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Diagnostic Performance of TIRADS in Thyroid Nodules: Correlation with FNAC and Histopathology

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Abstract: ***Aims & Objective: To evaluate the diagnostic utility of TIRADS in differentiating benign and malignant thyroid nodules and to correlate TIRADS categories with fine-needle aspiration cytology (FNAC) and surgical histopathology. Materials and Methods: This prospective single-centre observational study included 50 patients with thyroid nodules larger than 1 cm who underwent ultrasound evaluation followed by FNAC and surgical excision. Nodules were assessed for composition, echogenicity, shape, margins and echogenic foci and assigned a TIRADS category. Categorical variables were expressed as percentages; associations were assessed using the chi-square test, with p<0.05 considered statistically significant. Results & Conclusion: The mean age was 40.4 years (15–60 years), and 96% of participants were women. Histopathology showed 35 benign and 15 malignant nodules. Malignancy was present in 14.3% of TIRADS 1, 15% of TIRADS 2, 0% of TIRADS 3, 66.7% of TIRADS 4 and 100% of TIRADS 5 nodules. Punctate echogenic foci, very hypoechoic echogenicity, irregular/lobulated margins, extrathyroidal extension and a taller-than-wide shape were associated with malignant histopathology. The association between TIRADS category and histopathology was statistically significant (p<0.001). TIRADS provided a structured reproducible method for stratifying thyroid nodules according to sonographic features. Higher TIRADS categories showed a greater proportion of malignant nodules on histopathology.***

Keywords: thyroid nodule; ultrasonography; TIRADS; FNAC; histopathology; thyroid malignancy

1. Introduction

Thyroid nodules are frequently encountered in clinical practice and may be detected incidentally or during evaluation of thyroid-related symptoms. The superficial location of the thyroid permits high-resolution ultrasound assessment, making ultrasonography the principal imaging modality for characterizing thyroid nodules. Ultrasound can evaluate multiple morphological features that contribute to the estimation of malignancy risk.

The increasing detection of thyroid nodules has created a need for standardized reporting and risk stratification. TIRADS was developed to organize sonographic findings into categories reflecting the likelihood of malignancy, analogous in concept to other structured reporting systems. The evolution of TIRADS included work by Horvath et al., Kwak et al. and subsequent development of the ACR scoring framework.

Individual ultrasound findings are not sufficient in isolation to establish malignancy; however, combinations of features such as marked hypoechogenicity, irregular margins, a taller-than-wide shape and punctate echogenic foci may increase suspicion. A structured scoring system can therefore assist in deciding which nodules warrant cytological assessment or further management.

The present study evaluated thyroid nodules using TIRADS and correlated the sonographic categories and individual ultrasound characteristics with FNAC and final surgical histopathology.

2. Materials and Methods

Study design and setting

This was a prospective observational study conducted in the Department of Radiodiagnosis, Mahatma Gandhi Medical College and Research Institute, Pondicherry, after approval by the Institutional Medical Ethics Committee. The dissertation records the data-collection period as February 2017 to June 2018 (16 months in the Methods section).

Study population

Fifty patients referred for thyroid ultrasound and found to have thyroid nodules larger than 1 cm were included. Patients underwent FNAC and subsequently surgical excision as part of clinical management. Written informed consent was obtained.

Inclusion criteria

- Patients referred for thyroid ultrasound with thyroid nodules >1 cm.
- Patients who underwent FNAC and surgical excision of the characterized nodule.

Exclusion criteria

- Patients who did not undergo surgical excision.
- Nodules <10 mm.
- Lactating women.
- Patients unwilling to participate.

Ultrasound technique and TIRADS assessment

Patients were examined supine with the neck hyperextended using a high-frequency transducer (7–15 MHz). Grey-scale ultrasound and colour Doppler were used. Transverse and

longitudinal measurements were obtained. Each nodule was assessed for composition, echogenicity, shape, margins and echogenic foci and categorized using the TIRADS scoring system employed in the original study.

Cytology and histopathology

FNAC findings were recorded as benign, malignant or inconclusive. Patients subsequently underwent thyroid surgery, and the final surgical histopathological diagnosis was used as the reference standard for analysis.

Statistical analysis

Categorical variables including age group, sex, echogenicity, composition, margins, calcification, shape, FNAC findings and TIRADS categories were summarized as frequencies and percentages. Quantitative variables were summarized using mean and standard deviation. Associations between tumour characteristics and histopathological diagnosis were assessed using the chi-square test. A p value <0.05 was considered statistically significant. Diagnostic performance measures were calculated with histopathology as the reference standard.

3. Results

Patient characteristics

Fifty patients were included. The mean age was 40.4 years, with an age range of 15–60 years. The largest age group was 45–60 years (46%), followed by 31–44 years (28%) and 15–30 years (26%). Females constituted 96% of the study population.

Age group (years)	n	%
15–30	13	26
31–44	14	28
45–60	23	46

Sonographic characteristics

Most nodules were mixed in composition (66%), while 20% were cystic/spongiform and 14% were solid. Forty-five nodules (90%) had smooth/ill-defined margins, four (8%) were lobulated/irregular and one (2%) demonstrated extrathyroidal extension. Punctate echogenic foci were present in 22% of nodules, while macrocalcification and peripheral/rim calcification were seen in 8% and 4%, respectively. Ninety-four percent of nodules were wider than tall, while 6% were taller than wide.

Feature	Category	n	%
Composition	Cystic/spongiform	10	20
	Mixed	33	66
	Solid	7	14
Margins	Smooth/ill-defined	45	90
	Lobulated/irregular	4	8
	Extrathyroidal extension	1	2
Echogenic foci	None/large comet-tail	33	66
	Macrocalcification	4	8
	Peripheral/rim calcification	2	4
	Punctate echogenic foci	11	22
Shape	Wider than tall	47	94
	Taller than wide	3	6

Echogenicity and malignancy

Among 37 hyperechoic nodules, 75% were benign and 25% malignant. All six anechoic nodules were benign. Of five hypoechoic nodules, 20% were benign and 80% malignant, while both very hypoechoic nodules were malignant. In the diagnostic analysis table, very hypoechoic nodules showed a positive predictive value of 100% and specificity of 100%, while hypoechoic nodules showed a positive predictive value of 80% and specificity of 97.1%.

Other ultrasound features associated with malignancy

Of the four nodules with lobulated/irregular margins, all were malignant on histopathology. The single nodule with extrathyroidal extension was also malignant. Punctate echogenic foci were present in 11 nodules, of which 10 (90.9%) were malignant. All three taller-than-wide nodules were malignant. In contrast, all four nodules with macrocalcification and both nodules with peripheral/rim calcification were benign in this cohort.

Ultrasound feature	Total	Malignant (HPE)	Sensitivity	Specificity	PPV	NPV
Anechoic	6	0	0%	82.3%	0%	66%
Hyperechoic	37	9	60%	20%	24.3%	53.9%
Hypoechoic	5	4	26.7%	97.1%	80%	75.6%
Very hypoechoic	2	2	13.3%	100%	100%	73%
Solid composition	7	5	33.3%	94.3%	71.4%	76.7%
Lobulated/irregular margin	4	4	26.7%	100%	100%	76.1%
Extrathyroidal extension	1	1	6.7%	100%	100%	71.4%
Punctate echogenic foci	11	10	66.7%	97.1%	90.9%	87.2%
Taller than wide	3	3	20%	100%	100%	74.5%

TIRADS distribution and histopathological correlation

The TIRADS distribution was: category 1, 28%; category 2, 40%; category 3, 8%; category 4, 12%; and category 5, 12%. Histopathology demonstrated 35 benign nodules (70%) and 15 malignant nodules (30%). Among malignant lesions, 11 were papillary carcinoma, two medullary carcinoma and two follicular carcinoma.

TIRADS category	n	Benign n (%)	Malignant n (%)
1	14	12 (85.7)	2 (14.3)
2	20	17 (85.0)	3 (15.0)
3	4	4 (100)	0 (0)
4	6	2 (33.3)	4 (66.7)
5	6	0 (0)	6 (100)

There was a strong association between TIRADS category and histopathological diagnosis (p<0.001). The proportion of malignant nodules increased across the higher-risk categories in this study, with all six TIRADS 5 nodules proving malignant on histopathology.

FNAC findings and correlation with histopathology

FNAC was benign in 37 cases (74%), malignant in eight (16%) and inconclusive in five (10%). Among the five inconclusive FNAC results, three were benign and two malignant on histopathology. Of 37 nodules categorized as benign on FNAC, 31 (83.8%) were benign and six (16.2%) malignant on final histopathology. Of eight nodules reported as malignant on FNAC, seven (87.5%) were malignant on histopathology and one was benign.

FNAC result	HPE benign n (%)	HPE malignant n (%)
Inconclusive	3 (60)	2 (40)
Benign	31 (83.8)	6 (16.2)
Malignant	1 (12.5)	7 (87.5)

4. Discussion

The present study demonstrates the utility of a structured ultrasound-based TIRADS approach for risk stratification of thyroid nodules. In this cohort of 50 surgically treated patients, 30% of nodules were malignant on histopathology. Higher TIRADS categories showed a greater proportion of malignant nodules, with 66.7% malignancy in TIRADS 4 and 100% in TIRADS 5.

The individual sonographic findings associated with malignancy in this study were consistent with the established ultrasound descriptors used in TIRADS systems. Marked hypoechogenicity was strongly associated with malignancy, with both very hypoechoic nodules proving malignant. Similarly, irregular or lobulated margins and extrathyroidal extension showed a positive predictive value of 100% in this small cohort. A taller-than-wide shape was also observed exclusively in malignant nodules.

Punctate echogenic foci were particularly informative: 10 of 11 nodules containing this feature were malignant, giving a positive predictive value of 90.9% in this cohort. This finding is clinically relevant because punctate echogenic foci may correspond to psammomatous calcification in papillary thyroid carcinoma. Conversely, anechoic and cystic/spongiform appearances were predominantly associated with benign nodules.

The study findings are broadly concordant with earlier work describing the progressive increase in malignancy risk with increasing numbers of suspicious ultrasound features. Horvath et al. introduced TIRADS as a structured thyroid ultrasound reporting system, while Kwak et al. demonstrated the relationship between the number of suspicious ultrasound features and malignancy risk. The ACR TI-RADS framework subsequently formalized a point-based approach incorporating composition, echogenicity, shape, margins and echogenic foci.

The strong association between TIRADS category and histopathology in this study ($p<0.001$) supports the use of structured sonographic assessment as an aid to clinical decision-making. However, the observed malignancy proportions should be interpreted in the context of the study design: all included patients underwent surgery, creating a selected population enriched for lesions requiring definitive treatment. Therefore, the results should not be interpreted as population-level malignancy risks for all thyroid nodules.

FNAC also showed substantial agreement with histopathology, but inconclusive and apparently benign cytology results included malignant lesions. This reinforces the complementary role of ultrasound risk stratification and cytology rather than reliance on either modality in isolation.

5. Limitations

- The sample size was small (50 patients), limiting precision and generalizability.
- All included patients underwent thyroidectomy, introducing potential selection bias toward nodules considered sufficiently suspicious or clinically significant for surgery.
- Interobserver variability was not assessed.
- The study period was relatively short and follow-up of patients with nodules managed without surgery was not available.
- The histopathological reference standard was available only in the surgically treated cohort.

6. Conclusion

TIRADS provided a structured approach to ultrasound characterization and risk stratification of thyroid nodules in this prospective single-centre cohort. The proportion of malignancy increased from TIRADS 3 through TIRADS 5, with all TIRADS 5 nodules proving malignant on final histopathology. Punctate echogenic foci, marked hypoechogenicity, irregular margins, extrathyroidal extension and a taller-than-wide shape were important suspicious sonographic findings. TIRADS may therefore facilitate standardized reporting and help guide selection of nodules for cytological assessment. Larger multicentre studies incorporating interobserver assessment and longitudinal follow-up are needed to establish broader diagnostic performance.

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