Original Article

Accuracy of Triple Diagnostic Tests in Patients with Thyroid Nodule: A Prospective Diagnostic Study

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Abstract

Background: Thyroid nodules are common clinical findings, and the major diagnostic challenge is to differentiate benign from malignant lesions. Clinical examination, ultrasonography and fine-needle aspiration cytology (FNAC) are important components of preoperative evaluation, with postoperative histopathology serving as the definitive diagnostic standard. **Material and Methods:** A prospective diagnostic study was conducted in the Department of General Surgery, Government Dharmapuri Medical College and Hospital, from April 2024 to September 2025. Fifty patients presenting with thyroid nodules and fulfilling the study criteria were included. All patients underwent clinical examination, ultrasonography of the neck and FNAC. The diagnostic impression was recorded after each test and after combining all three modalities. Postoperative histopathological examination (HPE) was considered the reference standard. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy were calculated. **Results:** Among 50 patients, 43 (86%) were females and 7 (14%) were males. Seventeen patients (34%) were aged above 50 years. Clinical examination classified 44 (88%) nodules as benign and 6 (12%) as malignant. Ultrasonography classified 41 (82%) as benign and 9 (18%) as malignant. FNAC classified 40 (80%) as benign and 10 (20%) as malignant. The combined triple test also classified 40 (80%) as benign and 10 (20%) as malignant. Postoperative HPE showed 36 (72%) benign and 14 (28%) malignant lesions. Clinical examination had an accuracy of 84%, ultrasonography 90%, FNAC 92% and the combined triple test 92%. Sensitivity was reported as 100% for all four approaches, while specificity was 81.82%, 87.80%, 90% and 90%, respectively. **Conclusion:** Clinical examination, ultrasonography and FNAC demonstrated useful diagnostic performance in thyroid nodules. In the present cohort, FNAC and the combined triple test had the highest reported accuracy of 92%. The combination of clinical, radiological and cytological assessment provides complementary information for preoperative evaluation of thyroid nodules.

Keywords: Thyroid nodule, clinical examination, ultrasonography, fine-needle aspiration cytology, triple diagnostic test, histopathology, diagnostic accuracy.

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Introduction

Thyroid nodules are frequently encountered in clinical practice. Although the majority are benign, identification of the relatively smaller proportion of nodules harbouring malignancy is an important component of thyroid disease management. The evaluation of a thyroid nodule generally incorporates clinical assessment, thyroid function testing, ultrasonography and cytological evaluation where indicated.[1,2]

Clinical examination is the initial step in the evaluation of a thyroid swelling. Features such as a hard consistency, fixation, rapid enlargement, cervical lymphadenopathy, hoarseness and compressive symptoms may raise suspicion of malignancy. However, physical examination has limitations in detecting small, deep or nonpalpable lesions. Studies have demonstrated that palpation alone has limited sensitivity for identifying thyroid nodules, supporting the complementary role of imaging.[3]

High-resolution ultrasonography is the principal imaging modality for evaluating thyroid nodules. It provides information regarding the size, composition, echogenicity, margins, calcifications, shape and associated cervical lymph nodes. Several sonographic characteristics have been associated with an increased risk of malignancy, including marked hypoechogenicity, microcalcifications, irregular margins and a taller-than-wide configuration.[4,6] Standardized ultrasound risk-stratification systems such as the American College of Radiology Thyroid Imaging Reporting and Data System (ACR TI-RADS) have further improved consistency in assessment and decision-making.[7]

FNAC is an established and widely used diagnostic procedure for thyroid nodules. The Bethesda System for Reporting Thyroid Cytopathology provides standardized terminology and risk-based categories that facilitate clinical decision-making.[8,9] FNAC has high diagnostic value for many thyroid malignancies, although limitations exist, particularly in

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follicular-patterned lesions where the distinction between follicular adenoma and carcinoma depends on capsular or vascular invasion, which cannot be established reliably by cytology alone.[10]

The diagnostic performance of each modality varies according to the patient population, disease prevalence, technical expertise and criteria used for interpretation. Meta-analyses have demonstrated that specific ultrasound features can improve identification of malignant nodules, while FNAC provides important cytological information for determining subsequent management.[5,6,11]

Because clinical examination, ultrasonography and FNAC assess different characteristics of a thyroid nodule, combining their findings may provide a more comprehensive preoperative assessment. The present study was therefore undertaken to determine the diagnostic accuracy of clinical examination, ultrasonography and FNAC individually and in combination, using postoperative histopathology as the reference standard.

The objectives of the study is to determine the accuracy of clinical examination, ultrasonography and FNAC in predicting the nature of thyroid nodules. Also to compare the diagnostic performance of the three individual modalities, to determine whether combining clinical examination, ultrasonography and FNAC improves diagnostic accuracy and to assess the usefulness of the triple diagnostic approach in preoperative surgical planning.

Materials and Methods

This prospective diagnostic study was conducted in the Department of General Surgery, Government Dharmapuri Medical College and Hospital, Dharmapuri, Tamil Nadu, from April 2024 to September 2025. Fifty patients presenting with thyroid nodules to the surgical outpatient department or as inpatients were included. Patients who were fit and willing to undergo surgery were eligible for inclusion. The study was conducted after institutional ethical approval and after obtaining informed consent from the participants. Each enrolled patient underwent a standardized preoperative diagnostic evaluation consisting of clinical examination, ultrasonography of the neck and fine-needle aspiration cytology of the thyroid nodule. Clinical examination included assessment of the thyroid swelling and relevant clinical features suggestive of benign or malignant disease, including the consistency, mobility, fixation, recent increase in size and associated cervical lymphadenopathy or compressive symptoms.

Ultrasonography was performed to assess the morphological characteristics of the thyroid nodule and associated cervical structures. FNAC was performed from the thyroid nodule using a 23-gauge needle, and the cytological findings were categorized according to the cytological interpretation documented in the study. Following completion of the three investigations, the findings were considered individually and collectively. The combined assessment of clinical examination, ultrasonography and FNAC was designated the triple diagnostic test and was used for preoperative prediction of the nature of the thyroid nodule and surgical planning. Patients subsequently underwent appropriate surgical management, and the excised thyroid specimens were subjected to postoperative histopathological examination. The postoperative HPE diagnosis was considered the reference standard for determining the final benign or malignant nature of the lesion.

The results of clinical examination, ultrasonography, FNAC and the combined triple diagnostic test were compared with postoperative HPE. True-positive, false-positive, true-negative and false-negative results were identified, and sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were calculated for each diagnostic modality. Demographic variables were summarized using frequencies and percentages, and the association between age and sex was evaluated using the chi-square test. The study included a total of 50 patients, and postoperative HPE demonstrated 36 benign and 14 malignant lesions.

Results

Table 1: Age distribution of study participants

Age group	Number	Percentage
<30 years	7	14%
31–40 years	14	28%
41–50 years	12	24%
>50 years	17	34%
Total	50	100%

The largest proportion of patients belonged to the age group above 50 years, comprising 17 (34%) of the 50 participants. Patients aged 31–40 years accounted for 28%, followed by those aged 41–50 years at 24%, while 14% were below 30 years.

Table 2: Sex distribution

Sex	Number	Percentage
Male	7	14%
Female	43	86%
Total	50	100%

A marked female predominance was observed. Females constituted 43 (86%) of the study participants, whereas males constituted 7 (14%). The age-versus-sex analysis reported a p value of 0.147 and was considered statistically

non-significant.

Table 3: Classification of thyroid nodules by different diagnostic modalities

Diagnostic modality	Benign, n (%)	Malignant, n (%)
Clinical examination	44 (88%)	6 (12%)
Ultrasonography	41 (82%)	9 (18%)
FNAC	40 (80%)	10 (20%)
Triple test	40 (80%)	10 (20%)
Postoperative HPE	36 (72%)	14 (28%)

Clinical examination classified 44 (88%) patients as having benign nodules and 6 (12%) as having malignant nodules. Ultrasonography classified 41 (82%) as benign and 9 (18%) as malignant. FNAC identified 40 (80%) as benign and 10 (20%) as malignant. The combined triple test similarly classified 40 (80%) as benign and 10 (20%) as malignant. Final postoperative HPE demonstrated 36 (72%) benign and 14 (28%) malignant lesions.

Table 4: Diagnostic performance of individual tests and triple test

Diagnostic parameter	Clinical examination	USG	FNAC	Triple test
Sensitivity	100%	100%	100%	100%
Specificity	81.82%	87.80%	90.00%	90.00%
PPV	42.56%	64.29%	71.43%	71.43%
NPV	100%	100%	100%	100%
Accuracy	84%	90%	92%	92%

Clinical examination showed a reported sensitivity of 100%, specificity of 81.82% and accuracy of 84%. Ultrasonography demonstrated a sensitivity of 100%, specificity of 87.80% and accuracy of 90%. FNAC demonstrated sensitivity of 100%, specificity of 90% and accuracy of 92%. The combined triple test demonstrated sensitivity of 100%, specificity of 90%, NPV of 100% and accuracy of 92%.

Table 5: Comparison of diagnostic tests with postoperative histopathology

Test	True positive	False positive	False negative	True negative	Accuracy
Clinical examination	6	8	0	36	84%
Ultrasonography	9	5	0	36	90%
FNAC	10	4	0	36	92%
Triple test	10	4	0	36	92%

The diagnostic comparison demonstrated a progressive increase in specificity from clinical examination to ultrasonography and FNAC. Accuracy increased from 84% with clinical examination to 90% with ultrasonography and 92% with FNAC. The combined triple test also demonstrated an accuracy of 92%.

Discussion

The present prospective study evaluated the diagnostic performance of clinical examination, ultrasonography and FNAC in 50 patients with thyroid nodules, using postoperative HPE as the reference standard. The study population showed a marked female predominance, with females comprising 86% of participants. Female predominance among patients with thyroid nodules is consistent with the epidemiological pattern described in previous studies.[12,13]

Patients above 50 years constituted the largest age group, accounting for 34% of the study population. Age is an important component of clinical risk assessment in thyroid nodules, although age alone is insufficient to establish malignancy. Current guidelines recommend that age and other clinical characteristics be interpreted together with ultrasound findings and cytology.[1,2]

Clinical examination classified 88% of the lesions as benign and 12% as malignant. When compared with postoperative HPE, it demonstrated a reported accuracy of 84% and specificity of 81.82%. The relatively lower specificity compared with the other modalities indicates that clinical assessment alone may result in some benign nodules being clinically suspected as malignant. Physical examination remains important as the first step, but its limitations in detecting small and nonpalpable lesions have been documented.[3]

Ultrasonography classified 82% of nodules as benign and 18% as malignant and demonstrated an accuracy of 90%. Its specificity of 87.80% was higher than that of clinical examination.

This finding is compatible with the established role of ultrasonography in identifying morphological characteristics associated with malignancy. Systematic reviews have demonstrated significant associations between malignancy and features such as microcalcifications, irregular margins, hypoechogenicity and taller-than-wide configuration.[5,6]

The use of standardized ultrasound classification systems has further improved risk assessment. ACR TI-RADS uses a combination of composition, echogenicity, shape, margin and echogenic foci to classify nodules according to malignancy risk and guide recommendations for FNAC or follow-up.[7]

FNAC demonstrated the highest accuracy among the individual diagnostic modalities in the present study, with an accuracy of 92% and specificity of 90%. This finding supports the

established role of FNAC as a major component of preoperative thyroid nodule evaluation. The Bethesda system provides standardized cytological categories and associated malignancy risks, facilitating communication and management decisions.[8,9]

The high diagnostic performance of FNAC in the present study should nevertheless be interpreted in light of its known limitations. Cytological examination cannot reliably distinguish follicular carcinoma from follicular adenoma because the diagnosis of carcinoma requires demonstration of capsular and/or vascular invasion.[10] Therefore, even a highly useful cytological test cannot completely replace histopathological examination in all surgically managed thyroid lesions.

The combined triple diagnostic test demonstrated a reported sensitivity of 100%, specificity of 90%, PPV of 71.43%, NPV of 100% and accuracy of 92%. Thus, the combined approach provided the same overall accuracy as FNAC alone in this particular dataset. The original dissertation states that combining the tests increased accuracy; however, the numerical comparison presented in the results shows 92% accuracy for both FNAC and the combined triple test. Therefore, the data support the complementary value of combining the modalities, but they do not demonstrate a numerical improvement in overall accuracy beyond FNAC in this cohort.

The high reported sensitivity of all diagnostic approaches should also be interpreted cautiously because only 14 malignant cases were present. Although all 14 malignant lesions were identified by the reported diagnostic approaches, a larger study would be required to establish whether a sensitivity of 100% is reproducible. Diagnostic accuracy estimates are influenced by sample size and disease prevalence.

The present findings are consistent with the broader evidence supporting multimodal evaluation of thyroid nodules. The American Thyroid Association recommends clinical assessment, serum TSH, ultrasound evaluation and FNAC according to the characteristics and risk profile of the nodule.[1] The 2023 European Thyroid Association guidelines similarly emphasize individualized, risk-adapted assessment.[2]

Several studies have demonstrated that ultrasound and FNAC provide complementary diagnostic information.[14-16] Ultrasound provides morphological and anatomical information, while FNAC provides cellular information. The combination therefore allows the clinician to integrate different dimensions of the lesion rather than relying on a single parameter.

The importance of appropriate patient selection and standardized diagnostic pathways is also emphasized by studies examining the natural history of benign thyroid nodules. Durante et al. demonstrated that many benign nodules remain stable or show only limited changes during follow-up, highlighting the importance of avoiding unnecessary intervention while ensuring appropriate identification of suspicious lesions.[17]

Overall, the present study demonstrates that clinical examination, ultrasonography and FNAC each contribute useful information to the assessment of thyroid nodules. The results support a multimodal diagnostic strategy, particularly before surgical intervention, while recognizing that postoperative histopathology remains the definitive diagnostic reference for surgically excised lesions.

Conclusion

The present prospective study of 50 patients demonstrated that thyroid nodules were predominantly seen in females, with 86% of participants being women. Postoperative histopathology identified 28% of lesions as malignant. Clinical examination, ultrasonography and FNAC demonstrated reported accuracies of 84%, 90% and 92%, respectively, while the combined triple diagnostic test demonstrated an accuracy of 92%. Clinical examination, ultrasound and FNAC should therefore be viewed as complementary components of thyroid nodule assessment, consistent with current guideline-based approaches to thyroid nodule evaluation

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Conflicts of interest

There are no conflicts of interest.

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