

Original Research Article

Diagnostic accuracy of ultrasonography and fine needle aspiration cytology in thyroid swellings: correlation with final histopathology

Usha Kiran Kondepati*, Annappa Kudva

Department of General Surgery, Kasturba Medical College, Manipal, Karnataka, India

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*Correspondence:

Dr. Usha Kiran Kondepati,

E-mail: ushakiran.kondepati@gmail.com

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ABSTRACT

Background: Thyroid nodules are common in clinical practice and accurate preoperative differentiation between benign and malignant thyroid nodules is essential to avoid unnecessary surgery while ensuring timely management of malignancy. Ultrasonography (USG) and fine needle aspiration cytology (FNAC) are commonly used diagnostic tools, but their accuracy varies across clinical settings. To evaluate the diagnostic accuracy of USG and FNAC in thyroid swellings by comparing preoperative findings with final histopathological examination.

Methods: This retrospective observational study included 190 patients with thyroid swellings who underwent thyroidectomy at a tertiary care centre between January 2015 and May 2022. Preoperative USG and FNAC findings were correlated with postoperative histopathology. Sensitivity, specificity and diagnostic accuracy of each modality were calculated.

Results: Of the 190 patients screened, 187 with complete histopathological data were included in the final correlation analysis. Histopathology confirmed malignancy in 75 cases (40.1%) and benign disease in 112 cases (59.9%). When correlated with final histopathology, FNAC demonstrated sensitivity of 77.3%, specificity of 87.5% and diagnostic accuracy of 83.4% as compared to USG with sensitivity of 82.7%, specificity of 63.4% and diagnostic accuracy of 71.1%. Sonographic features such as taller-than-wide shape, solid composition and punctate echogenic foci showed significant association with malignancy ($p < 0.01$).

Conclusions: USG and FNAC are valuable complementary tools in evaluating thyroid swellings. FNAC is a highly specific and accurate diagnostic modality for thyroid swellings, while USG serves as an effective screening and risk stratification tool. Their combined use significantly improves diagnostic accuracy and helps reduce unnecessary thyroid surgery, although histopathology remains the definitive diagnostic modality.

Keywords: Thyroid nodules, FNAC, USG

INTRODUCTION

Thyroid nodules are frequently encountered in surgical practice, with a prevalence of 4–10% in adults and lower incidence in children.¹ Although most thyroid nodules are benign, malignancy is reported in approximately 5–15% of cases, necessitating accurate pre-operative evaluation.² High-resolution ultrasonography (HRUSG) is the primary imaging modality used to evaluate thyroid nodules, aiding in morphological characteristics and risk stratification. Thyroid nodules may be identified in a

small proportion of patients on clinical examination but are detected much more frequently with ultrasonography and detailed pathological evaluation.³ Palpation detects thyroid nodules in only about 4% of individuals, whereas high-resolution ultrasonography can identify nodules in up to 67%, underscoring the need for imaging-based evaluation beyond clinical examination.^{3,4} Standardized reporting systems like TIRADS and Bethesda classification improve diagnostic accuracy and help determine appropriate surgical management in thyroid nodules. Combining ultrasonography with cytology

improves diagnostic reliability and reduces unnecessary surgery in thyroid nodules.² Despite their usefulness, both ultrasonography (USG) and fine needle aspiration cytology (FNAC) have limitations related to sampling adequacy, variability in interpretation and overlap of benign and malignant features.⁵ Therefore, final histopathological examination remains the definitive method for diagnosing thyroid malignancy, as clinical findings, ultrasonography and cytology are primarily screening and risk-stratification tools that require histopathological confirmation.⁶

While several studies have evaluated the diagnostic accuracy of USG and FNAC individually, relatively fewer studies have examined their combined efficacy. Such analysis reflects real-world surgical practice and helps determine how reliably these preoperative tools guide operative decisions. Accurate preoperative risk stratification is particularly important in tertiary care surgical settings, where decisions regarding the extent of surgery depend largely on imaging and cytological findings. However, variations in patient profiles and reporting practices across institutions necessitate centre-specific evaluation of diagnostic performance.

The present study was therefore undertaken to evaluate the diagnostic accuracy of USG and FNAC in thyroid swellings by correlating their findings with final histopathology in a tertiary care setting. It also aimed to analyse specific sonographic features associated with malignancy and to assess the complementary role of imaging and cytology in guiding surgical decision-making.

METHODS

Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement of the study (Approval No: IEC2-526-2022).

This was a retrospective observational study conducted in the Department of General Surgery, Kasturba Medical College, Manipal, Karnataka, India. All adult patients (>18 years) presenting with thyroid swellings who underwent thyroidectomy between January 2015 and May 2022 were screened. A total of 190 patients met eligibility criteria.

Ultrasonography and FNAC findings were available for all 190 patients. However, complete clinical, ultrasonography, FNAC and histopathological data were available for 187 patients, who were included in the final histopathological correlation analysis. Consecutive eligible cases during the study period were included to minimize selection bias.

Inclusion criteria comprised adult euthyroid patients with thyroid swelling who underwent thyroid surgery followed by histopathological examination. Patients younger than 18 years, those with thyroiditis, hypothyroid or

hyperthyroid state, inoperable malignancy, significant comorbidities precluding surgery or incomplete records were excluded.

Clinical records were reviewed and preoperative ultrasonography and FNAC reports were collected. Ultrasonography was performed by radiologists using high-resolution ultrasound equipment and sonographic features including composition, shape and echogenic foci were recorded. FNAC was performed under aseptic precautions and cytological findings were categorised according to the Bethesda system.⁷ Final histopathology of the thyroidectomy specimen was considered the reference standard.

Statistical analysis

Data were entered into Microsoft Excel and statistical analysis was performed using Python software. Sensitivity, specificity and diagnostic accuracy of USG and FNAC were calculated. Associations between sonographic features and malignancy were analysed using Chi-square and Fisher exact tests. A P-value<0.05 was considered significant. Diagnostic performance of ultrasonography was evaluated both independently and in correlation with FNAC findings, using final histopathology as reference standard.

RESULTS

A total of 190 patients who underwent thyroidectomy during the study period were screened. Ultrasonography and FNAC findings were available for all 190 patients. However, complete clinical, ultrasonography, FNAC and histopathological data were available for 187 patients, who were included in the final histopathological correlation analysis. Final histopathological examination confirmed malignancy in 75 cases (40.1%) and benign disease in 112 cases (59.9%).

The study population comprised 190 patients who underwent thyroidectomy. The majority of patients belonged to the 31-40 years age group (62, 32.6%), followed by the 41-50 years age group (48, 25.3%). Females constituted 152 (80.0%) of the study population, while males accounted for 38 (20.0%). The baseline demographic characteristics of the study population are summarised in Table 1.

Although demographic data were available for all 190 patients, complete histopathological data were available for 187 patients, who were included in the subsequent diagnostic performance analyses.

Diagnostic performance of ultrasonography

Ultrasonography identified malignancy in 62 cases and benign disease in 71 cases. When correlated with histopathology, USG demonstrated a sensitivity of 82.7%, specificity of 63.4% and an overall diagnostic

accuracy of 71.1% when compared with histopathology. The correlation between USG findings and histopathology is shown in Table 2.

Diagnostic performance of fine needle aspiration cytology

Fine-needle aspiration cytology correctly identified malignancy in 58 cases and benign disease in 98 cases. FNAC demonstrated a sensitivity of 77.3%, specificity of 87.5% and an overall diagnostic accuracy of 83.4% when compared with final histopathology. The correlation between FNAC findings and histopathology is shown in Table 3.

Association of sonographic features with malignancy

The association between specific ultra-sonographic features and final histopathology was analysed.

Nodule composition showed a statistically significant association with malignancy ($p < 0.01$). Solid and predominantly solid nodules demonstrated higher malignancy rates, whereas cystic and predominantly cystic nodules were more commonly benign. This relationship is illustrated in Table 4. Nodules with a solid component demonstrated a significantly higher rate of malignancy, whereas cystic lesions were predominantly benign ($p < 0.01$).

Nodule shape was also significantly associated with malignancy ($p < 0.01$). A taller-than-wide configuration showed a strong association with malignant histopathology, while wider-than-tall nodules were predominantly benign. These findings are presented in Table 5. A taller-than-wide shape is highly suggestive of malignancy. Of the 11 cases that had nodules whose AP diameter was larger than the transverse, 10 cases had a malignant final histopathology.

Echogenic foci demonstrated significant correlation with malignancy ($p < 0.01$). Nodules with punctate echogenic foci were more frequently malignant, whereas macrocalcifications and peripheral calcifications were observed in both benign and malignant lesions. The distribution of echogenic features is shown in Table 6.

Correlation between diagnostic modalities

In the present study, 66 cases were reported as malignant by both ultrasonography and FNAC. However, 40 cases that were labelled malignant on ultrasonography were benign on cytology, reflecting the higher false-positive rate of USG. Ultrasonography and FNAC findings were available for all 190 patients. The comparative diagnostic correlations of USG and FNAC are summarised in Table 7.

Table 1: Baseline demographic characteristics of the study population.

Characteristics	N (%)
Age group (in years)	
<20	5 (2.6)
21-30	20 (10.5)
31-40	62 (32.6)
41-50	48 (25.3)
51-60	33 (17.4)
>60	22 (11.6)
Sex	
Female	152 (80.0)
Male	38 (20.0)
Total	190 (100)

Table 2: Correlation between USG and final histopathology.

USG reports	Histopathology: malignant	Histopathology: benign	Total
Malignant	62	41	103
Benign	13	71	84
Total	75	112	187

Table 3: Correlation between FNAC and final histopathology.

FNAC report	Histopathology: malignant	Histopathology: benign	Total
Malignant	58	14	72
Benign	17	98	115
Total	75	112	187

Table 4: Association of composition of thyroid nodule and final histopathology.

Compositions	Histopathology: malignant	Histopathology: benign	P value
Cystic	4	20	<0.01
Solid	27	19	
Predominantly cystic	0	14	
Predominantly solid	15	8	
Mixed	29	51	

Table 5: Association of shape of thyroid nodule and final histopathology.

Shapes	Histopathology: malignant	Histopathology: benign	P value
Wider than tall	63	107	<0.01
Taller than wide	10	1	
Round	2	4	

Table 6: Association of echogenic foci of thyroid nodule and final histopathology.

Echogenic Foci	Histopathology: malignant	Histopathology: benign	P value
None	41	81	<0.01
Macrocalcifications	8	9	
Peripheral/rim calcifications	9	15	
Punctate echogenic foci	17	7	

Table 7: Correlation between USG and FNAC.

USG report	FNAC diagnosis: malignant	FNAC diagnosis: benign	Total
Malignant	66	40	106
Benign	8	76	84
Total	74	116	190

DISCUSSION

Although thyroid nodules are a common clinical issue, only a small percentage of them are malignant. Therefore, the main challenge in management is appropriate risk stratification, identifying patients who need surgical intervention while avoiding unnecessary treatments in those with benign disease. The purpose of this study was to compare the accuracy of preoperative USG and FNAC for malignancy to postoperative histopathology, the gold standard for diagnosis. The study further aimed to elucidate the complementary functions of imaging and cytological modalities by comparing these findings with final histopathologic outcomes.

Postoperative histopathology demonstrated a malignancy prevalence of approximately 40% in this cohort, underscoring the importance of precise preoperative risk classification. Using histopathology as the reference standard strengthened internal validity, as all cases had uniform confirmatory diagnosis. Although the retrospective design and restriction to a single tertiary care centre can lead to potential selection and observer bias, the relatively large sample size of 190 supports the reliability of the findings. Importantly, the persistence of both false-positive and false-negative results with USG and FNAC confirms that neither modality can replace

histopathology, which alone determines the tumour subtype and pathologic characteristics necessary for staging and definitive treatment.

In this study, USG and FNAC demonstrated complementary diagnostic roles. Ultrasonography showed higher sensitivity (82.7%) but lower specificity (63.4%), supporting its function as an initial screening and risk-stratification tool. Its negative predictive value (84.52%) indicates that a benign sonographic impression substantially lowers, though does not eliminate, the probability of malignancy. The lower specificity and positive predictive value reflect a tendency to over-classify benign nodules as suspicious based on high-risk morphological features. Nonetheless, USG remains indispensable for distinguishing solid from cystic lesions, assessing morphological risk characteristics and direct targeted aspiration. Similar performance metrics have been reported in previous studies.^{8,9}

FNAC, in contrast, demonstrated a higher specificity (87.50%), positive predictive value (80.56%) and overall diagnostic accuracy (83.42%). Its substantially higher positive likelihood ratio compared with USG indicates that a malignant cytology result markedly increases post-test probability. These findings support FNAC as the principal “rule-in” test for malignancy. The higher

specificity reflects direct cellular evaluation, though false negatives may occur due to sampling error, inadequate aspirates or cytological overlap. The findings of the present study are comparable to those of Abbaraju et al who reported FNAC as the most reliable preoperative diagnostic modality with an accuracy of about 88%. They also observed that ultrasonography alone has moderate accuracy and is better used as an adjunct investigation. Their study further showed that combining USG with FNAC improves diagnostic sensitivity, while histopathology remains the definitive gold standard for final diagnosis.¹⁰ Similar findings were reported by Battina et al.¹¹

From a clinical perspective, the combined use of USG and FNAC provides a more reliable diagnostic approach than either modality alone. USG serves as an initial screening and risk-stratification tool by identifying suspicious nodules and guiding aspiration, whereas FNAC confirms cytological diagnosis and informs surgical decision-making. By integrating morphologic and cytological assessment, this approach improves preoperative planning and helps avoid unnecessary thyroidectomy in benign cases. Similar observations have been reported in prior studies demonstrating that ultrasonography alone may produce false-positive findings, while FNAC may yield false-negative results and their combined application significantly enhances diagnostic accuracy and clinical decision-making.^{12,13}

A statistically significant association was observed between USG and FNAC diagnoses in the present study ($p < 0.001$). When ultrasonography findings were correlated with FNAC results, USG demonstrated a sensitivity of 89.19% and specificity of 65.52%, with a positive predictive value of 62.26%, negative predictive value of 90.48% and an overall diagnostic accuracy of 74.74% when correlated with FNAC findings. The high sensitivity and negative predictive value indicate that USG is effective in identifying malignant nodules and ruling out disease, whereas its moderate specificity suggests a tendency toward false-positive interpretations. These complementary limitations highlight the importance of combining USG with FNAC to improve diagnostic accuracy and clinical decision-making, as similarly emphasized in previous imaging-cytology correlation studies.^{14,15}

Sonographic composition correlates with malignancy risk. Solid nodules exhibited malignancy rates of ~59% and predominantly solid nodules exceeded 65%, whereas cystic-predominant and purely cystic lesions were largely benign. This observation is consistent with established thyroid imaging literature, which suggests that malignant nodules typically represent vigorous cell growth rather than fluid build-up, emphasizing composition as a key determinant of malignancy risk.^{16,17} Nodule shape emerged as one of the strongest predictors of malignancy. Taller-than-wide nodules had a 91% malignancy rate versus 37% for wider-than-tall nodules, occurring in 90.9% of malignant but only 9.1% of benign cases. This

reflects malignant infiltrative growth and supports its weighted role in risk stratification and surgical prioritization.

Echogenic foci, particularly punctate microcalcifications, were also strongly associated with malignancy, in the present study. Nodules with microcalcifications demonstrated malignancy rates exceeding 70%, whereas those without echogenic foci showed malignancy in approximately one-third of cases. Microcalcifications were observed in 70.8% of malignant nodules compared with 29.2% of benign nodules; benign lesions more frequently exhibited macrocalcifications or no calcifications. These findings are consistent with prior sonographic studies showing that punctate echogenic foci correspond to psammoma bodies and are highly predictive of papillary thyroid carcinoma.¹⁷⁻²⁰

Collectively, solid composition, taller-than-wide shape and punctate echogenic foci showed significant associations with malignancy and are consistent with established TIRADS-based risk indicators. Clinically, these results support an integrated diagnostic pathway in which ultrasonography serves as the initial screening and risk-stratification modality and guides targeted biopsy, while FNAC provides cytological confirmation.¹⁶⁻¹⁸

Limitations

This study has certain limitations. Being a retrospective analysis from a single tertiary care centre, the findings may be influenced by selection bias, particularly as only surgically treated patients were included. Inter-observer variability in ultrasound interpretation and cytological reporting could also affect diagnostic accuracy. Additionally, correlation with long-term clinical outcomes was not assessed.

Despite these limitations, the relatively large sample size and direct comparison with final histopathology strengthen the validity of the findings. The results emphasise that while histopathology remains the definitive diagnostic modality, the combined interpretation of USG and FNAC provides a reliable and practical strategy for preoperative assessment of thyroid nodules.

CONCLUSION

This study demonstrates that USG and fine-needle aspiration cytology FNAC provide reliable and complementary information in the evaluation of thyroid swellings. Their combined use improves preoperative diagnostic accuracy, aids appropriate patient selection for surgery and may help reduce unnecessary thyroidectomies and associated morbidity.

Although histopathology remains the definitive diagnostic standard, the findings support routine combined USG-FNAC assessment as an effective,

practical and cost-efficient frontline approach in the management of thyroid nodules.

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