary nodule is its potential of being a thyroid carcinoma that requires proper evaluation for its appropriate treatment.[3] In the majority of the cases, the STNs are symptomless, and clinical examination cannot reliably ascertain a difference between a malignant and a benign nodule.[4] Thus, the additional diagnostic work-up in the form of imaging and biopsy is the key in ascertaining the risk of malignancy.[4]

Thyroid carcinoma is a relatively infrequent but well-recognized malignancy with an increased incidence in the past few decades.[5] It is generally classified into the different forms of histology like papillary, follicular, medullary, and anaplastic carcinoma.[6] Of these, the most prevalent form is papillary thyroid carcinoma (PTC), which accounts for 80% of tumors.[7] Clinical presentation of thyroid cancer is generally nonspecific with a neck mass that is not painful.[6] Risk factors of thyroid carcinoma include family history of thyroid cancer, history of neck irradiation, and certain genetic mutations.[8] Early detection and accurate diagnosis are crucial as most thyroid carcinomas have a good prognosis if they are detected early.

Diagnosis of thyroid carcinoma is a combination of clinical examination, image and histopathological correlation.[9] A fine-needle aspiration cytology (FNAC) biopsy is the gold standard for the assessment of thyroid nodules as it presents direct cellular analysis.[9] Despite that, FNAC is not perfect and is susceptible to false negatives and indeterminate tests and thus needs further testing.[10] Imaging with techniques like ultrasound plays a significant part in the pre-operative assessment of thyroid nodules in the prediction of their vascularity, morphology, and size.[11] The American College of Radiology (ACR) Thyroid Imaging-Reporting and Data System (TI-RADS) is an evidence-based ultrasound-based system for risk stratification of malignancy in thyroid nodules.[12] The TI-RADS system classifies a nodular aspect according to certain ultrasound characteristics such as nodule composition, echogenicity, shape, margin, and the

presence of calcifications using a scoring system.[13] It assists in clinical decision-making by classifying the nodules into various risk categories ranging from benign to highly suspicious of malignancy based on the given scores.[13] The utilization of TI-RADS has proven helpful in the earlier detection of thyroid carcinoma with improved diagnostic precision and decreasing the number of unnecessary biopsies in low-risk patients.[14] Although the incorporation of TI-RADS simplifies the diagnostic process, it must be combined with FNAC and clinical acumen in order to provide the most precise diagnosis.

The study reported that the ACR TI-RADS cut-off value for TR4 yielded the following performance metrics: sensitivity of 85.7%, specificity of 54.1%, positive predictive value (PPV) of 58.5%, and accuracy of 67.7% (AUC = 0.738; $p < 0.001$). According to the ACR TI-RADS system, approximately one-third of patients were misclassified, with 17.9% of thyroid carcinomas, specifically micropapillary carcinomas, being missed.[15]

The need for this study emanates from the fact that there is a rising prevalence of thyroid nodules which are usually incidentally picked up during imaging. Despite the fact that distinguishing benign thyroid carcinoma among solitary thyroid nodule cases is still a clinical challenge, the precise diagnosis of thyroid carcinoma is of crucial importance for the adequate treatment management. Although the Fine Needle Aspiration Cytology has remained the gold standard, factors limiting it such as the inadequacy of the sample and dependence of the operator means the time calls for non-invasive diagnostic techniques to be reviewed which include the ACR TI-RADS. This study will help in determining the diagnostic accuracy of ACR TI-RADS in diagnosing thyroid carcinoma; it may provide an opportunity for enhancing the efficiency of diagnostic processes and clinical decision-making.

METHODOLOGY

This cross-sectional validation study was conducted from February 2025 to May 2025 at the Department of Diagnostic Radiology, Shifa International Hospital in Islamabad. A total of 423 patients were included in the study, with sample size calculations based on a sensitivity of 85.7%, a specificity of 54%,[15] and an incidence of thyroid carcinoma among patients with solitary thyroid nodules (STN) of 31%.[16] The study included patients aged 18 to 65, of either gender, who presented with suspicious thyroid nodules displaying characteristics such as hypo-echogenicity, irregular or micro-lobulated margins, taller-than-wide shape, punctate echogenic foci, and solid components on ultrasonography (US). Exclusion criteria consisted of patients with a history of thyroid surgery, radiation therapy, or those presenting with completely cystic nodules. After obtaining informed consent, demographic information was collected from all participants, including age, gender, and any relevant medical history.

Ultrasound scanning using an Apollo or Xario machine measured the nodule's dimensions, composition, echogenicity, configuration, margins, and echogenic foci. The nodules with characteristics that fall within a TIRADS 3 to 5 (values 3 to 7 points) based on these parameters were considered for fine needle aspiration cytology (FNAC). FNAC consisted of the insertion of the needle into the nodule under the ultrasound with a view to taking the biopsy for examination. The biopsy was then sent for examination by the Pathology Department based on parameters such as the rounded and cuboidal nature of the cell as well as the size of the cells and the identification of certain features such as the presence of psammoma bodies or colloid material. The pathologist's findings were communicated with the Radiology Department within 3 to 5 days.

The diagnostic performance of ACR Ti-RADS in identifying thyroid carcinoma in solitary thyroid nodules was evaluated against FNAC as the gold standard. Positive thyroid carcinoma was confirmed using the malignancy of the FNAC result. Lack of carcinoma represented the negative diagnosis. Status of patients as true positive, true negative, false positive, or false negative depended on the concordance of ACR Ti-RADS classification and FNAC result. True positive consisted of situations when nodule classification as ACR Ti-RADS suspicious/malignancy agreed with confirmed thyroid carcinoma by FNAC. True negatives consisted of situations when the nodule appeared as benign by ACR Ti-RADS but as non-malignant by FNAC. False positives consisted of situations when malignancy was detected by ACR Ti-RADS but the nodule appeared as benign by FNAC. False negatives consisted of situations when ACR Ti-RADS did not show malignancy but FNAC identified the nodule as thyroid carcinoma.

Sensitivity and specificity, positive predictive value and negative predictive value, and diagnostic accuracy were calculated using a 2x2 contingency table. ACR Ti-RADS' ability to differentiate known cases of thyroid carcinoma was its sensitivity. ACR Ti-RADS' ability to correctly differentiate benign nodules equated its specificity. ACR Ti-RADS' chance of correctly diagnosing thyroid carcinoma with a suspicious outcome equated its positive predictive value. The chance that a benign ACR Ti-RADS result correctly labeled a non-cancerous nodule equated its negative predictive value. Diagnostic accuracy equated the proportion of ACR Ti-RADS' accurate classification from all of its diagnoses. Data were entered and analyzed using SPSS version 23. Qualitative variables were presented as frequencies and percentages, while quantitative variables, such as age, were presented as means and standard deviations. The diagnostic performance of ACR Ti-RADS for identifying thyroid carcinoma in STN patients was assessed, with FNAC results serving as the reference standard.

RESULTS

The study included 423 patients with a mean age of 46.787 ± 9.97 years, with females comprising the majority (71.2%, n=301) of the sample, while males represented 28.8% (n=122) (as shown in Table 1).

Table 1

Patient Demographics

Demographics		Mean ± SD
Age (years)		46.787 ± 9.97
Gender	Male n (%)	122 (28.8%)
	Female n (%)	301 (71.2%)

The diagnostic results indicated that ACR Ti-RADS classified 52.2% (n=221) of thyroid nodules as positive (suspicious for malignancy) and 47.8% (n=202) as negative, whereas FNAC identified a lower percentage of malignant cases at 24.6% (n=104) with 75.4% (n=319) being benign (as shown in Table 2).

Table 2
Overall Results of ACR Ti-RADS and FNAC

Diagnostic Results	ACR Ti-RADS	FNAC
Positive	221 (52.2%)	104 (24.6%)
Negative	202 (47.8%)	319 (75.4%)
Total	423 (100%)	423 (100%)

The comparison between ACR Ti-RADS and FNAC revealed 91 true positives, 130 false positives, 13 false negatives, and 189 true negatives (as shown in Table 3).

Table 3
Comparison of ACR Ti-RADS versus FNAC

ACR Ti-RADS	FNAC		Total
	Positive	Negative	
Positive	91 (TP)	130 (FP)	221
Negative	13 (FN)	189 (TN)	202
Total	104	319	423

Key: TP = True positive FP = False positive
FN = False negative TN = True negative

Overall, ACR Ti-RADS demonstrated a high sensitivity of 87.50% and NPV of 93.60%, but moderate specificity of 59.20%, diagnostic accuracy of 66.20%, and relatively low PPV of 41.20% in detecting thyroid carcinoma compared to FNAC (as shown in Table 4).

Table 4
Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of ACR Ti-RADS in Diagnosis Compared to FNAC

Diagnostic Parameter	Result
Sensitivity	87.50%
Specificity	59.20%
Diagnostic Accuracy	66.20%
PPV	41.20%
NPV	93.60%

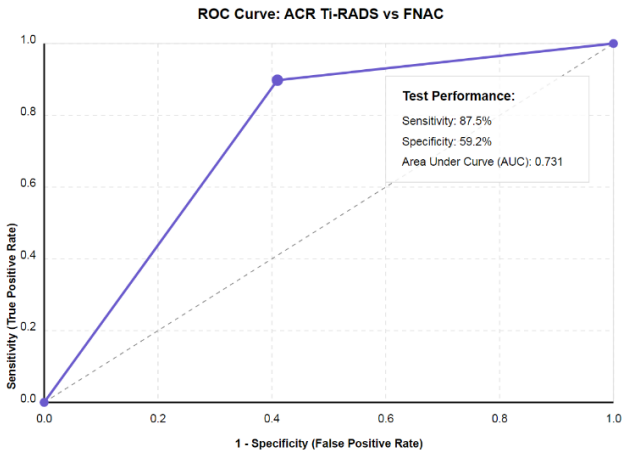
In stratified analyses, patients ≤40 years showed better diagnostic performance with higher sensitivity (90.90% vs 85.00%), specificity (66.30% vs 56.30%), diagnostic accuracy (74.10% vs 62.30%), and PPV (55.60% vs 34.20%) compared to patients >40 years. Regarding gender differences, males exhibited lower sensitivity (84.00% vs 88.60%) but higher specificity (74.20% vs 52.70%), higher diagnostic accuracy (76.20% vs 62.10%), higher PPV (45.70% vs 40.00%), and slightly higher NPV (94.70% vs 92.90%) compared to females in the detection of thyroid carcinoma using ACR Ti-RADS (as shown in Table 5).

Table 5
Stratified analysis of Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of ACR Ti-RADS in Diagnosis Compared to FNAC with Age and Gender

Variables	Groups	Diagnostic Parameter	Result
Age (years)	≤40	Sen	90.90%
		Spec	66.30%
		DA	74.10%
		PPV	55.60%
		NPV	94.00%
	>40	Sen	85.00%
		Spec	56.30%
		DA	62.30%
		PPV	34.20%
		NPV	93.30%
Gender	Male	Sen	84.00%
		Spec	74.20%
		DA	76.20%
		PPV	45.70%
		NPV	94.70%
	Female	Sen	88.60%
		Spec	52.70%
		DA	62.10%
		PPV	40.00%
		NPV	92.90%

The Receiver Operating Characteristic (ROC) curve (Figure 1) illustrates the diagnostic performance of ACR Ti-RADS when using FNAC as the reference standard. With a sensitivity of 87.5% and specificity of 59.2%, the ACR Ti-RADS demonstrates good ability to identify true positive cases but moderate capability in ruling out negative cases. The AUC of 0.731 demonstrates good discriminatory ability since the range 0.7-0.8 is an acceptable range for diagnostic tests. It means that ACR Ti-RADS is better in detecting positive outcomes that will be confirmed with FNAC but is creating a high number of false positives. To clinical practice, the test is more likely to be of assistance as a screening exercise rather than a decision-making type of procedure.

Figure 1
ROC Curve



DISCUSSION

Our findings indicate ACR Ti-RADS is highly sensitive (87.5%) but its specificity is 59.2% with a 66.2% diagnostic accuracy and an AUC of 0.731. ACR Ti-RADS is highly sensitive because of its comprehensive

ultrasonographic criteria which pick up on suspicious sonographic features of malignancy like microcalcifications, irregular borders, and hypoechogenicity. The 59.2% moderate specificity translates into ACR Ti-RADS overclassifying a high proportion of benign nodules as suspicious hence yielding a high number of false positives (n=130). This limitation may stem from the inherent overlap in ultrasonographic features between certain benign conditions (such as lymphocytic thyroiditis) and malignant lesions. Stratified analysis revealed better diagnostic performance in younger patients (Age ≤40 years group) with higher specificity (66.3%) compared to the Age >40 years group (56.3%). This age-dependent variation could be explained by the increased prevalence of benign nodular disease and architectural distortion in older populations, which may mimic malignant features on ultrasound imaging. Similarly, our gender-stratified analysis showed that Ti-RADS performed better in males (specificity 74.2%) than females (specificity 52.7%), possibly due to differences in hormonal influences on thyroid tissue composition and nodular characteristics.

The positive predictive value (PPV) of 41.2% indicates that less than half of the nodules classified as suspicious by ACR Ti-RADS were confirmed malignant by FNAC, suggesting a potential for reducing unnecessary invasive procedures. Conversely, the high negative predictive value (NPV) of 93.6% provides strong reassurance that nodules categorized as likely benign by Ti-RADS are indeed non-malignant, supporting its value as a reliable screening tool. In the study of Kang et al. [16] diagnostic performance of ACR and Kwak TI-RADS systems in the differentiation of malignant and benign thyroid nodules was evaluated with the observations demonstrating that both systems possessed high diagnostic potential with the optimum cut-off scores being TR4 for ACR and 4B for Kwak TI-RADS. Sensitivity and specificity of ACR-TIRADS (94.3% and 52.2%, respectively) and of Kwak TI-RADS (96.4% and 53.7%, respectively) is comparable with the findings of the current study of ACR-TIRADS with a sensitivity of 87.50%, a specificity of 59.20%, and a high NPV of 93.60%. The two studies establish that ACR-TIRADS is highly sensitive but with moderate specificity with a finding that is common in the current study with a moderate specificity value of 59.20%.

Hekimsoy et al. [17] presented that the ACR-TIRADS sensitivity and specificity were 71% and 75%, but Nighat et al. [19] estimated the TI-RADS sensitivity and specificity as 77.8% and 75.5%. Our current work has a better sensitivity of 87.50%, but lower specificity of 59.20%. Our enhanced sensitivity within the current work is perhaps a result of the increased sample population and more diverse demography of the patients that enables ACR-TIRADS to capture true positives but with the tradeoff of increased false positives. Hekimsoy's work emphasized moderate diagnostic performance that perhaps is a result of the difference in clinical settings or the patients' population.

The findings of Khatti et al. [18] also support the utility of ACR-TIRADS when combined with FNAC with evidence of increased diagnostic rate with ultrasonography (TI-RADS being part of it), with 98.88% sensitivity when combined with FNAC. Our study similarly confirmed the added utility of ACR-TIRADS with FNAC with more emphasis on NPV (93.60%) and the reduction in avoidable biopsies. Higher sensitivity and NPV in both the studies reiterate the utility of ACR-TIRADS as a tool that raises the diagnostic rate of carcinoma of the thyroid.

Conversely, Nasser et al. [20] and Khan et al. [21] contrasted ACR-TIRADS with other diagnostic modalities like thyroid scans and FNAC. ACR-TIRADS performed better in the detection of malignancy compared with thyroid scans for Nasser et al. [20] with a sensitivity of 100%. Our results document that ACR-TIRADS had a sensitivity of 87.50% with moderate specificity as evident from its comparative efficacy with other modalities like FNAC with reduced sensitivity of 24.6%. The difference is perhaps due to the intrinsic weakness of FNAC in detecting certain malignancy as ACR-TIRADS presents a non-invasive and reproducible risk stratification tool.

Our examination further revealed differences in the diagnostic performance of males and females with males being more specific and diagnostically accurate compared to females. This agrees with Wahid et al. [22] who reported high diagnostic accuracy of ultrasound for the detection of malignant thyroid nodules. Our analysis indicates that the diagnostic performance of males with ACR-TIRADS was better compared with that of females and that it might likely be due to the role of biology or physiology in the interpretation of test results.

These findings reinforce earlier publications and further elucidate the utility of ACR-TIRADS as an essential tool in clinical practice. By comparing ACR-TIRADS with FNAC and taking into account age, sex, and diagnostic performance, we learn about certain groups of patients that benefit the most from this method. Our evidence is indicative of the benefit of implementing ACR-TIRADS into routine clinical practice with the possibility of reducing unnecessary biopsies and improved outcomes for patients. Despite the significant results of the present work, the study does have some limits. It is a single-center study and thus its outcomes may not apply across other groups and other healthcare settings. It is uncertain that even the current sample population of the study is capable of explaining all the variation of thyroid nodule features among different groups and regions of the world. More multicenter prospective works with larger and more diverse groups of the population should be carried out in the future in an effort to validate and make these observations generalizable.

CONCLUSION

Based on our findings, we have concluded that ACR-TIRADS is an extremely valuable tool in the differentiation of the malignant and the benign thyroid nodules with a high sensitivity and good negative predictive value. It has a high clinical potential of applicability where it is used in combination with FNAC for the enhancement of diagnostics and the prevention of avoidable biopsy. Based on this finding, ACR-TIRADS is observed to have a potential of great importance in the management of thyroid nodules in that it is a reliable and non-invasive malignancy stratification tool. It is required that more research work is carried out in an attempt to establish its

thrust when dealing with diverse patients.

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REFERENCES

1. Rehman AU, Ehsan M, Javed H, Ameer MZ, Mohsin A, Aemaz Ur Rehman M, et al. Solitary and multiple thyroid nodules as predictors of malignancy: a systematic review and meta-analysis. Thyroid Res 2022;15(1):22. https://doi.org/10.1186/s13044-022-00140-6.
2. McQueen A, Al-Zuhir N, Ali T. Incidentalomas in the head & neck. Br J Radiol 2023;96(1142):20220164. https://doi.org/10.1259/bjr.20220164.
3. AlSaedi AH, Almalki DS, ElKady RM. Approach to thyroid nodules: diagnosis and treatment. Cureus 2024;16(1):e52232. https://doi.org/10.7759/cureus.52232.
4. Venkatesh N, Ho JT. Investigating thyroid nodules. Aust Prescr 2021;44(6):200-204. https://doi.org/10.18773/austprescr.2021.055.
5. Tong J, Ruan M, Jin Y, Fu H, Cheng L, Luo Q, Liu Z, et al. Poorly differentiated thyroid carcinoma: a clinician's perspective. Eur Thyroid J 2022;11(2):e220021. https://doi.org/10.1530/ETJ-22-0021.
6. Jung CK, Bychkov A, Kakudo K. Update from the 2022 World Health Organization classification of thyroid tumors: a standardized diagnostic approach. Endocrinol Metab (Seoul) 2022;37(5):703-718. https://doi.org/10.3803/EnM.2022.1553.
7. Metovic J, Cabutti F, Osella-Abate S, Orlando G, Tampieri C, Napoli F, et al. Clinical and pathological features and gene expression profiles of clinically aggressive papillary thyroid carcinomas. Endocr Pathol 2023;34(3):298-310. https://doi.org/10.1007/s12022-023-09769-x.
8. Hu J, Yuan IJ, Mirshahidi S, Simental A, Lee SC, Yuan X. Thyroid carcinoma: phenotypic features, underlying biology and potential relevance for targeting therapy. Int J Mol Sci 2021;22(4):1950. https://doi.org/10.3390/ijms22041950.
9. Rajyakodi K, Balasubramanian A, Sundaram S, Gnanavel H. Clinicopathological and radiological correlation among the spectrum of nodular thyroid lesions. Cureus 2024;16(10):e70725. https://doi.org/10.7759/cureus.70725.
10. Alhassan R, Al Busaidi N, Al Rawahi AH, Al Musalhi H, Al Muqbali A, Shanmugam P, et al. Features and diagnostic accuracy of fine needle aspiration cytology of thyroid nodules: retrospective study from Oman. Ann Saudi Med 2022;42(4):246-251. https://doi.org/10.5144/0256-4947.2022.246.
11. Gao L, Ma L, Li X, Liu C, Li N, Lian X, et al. Using preoperative ultrasound vascularity characteristics to estimate medullary thyroid cancer. Cancer Imaging 2023;23(1):64. https://doi.org/10.1186/s40644-023-00583-6.
12. Sharafi SN, Moarefzadeh M, Moradi MT. The horizon of thyroid imaging reporting and data system in the diagnostic performance of thyroid nodules: clinical application and future perspectives. touchREV Endocrinol 2024;20(2):81-90. https://doi.org/10.17925/EE.2024.20.2.11.
13. Pires AT, Mustafá AMM, Magalhães MOG. The 2017 ACR TI-RADS: pictorial essay. Radiol Bras 2022;55(1):47-53. https://doi.org/10.1590/0100-3984.2020.0141.
14. Anwar K, Mohammad AY, Khan S. The sensitivity of TIRADS scoring on ultrasonography in the management of thyroid nodules. Pak J Med Sci 2023;39(3):870-874. https://doi.org/10.12669/pjms.39.3.7313.
15. Grimmichová T, Pacesová P, Šbrová L, Vrbíková J, Havrdová T, Hill M. The gold standard of thyroid nodule examination? Prospective validation of the ACR TI-RADS in a secondary referral center. Physiol Res 2020;69(Suppl 2):S329-S337. https://doi.org/10.33549/physiolres.934515
16. Kang YJ, Stybayeya G, Lee JE, Hwang SH. Diagnostic performance of ACR and Kwak TI-RADS for benign and malignant thyroid nodules: an update systematic review and meta-analysis. Cancers 2022;14(12):5961. https://doi.org/10.3390/cancers14235961.
17. Hekimsoy İ, Öztürk E, Ertan Y, et al. Diagnostic performance rates of the ACR-TIRADS and EU-TIRADS based on histopathological evidence. Diagn Interv Radiol 2021;27:511-518. https://doi.org/10.5152/dir.2021.20813.
18. Khatti SN, Soomro IA, Khan AGA, et al. Predictive value of fine needle aspiration cytology versus ultrasound TI-RADS in solitary thyroid nodule comparing with gold standard. J Popul Ther Clin Pharmacol 2024;31(7):233-238. https://doi.org/10.53555/jptcp.v31i7.6926.
19. Nighat S, Zahra M, Javed AM, et al. Diagnostic accuracy of TI-RADS classification in differentiating benign and malignant thyroid nodules-a study from Southern Punjab, Pakistan. Biomedica 2021;37(3):159-163. https://doi.org/10.51441.BioMedica.5-504.
20. Nasser IH, Aleem MA. Thyroid imaging reporting and data system (TIRADS) versus thyroid scan for solitary thyroid nodules. Med J Cairo Univ 2019;87(6):3789-3794.
21. Khan TB, Shaikh TA, Akram S, et al. Determination of diagnostic accuracy of ACR-TIRADS in detecting malignancy in thyroid nodules on ultrasonography, keeping Bethesda cytological score at FNAC as gold standard. Pak J Health Sci 2025;6(3):291-295. https://doi.org/10.54393/pjhs.v6i3.2685.
22. Wahid G, Tamkeen N, Maqsood F, et al. Diagnostic accuracy of ultrasound in detecting malignant thyroid nodules keeping histopathology as gold standard. J Postgrad Med Inst 2024;38(3):165-169. http://doi.org/10.54079/jpmi.38.3.3323.