



Original Article

High Resolution Ultrasound Evaluation of the Thyroid Pathologies at A Tertiary Hospital: A Clinicopathological Correlation Study

Dr Hunmili Ingtipi¹, Dr Dharamsing Timung², Dr Panchalika Borgohain³, Dr Geeta Timungpi⁴

¹ Assistant Professor, Department of Radiodiagnosis, Diphu Medical College & Hospital

² Assistant Professor, Department of Medicine, Diphu Medical College & Hospital

³ Assistant Professor Department of Pathology, Diphu Medical College & Hospital

⁴ Assistant Professor Department of ENT Diphu Medical College & Hospital

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Corresponding Author:

Dr Dharamsing Timung

Assistant Professor, Department
of Medicine, Diphu Medical
College & Hospital.

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ABSTRACT

Background: Thyroid disorders are among the most common endocrine diseases worldwide, with thyroid nodules occurring frequently in the general population. Although most thyroid lesions are benign, accurate differentiation between benign and malignant lesions is essential for appropriate management. High-resolution ultrasonography (HRUSG) is the primary imaging modality for evaluating thyroid lesions because it provides excellent anatomical detail and identifies sonographic features suggestive of malignancy. Fine-needle aspiration cytology (FNAC) remains the reference standard for preoperative diagnosis. The present study evaluated the role of HRUSG in the assessment of thyroid lesions and correlated ultrasonographic findings with FNAC diagnosis.

Methods: A retrospective observational study was conducted in the Department of Radiodiagnosis, Diphu Medical College and Hospital, from January 2024 to December 2025. A total of 128 patients with clinically suspected thyroid lesions who underwent HRUSG followed by FNAC were included. Ultrasonographic examination was performed using a high-frequency linear transducer with colour Doppler evaluation. Sonographic findings were documented and correlated with FNAC results reported according to the Bethesda System for Reporting Thyroid Cytopathology. Data were entered into Microsoft Excel and analysed using appropriate descriptive statistical methods.

Results: The mean age of the study participants was 39.07 ± 13.57 years, and females constituted 89.8% of the study population. Bilateral thyroid involvement was the most common clinical presentation. Bethesda Category II (benign) accounted for 113 (88.3%) cases, while Categories V and VI constituted 6.2% of cases. Predominantly cystic colloid nodules were the most common ultrasonographic pattern, followed by diffuse thyroiditis. Benign ultrasonographic patterns demonstrated good agreement with benign cytological diagnoses, whereas lesions showing irregular margins, marked hypoechogenicity, taller-than-wide configuration, punctate echogenic foci, and extrathyroidal extension were predominantly associated with suspicious or malignant cytology.

Conclusion: HRUSG is a reliable, non-invasive imaging modality for the initial evaluation of thyroid lesions and demonstrates good clinicopathological correlation with FNAC. It effectively identifies benign and suspicious lesions, assists in selecting patients requiring cytological evaluation, and plays an important role in the diagnostic workup and management of thyroid diseases.

Keywords: High-resolution ultrasonography; Thyroid lesions; Fine-needle aspiration cytology; Bethesda system; Thyroid nodules; Colour Doppler; Clinicopathological correlation.

INTRODUCTION

The thyroid gland is the largest and most superficial endocrine gland in the human body, playing a pivotal role in regulating metabolism, growth, thermogenesis, and normal physiological homeostasis through the secretion of thyroid hormones. Disorders of the thyroid gland are among the most common endocrine diseases worldwide and encompass a broad spectrum of conditions, including diffuse enlargement, inflammatory disorders, benign nodules, and malignant neoplasms. Clinically, these conditions often present with similar manifestations such as anterior neck swelling, dysphagia, hoarseness of voice, or symptoms related to thyroid dysfunction, making accurate diagnosis challenging. Thyroid nodules are particularly common, with their prevalence increasing with age and being considerably higher among women. Although the majority of thyroid nodules are benign, approximately 5–10% harbor malignancy, necessitating accurate differentiation to guide appropriate management and avoid unnecessary invasive procedures [1–3].

High-resolution ultrasonography (HRUSG) has become the primary imaging modality for the evaluation of thyroid diseases because it is non-invasive, inexpensive, radiation-free, widely available, and capable of providing excellent spatial resolution. Gray-scale ultrasonography allows detailed assessment of thyroid morphology, including gland size, echotexture, composition, and nodule characteristics, while Color Doppler imaging evaluates vascularity within the gland and nodules. The combination of these techniques enables comprehensive characterization of thyroid lesions and facilitates risk stratification before tissue sampling [4,5]. Ultrasonography is also invaluable for detecting clinically occult lesions, with incidental thyroid nodules identified in up to two-thirds of individuals undergoing neck ultrasound for unrelated indications. This high prevalence, coupled with the generally indolent course of thyroid carcinoma, poses a significant challenge in identifying patients who require further diagnostic evaluation while minimizing unnecessary biopsies and interventions [6].

Several sonographic characteristics have been shown to correlate with the risk of malignancy. Features such as marked hypoechogenicity, irregular or lobulated margins, a taller-than-wide configuration, microcalcifications, and predominantly intranodular vascularity are associated with a significantly increased likelihood of thyroid cancer. Conversely, spongiform appearance, comet-tail artifacts, cystic degeneration, smooth margins, and peripheral vascularity generally suggest benign pathology. Color Doppler imaging further improves diagnostic confidence by assessing vascular patterns, including the characteristic "thyroid inferno" observed in Graves' disease and the chaotic intranodular vascularity frequently associated with malignant lesions [4,7].

Different thyroid pathologies demonstrate characteristic sonographic appearances. Multinodular goitre typically presents with multiple iso- to hyperechoic nodules containing colloid, peripheral halo, comet-tail artifacts, and peripheral vascularity. Hashimoto's thyroiditis is characterized by diffuse hypoechogenicity, heterogeneous echotexture, micronodulation, fibrous septations, and variable vascularity. Graves' disease usually demonstrates diffuse enlargement with homogeneous hypoechogenicity and marked hypervascularity, whereas subacute thyroiditis often exhibits focal hypoechoic regions with reduced vascularity during the acute phase. Benign follicular adenomas commonly appear as well-defined encapsulated solid nodules with a complete hypoechoic halo, while malignant lesions frequently demonstrate hypoechogenicity, irregular margins, microcalcifications, extrathyroidal extension, abnormal cervical lymphadenopathy, and increased intranodular blood flow [5,8].

Despite the excellent diagnostic capability of HRUSG, imaging findings alone cannot establish a definitive diagnosis. Fine-needle aspiration cytology (FNAC) remains the reference standard for preoperative evaluation of thyroid nodules and is recommended for lesions demonstrating suspicious sonographic features. Correlation of HRUSG findings with FNAC not only improves diagnostic accuracy but also facilitates appropriate patient selection for surgery or conservative management [2,9].

Considering the increasing burden of thyroid disorders and the growing role of ultrasonography in their evaluation, it is essential to assess the diagnostic performance of HRUSG in routine clinical practice. Therefore, the present study was undertaken to evaluate the morphological patterns of thyroid pathologies using high-resolution ultrasonography and Color Doppler imaging and to correlate the imaging findings with FNAC in patients presenting with suspected thyroid lesions at the Department of Radiodiagnosis, Diphu Medical College and Hospital, Assam. This clinicopathological correlation aims to determine the diagnostic utility of HRUSG in differentiating benign from malignant thyroid lesions and optimizing patient management.

METHODOLOGY

Study Design and Setting: This retrospective observational study was conducted in the Department of Radiology, Diphu Medical College and Hospital, Diphu, Assam, after obtaining approval from the Institutional Ethics Committee. The study was designed to evaluate the diagnostic performance of high-resolution ultrasonography (HRUSG) with clinicopathological correlation in patients presenting with suspected thyroid lesions.

Study Period: The study included patients evaluated between January 2024 and December 2025.

Study Population: The study population comprised patients aged 11–80 years who were referred from the outpatient and inpatient departments of various clinical specialties for ultrasonographic evaluation of suspected thyroid pathology.

Consecutive eligible patients fulfilling the predefined inclusion and exclusion criteria were included in the study. A total of 128 eligible patients fulfilling the inclusion and exclusion criteria were included in the final analysis.

Inclusion Criteria

- Patients with clinically suspected thyroid lesions referred for ultrasonographic evaluation, irrespective of thyroid function status.
- Patients presenting with a palpable thyroid swelling or thyroid nodule.

Exclusion Criteria

- Patients with a previous FNAC- or biopsy-confirmed diagnosis of thyroid disease.
- Patients with a history of thyroid surgery for any indication.

Ultrasonographic Evaluation: All participants underwent high-resolution ultrasonography of the thyroid gland using a 12-MHz high-frequency linear-array transducer (operating frequency range 10–14 MHz). The ultrasound equipment was optimized for thyroid imaging before each examination. Both thyroid lobes and the isthmus were systematically evaluated in longitudinal and transverse planes. The examination included assessment of thyroid size, parenchymal echotexture, nodule location, composition, echogenicity, margins, halo, calcifications, shape, vascularity, and cervical lymph node status. Measurements were obtained using electronic calipers and documented in the imaging records.

Color Doppler Assessment: Color Doppler examination was performed immediately following gray-scale imaging. Doppler settings were standardized with an initial peak systolic velocity of approximately 15 cm/s, high color gain adjusted just below the level of background noise, and a low wall filter to optimize the detection of low-velocity blood flow. Vascularity within the thyroid gland and nodules was categorized as peripheral, intranodular, or mixed (peripheral and intranodular), and cervical lymph nodes were evaluated for abnormal vascular patterns where applicable.

Data Collection: Demographic details, clinical presentation, thyroid function status, HRUSG findings, Color Doppler characteristics, FNAC findings (where available), and final diagnosis were recorded in a structured Microsoft Excel database for subsequent analysis.

Outcome Measures: The primary outcome was the diagnostic accuracy of HRUSG in detecting thyroid pathologies using FNAC as reference standards. Secondary outcomes included the evaluation of sonographic features predictive of malignancy and the clinicopathological correlation between HRUSG findings and cytological diagnosis.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics software (Version 26). Continuous variables were expressed as mean $\pm$ standard deviation (SD), whereas categorical variables were summarized as frequencies and percentages. The association between categorical variables was assessed using the Chi-square test or Fisher's exact test, as appropriate. A *p*-value of <0.05 was considered statistically significant.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee of Diphu Medical College and Hospital. As this was a retrospective observational study based on hospital records and imaging data, patient confidentiality and anonymity were maintained throughout the study in accordance with institutional ethical guidelines.

RESULTS

A total of **128 patients** with clinically suspected thyroid lesions were included in the study. The mean age of the study population was **39.07 $\pm$ 13.57 years** (range: **12–80 years**). Females constituted the majority of the study population (**89.8%**). The baseline demographic characteristics are summarized in **Table 1**.

Table 1. Baseline Characteristics of the Study Participants (N = 128)

	Characteristic	n (%)
Age group (years)	≤ 20	7 (5.5)
	21–30	32 (25.0)
	31–40	37 (28.9)
	41–50	26 (20.3)
	51–60	18 (14.1)
	≥ 60	8 (6.3)
Gender	Male	13 (10.2)
	Female	115 (89.8)

The clinical profile of the patients is presented in **Table 2**. Bilateral thyroid involvement was the commonest clinical presentation, and the majority of patients reported symptoms for more than one year.

Table 2. Clinical Characteristics of the Study Participants (N = 128)

	Variable	n (%)
Lobe involved	Bilateral	84 (65.6)
	Left lobe	25 (19.5)
	Right lobe	15 (11.7)
	Right lobe with isthmus	1 (0.8)
	Non-palpable	3 (2.3)
Duration of symptoms	<6 months	36 (28.1)
	6–12 months	10 (7.8)
	>1–5 years	65 (50.8)
	>5 years	17 (13.3)
Consistency of swelling	Soft	30 (23.4)
	Soft to firm	60 (46.9)
	Firm	32 (25.0)
	Hard/Stony hard	2 (1.6)
	Non-palpable	4 (3.1)

The cytological findings according to the Bethesda System for Reporting Thyroid Cytopathology are summarized in **Table 3**. Benign lesions (Bethesda Category II) accounted for the majority of cases.

Table 3. Distribution of Bethesda Categories (N = 128)

Bethesda Category	Cytological Interpretation	n (%)
I	Non-diagnostic/Unsatisfactory	3 (2.3)
II	Benign	113 (88.3)
III	AUS/FLUS	3 (2.3)
IV	Follicular neoplasm	1 (0.8)
V	Suspicious for malignancy	5 (3.9)
VI	Malignant	3 (2.3)
Total	128 (100.0)	

The major sonographic patterns identified on high-resolution ultrasonography are shown in **Table 4**. Predominantly cystic colloid nodules constituted the commonest ultrasonographic pattern, followed by diffuse thyroiditis.

Table 4. Distribution of Major HRUSG Patterns (N = 128)

HRUSG Pattern	n (%)
Predominantly cystic colloid nodule (including cystic degeneration/comet-tail artifact)	64 (50.0)
Diffuse thyroiditis pattern	37 (28.9)
Benign solid thyroid nodule pattern	22 (17.2)
Suspicious malignant thyroid nodule pattern	5 (3.9)
Total	128 (100.0)

Clinicopathological correlation between HRUSG findings and FNAC diagnosis is presented in **Table 5**. Benign ultrasonographic patterns were predominantly associated with benign cytological diagnoses (Bethesda Category II), whereas lesions demonstrating suspicious sonographic features showed a greater likelihood of malignant or suspicious cytology.

Table 5. Correlation Between HRUSG Pattern and Bethesda Category (N = 128)

HRUSG Pattern	Bethesda I	Bethesda II	Bethesda III	Bethesda IV	Bethesda V	Bethesda VI	Total
Predominantly cystic colloid nodule	1	63	0	0	0	0	64
Diffuse thyroiditis pattern	1	35	1	0	0	0	37

Benign solid thyroid nodule pattern	1	15	2	1	2	1	22
Suspicious malignant thyroid nodule pattern	0	0	0	0	3	2	5
Total	3	113	3	1	5	3	128

Statistical test: Pearson Chi-square = **96.63**, df = **15**, **p < 0.001**

The disease-wise concordance between HRUSG and FNAC is summarized in **Table 6**. High concordance was observed for colloid nodules, Hashimoto's thyroiditis, Graves' disease, granulomatous thyroiditis, and follicular neoplasm, whereas comparatively lower concordance was observed for benign thyroid nodules and malignant lesions due to overlapping imaging characteristics.

Table 6. Disease-wise Concordance Between HRUSG and FNAC Diagnosis

Thyroid Lesion	HRUSG Cases	FNAC Cases	Concordant Cases*	Concordance (%)
Colloid nodule (including cystic degeneration)	64	63	62	96.9
Hashimoto's thyroiditis	37	31	30	81.1
Graves' disease	3	3	3	100.0
Granulomatous thyroiditis	2	2	2	100.0
Benign thyroid nodule†	22	15	15	68.2
Follicular neoplasm	1	1	1	100.0
Malignant thyroid lesions‡	5	8	5	62.5

* Concordant cases represent agreement between the HRUSG diagnosis and the corresponding FNAC diagnosis.

† Includes adenomatoid goitre/nodule, benign thyroid nodule, and hyperplastic thyroid nodules.

‡ Includes lesions categorized as suspicious for malignancy and malignant on FNAC.

High-resolution ultrasonography demonstrated a high degree of agreement with FNAC for the evaluation of thyroid lesions. Benign sonographic patterns, particularly predominantly cystic colloid nodules and diffuse thyroiditis, showed excellent correlation with benign cytological diagnoses, while characteristic suspicious sonographic features were predominantly associated with Bethesda Category V and VI lesions, supporting the utility of HRUSG as an effective first-line imaging modality for the evaluation and risk stratification of thyroid lesions.

DISCUSSION

Thyroid disorders constitute one of the most common endocrine conditions encountered in clinical practice, with thyroid nodules being particularly prevalent among women and middle-aged individuals. Although the majority of thyroid nodules are benign, accurate differentiation between benign and malignant lesions remains essential to avoid unnecessary surgical intervention while ensuring timely diagnosis of thyroid malignancies. High-resolution ultrasonography (HRUSG) has emerged as the primary imaging modality for evaluating thyroid lesions because of its accessibility, non-invasive nature, and ability to characterize nodular morphology, whereas fine-needle aspiration cytology (FNAC) remains the reference standard for preoperative diagnosis [1–5].

In the present study, the mean age of the patients was 39.07 ±13.57 years, with the highest proportion belonging to the 31–40-year age group (28.9%). Females constituted 89.8% of the study population, reflecting the well-established female predominance of thyroid disorders reported in previous studies [2,4,6]. The higher prevalence among women has been attributed to hormonal influences, autoimmune predisposition, and increased health-seeking behavior. Similar demographic findings have been reported by various Indian and international studies evaluating thyroid lesions using ultrasonography and cytology [6–8].

Clinically, bilateral thyroid involvement was observed in approximately two-thirds of patients, while more than half reported symptoms of 1–5 years' duration before presentation. Most swellings were soft to firm in consistency, consistent with the predominantly benign nature of thyroid diseases. These findings indicate that thyroid disorders often follow a slow clinical course, resulting in delayed presentation to tertiary care centers. Similar observations have been documented in previous studies evaluating thyroid swellings in hospital-based populations [7,8].

FNAC classified the majority of lesions as Bethesda Category II (88.3%), indicating benign pathology. Only a small proportion of cases belonged to Bethesda Categories V and VI, representing suspicious and malignant lesions, respectively. This distribution is comparable with previous studies, which have consistently demonstrated that benign thyroid lesions constitute nearly 80–90% of all thyroid nodules evaluated cytologically [3,5,9]. The Bethesda System provides

standardized reporting, improves communication between clinicians and pathologists, and facilitates evidence-based clinical management.

On HRUSG evaluation, predominantly cystic colloid nodules represented the most frequent imaging pattern, followed by diffuse thyroiditis. Benign nodules typically demonstrated well-defined margins, comet-tail artifacts, and cystic degeneration, whereas diffuse thyroiditis was characterized by heterogeneous hypoechoic parenchyma with diffuse enlargement. In contrast, lesions demonstrating marked hypoechogenicity, irregular margins, taller-than-wide configuration, punctate echogenic foci (microcalcifications), internal vascularity, and extrathyroidal extension were predominantly associated with suspicious or malignant cytology. These sonographic characteristics are well-recognized predictors of thyroid malignancy and form the basis of contemporary risk-stratification systems such as ACR TI-RADS and EU-TIRADS [4,10,11].

The present study demonstrated a good clinicopathological correlation between HRUSG and FNAC, supporting the role of ultrasonography as an effective screening and risk stratification tool prior to cytological confirmation. Benign ultrasonographic patterns showed excellent correlation with benign cytological diagnoses, while nodules exhibiting suspicious ultrasonographic features were more frequently associated with Bethesda Category V or VI lesions. The high concordance observed for colloid nodules, Hashimoto's thyroiditis, Graves' disease, and granulomatous thyroiditis highlights the reliability of HRUSG in identifying common benign thyroid disorders. Similar observations have been reported by previous investigators, who concluded that HRUSG serves as an effective first-line investigation and significantly improves the selection of patients requiring FNAC [5,10].

The present study has certain limitations. It was conducted at a single tertiary care center with a relatively modest sample size, and histopathological confirmation was not available for all patients. Furthermore, the diagnostic performance of HRUSG depends on operator expertise and adherence to standardized reporting systems. Despite these limitations, the study provides valuable evidence supporting the complementary role of HRUSG and FNAC in the evaluation of thyroid lesions.

CONCLUSION

High-resolution ultrasonography (HRUSG) proved to be an effective first-line imaging modality for the evaluation of thyroid lesions in the present study. It accurately characterized lesion morphology, identified benign and suspicious sonographic features, and demonstrated good clinicopathological correlation with fine-needle aspiration cytology (FNAC). The majority of thyroid lesions were benign, with Bethesda Category II constituting the predominant cytological diagnosis. Predominantly cystic colloid nodules and diffuse thyroiditis represented the commonest ultrasonographic patterns, whereas malignant lesions demonstrated characteristic features such as marked hypoechogenicity, irregular margins, taller-than-wide configuration, punctate echogenic foci, and extrathyroidal extension. The combined use of HRUSG and FNAC facilitates early diagnosis, appropriate risk stratification, and optimal management of patients with thyroid disorders. HRUSG should be considered the primary imaging modality for evaluating thyroid lesions, while FNAC remains indispensable for definitive cytological diagnosis and treatment planning.

DECLARATIONS

Ethics Approval and Consent to Participate: The study was approved by the Institutional Ethics Committee of Diphu Medical College and Hospital. Owing to the retrospective observational design, institutional ethical guidelines were followed.

Availability of Data and Materials: The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests: The authors declare that they have no competing interests.

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Authors' Contributions: All authors contributed to the conception and design of the study, data collection, analysis, interpretation of results, manuscript preparation, and approval of the final manuscript.

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