

CYTO-HISTOLOGICAL DISCORDANCE IN THYROID NODULES: A RETROSPECTIVE COMPARATIVE ANALYSIS OF CONVENTIONAL AND ULTRASOUND-GUIDED FINE-NEEDLE ASPIRATION CYTOLOGY

Pathology

Dr. Sukhendu
Dhibar

Dr. Piyali Ghosh

Dr. Aditi
Bhattacharyya

ABSTRACT

Aim: To compare conventional FNAC and USG-guided FNAC for the evaluation of thyroid nodules, classify cytological findings according to the Bethesda System for Reporting Thyroid Cytopathology (TBSRTC), and assess cytology–histopathology discordance and diagnostic pitfalls. **Background:** Thyroid nodules are common, and accurate preoperative assessment is important for appropriate management. Ultrasound-guided fine-needle aspiration cytology (USG-guided FNAC) permits targeted sampling of representative or suspicious areas of a thyroid nodule and may reduce sampling-related diagnostic discrepancies. **Materials and Methods:** This retrospective, observational, comparative study included 124 eligible thyroid FNAC cases. Histopathological correlation was available in 62 cases, comprising 28 conventional FNAC cases and 34 USG-guided FNAC cases. Histopathology was considered the reference standard. Cytological–histopathological concordance, discordance and specific diagnostic pitfalls were analysed. **Results:** Among the 62 HPE-correlated cases, 20/28 conventional FNAC cases were concordant (71.4%) and 8/28 were discordant (28.6%). In the USG-guided FNAC group, 31/34 cases were concordant (91.2%), and 3/34 were discordant (8.8%). Overall, 11 discordant cases were identified. The principal pitfalls involved adenomatoid goitre, follicular neoplasm and papillary carcinoma. ROC analysis showed an AUC of 0.958 for USG-guided FNAC compared with 0.656 for conventional FNAC. **Conclusion:** USG-guided FNAC showed higher cytology–histopathology concordance and lower diagnostic discordance than conventional FNAC in the HPE-correlated cohort. Accurate targeting, careful assessment of nuclear morphology and integration of ultrasound findings with cytology may help reduce diagnostic pitfalls, particularly in follicular-patterned lesions.

KEYWORDS

Thyroid Nodule; Fine-Needle Aspiration Cytology; Ultrasound-Guided FNAC

INTRODUCTION

Thyroid nodular lesions are one of the most common abnormalities encountered in clinical practice. With the increasing use and availability of high-resolution ultrasonography, the detection of both palpable and non-palpable thyroid nodules has improved diagnostic accuracy. Although most thyroid nodules are benign, a significant proportion represent thyroid malignancy, so accurate preoperative risk stratification is essential¹ and helps surgeons decide on the type of surgery.²

Ultrasonography is a readily available primary imaging modality for evaluating thyroid nodules because it provides information on nodule composition, echogenicity, margins, shape, calcifications, and other sonographic characteristics associated with malignancy risk. Various ultrasound-based risk stratification systems, including the American College of Radiology Thyroid Imaging Reporting and Data System (ACR TI-RADS) and the European Thyroid Association EU-TIRADS, have been developed to standardise assessment and determine which thyroid nodules require cytological evaluation.^{2,3}

Fine-needle aspiration cytology (FNAC) is an established, minimally invasive and cost-effective method for evaluating thyroid nodules in outpatient departments. It plays a pivotal role in distinguishing lesions that require surgical intervention from those that can be managed conservatively. However, conventional palpation-guided FNAC may be associated with sampling errors, particularly in small, deep, posteriorly located or predominantly cystic nodules. Ultrasound guidance allows direct visualisation of the needle and facilitates targeted sampling of the most representative component of the lesion, thereby reducing nondiagnostic and false-negative samples⁴.

The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC) was introduced to provide a standardised terminology and reporting framework for thyroid FNAC. The system categorises thyroid aspirates into six diagnostic categories, each associated with an estimated risk of malignancy and corresponding clinical management recommendations. Standardised cytological reporting improves communication between cytopathologists and clinicians and facilitates appropriate clinical decision-making.

Aims and Objectives

The main objectives were to classify thyroid nodules according to the TBSRTC using FNAC findings; compare the diagnostic performance

of USG-guided FNAC and conventional FNAC; and correlate cytological findings with histopathological diagnosis in cases undergoing surgery. Additional objectives were to identify major false-positive and false-negative diagnoses and other cytology–histopathology discordances.

To determine common diagnostic pitfalls, particularly in follicular-patterned lesions and papillary thyroid carcinoma, and to assess USG-guided FNAC as a preoperative diagnostic tool for more precise selection of patients for thyroid surgery. The present study highlights the potential role of USG-guided FNAC in reducing cytology–histopathology discordance and provides a basis for further development of precision thyroid management.

MATERIALS AND METHODS

Study Design and Study Population. This retrospective, observational, comparative study evaluated the diagnostic utility of conventional fine-needle aspiration cytology (FNAC) and ultrasound-guided FNAC in assessing thyroid nodules, with particular emphasis on cytological categorisation according to The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC) and the identification of diagnostic pitfalls. The study included 124 eligible thyroid FNAC cases. Cases in which histopathological examination (HPE) was available following surgical excision were further analysed for cytological–histopathological correlation. Histopathology was considered the reference standard for assessment of diagnostic concordance and discordance.

Sampling Technique: Thyroid aspirates were obtained either by conventional palpation-guided FNAC or by ultrasound (USG)-guided FNAC, depending on the clinical and radiological characteristics of the thyroid lesion. Conventional FNAC comprised 28 cases with subsequent histopathological correlation, whereas 34 histopathologically correlated cases underwent USG-guided FNAC. For USG-guided procedures, the target thyroid nodule was localised using a high-frequency linear array probe (15 MHz), and a 25-gauge needle was directed into the representative solid or suspicious component of the lesion. Care was taken to obtain adequate cellular material while avoiding unnecessary haemorrhage and sampling error.

Cytological Evaluation: The aspirated material was processed according to standard cytopathological techniques. Smears were prepared from the aspirated material and appropriately stained for

cytological evaluation. Cytological findings were assessed for cellularity, architectural pattern, nuclear and cytoplasmic features, colloid, background material, and other relevant morphological characteristics. Each case was assigned a diagnostic category according to TBSRTC. Particular attention was paid to lesions showing overlapping cytomorphological features, especially follicular-patterned lesions, adenomatoid/benign nodular lesions, and lesions suspicious for papillary thyroid carcinoma.

Histopathological Correlation: We performed histopathological examination on corresponding thyroidectomy specimens from cases with available surgical material. We used the histopathological diagnosis as the gold standard to evaluate the accuracy and diagnostic concordance of FNAC.

Among the 124 eligible cases, HPE correlation was available in 62 cases, comprising 28 conventional FNAC cases and 34 USG-guided FNAC cases. Cytological diagnoses were compared with the corresponding histopathological diagnoses. Cases in which the cytological diagnosis agreed with the final histopathological diagnosis were considered concordant & cases showing a difference between cytological and histopathological diagnoses were considered discordant.

Assessment of Diagnostic Pitfalls: We identified diagnostic pitfalls through a systematic review of discordant cytology–histopathology pairs. Particular emphasis was placed on false-negative and false-positive diagnoses and on lesions in which cytological overlap resulted in an incorrect or non-specific categorisation.

The principal diagnostic discrepancies identified in the histopathologically correlated cohort included:

- adenomatoid goitre diagnosed cytologically in cases subsequently found to have papillary carcinoma;
- adenomatoid goitre diagnosed cytologically in cases subsequently diagnosed as follicular neoplasm;
- follicular neoplasm diagnosed cytologically in cases subsequently found to have papillary carcinoma; and
- follicular neoplasm diagnosed cytologically in cases subsequently diagnosed as adenomatoid goitre.

We compared the frequency of these diagnostic pitfalls between conventional FNAC and USG-guided FNAC.

Statistical Analysis

We expressed categorical variables as frequencies and percentages. We calculated the rates of cytological–histopathological concordance and discordance separately for conventional FNAC and USG-guided FNAC.

Among the 62 cases with available HPE, 20 of 28 conventional FNAC cases were concordant, and 8 were discordant, corresponding to concordance and discordance rates of 71.4% and 28.6%, respectively. Among the 34 USG-guided FNAC cases, 31 were concordant, and 3 were discordant, corresponding to concordance and discordance rates of 91.2% and 8.8%, respectively.

The identified diagnostic pitfalls were further expressed as proportions of the total discordant cases and of the complete histopathologically correlated cohort. Appropriate statistical tests were applied as required to assess differences between the two sampling techniques, with p -values <0.05 considered statistically significant.

Ethical Considerations

The study was conducted in accordance with institutional ethical requirements and the principles of the Declaration of Helsinki. Ethical approval was obtained from the institutional Ethics Committee of Calcutta National Medical College Registration Number (CDSCO) – ECR/771/Inst/WB/2015. Patient confidentiality was maintained throughout the study, and written informed consent was obtained from each participant.

RESULTS AND ANALYSIS

Histopathology was available in 62 of the 124 eligible cases: 28 conventional FNAC cases and 34 USG-guided FNAC cases. For the diagnostic-pitfall analysis, histopathology was considered the reference standard ($n=62$).

We identified 11 cytology–histopathology discordant cases. Table 1 summarises the specific discordance patterns.

Table 1. Diagnostic Pitfalls Identified by Cytology in Comparison with Histopathology

Cytological diagnosis	Histopathological diagnosis	Type of discrepancy	Conventional FNAC, n	USG-FNAC, n	Total, n
Adenomatoid goitre	Papillary carcinoma	False-negative	2	–	2
Adenomatoid goitre	Follicular neoplasm	False-negative	4	–	4
Follicular neoplasm	Papillary carcinoma	Discordant diagnosis	1	2	3
Follicular neoplasm	Adenomatoid goitre	False-positive	1	1	2
Total discordant cases			8	3	11

Interpretation: Table 1 shows that 11 cytology–histopathology discordant cases were identified. The most frequent discrepancy was adenomatoid goitre diagnosed cytologically but found to be follicular neoplasm on histopathology (4 cases), followed by follicular neoplasm diagnosed cytologically but found to be papillary carcinoma (3 cases). Two cases each involved adenomatoid goitre being diagnosed cytologically in papillary carcinoma and follicular neoplasm being diagnosed cytologically in adenomatoid goitre. Conventional FNAC accounted for 8 of the 11 discordant cases, whereas USG-guided FNAC accounted for 3, suggesting fewer diagnostic discrepancies with ultrasound-guided sampling. The findings highlight the diagnostic difficulty of follicular-patterned lesions and papillary carcinoma with subtle nuclear features.

Table 2. Cytology–histopathology Concordance According to FNAC Technique

Diagnostic outcome	Conventional FNAC (n=28 HPE cases)	USG-FNAC (n=34 HPE cases)	Total (n=62)
Concordant with HPE	20 (71.4%)	31 (91.2%)	51 (82.3%)
Discordant with HPE	8 (28.6%)	3 (8.8%)	11 (17.7%)
Total	28 (100%)	34 (100%)	62 (100%)

Interpretation: Table 2 demonstrates higher cytology–histopathology concordance with USG-guided FNAC than with conventional FNAC. Among conventional FNAC cases, 20 of 28 (71.4%) were concordant and 8 of 28 (28.6%) were discordant. In contrast, 31 of 34 (91.2%) USG-guided FNAC cases were concordant and only 3 of 34 (8.8%) were discordant. Overall, 51 of 62 cases (82.3%) were concordant and 11 of 62 (17.7%) were discordant. Thus, in this HPE-correlated cohort, USG-guided FNAC was associated with a substantially higher concordance rate and lower discordance rate than conventional FNAC.

Table 3. Distribution of Diagnostic Pitfalls Among HPE-correlated Cases

Diagnostic pitfall	No. of cases	Percentage among discordant cases (n=11)	Percentage among all HPE cases (n=62)
Adenomatoid goitre → papillary carcinoma	2	18.2%	3.2%
Adenomatoid goitre → follicular neoplasm	4	36.4%	6.5%
Follicular neoplasm → papillary carcinoma	3	27.3%	4.8%
Follicular neoplasm → adenomatoid goitre	2	18.2%	3.2%
Total	11	100%	17.7%

Interpretation: Table 3 shows that adenomatoid goitre being diagnosed as follicular neoplasm was the most common diagnostic pitfall, accounting for 4 of 11 discordant cases (36.4%) and 6.5% of all HPE-correlated cases. This was followed by follicular neoplasm diagnosed as papillary carcinoma, comprising 3 cases (27.3% of discordant cases; 4.8% of all HPE cases). Adenomatoid goitre diagnosed as papillary carcinoma and follicular neoplasm diagnosed as adenomatoid goitre each accounted for 2 cases (18.2% of discordant cases; 3.2% of all HPE cases). Overall, the 11 discordant cases represented 17.7% of the

HPE-correlated cohort, with the majority of pitfalls involving overlap among benign adenomatoid, follicular-patterned and papillary lesions.

Table 4. Comparison of Diagnostic Discordance Between Conventional and USG-guided FNAC

Parameter	Conventional FNAC	USG-guided FNAC
HPE-correlated cases	28	34
Concordant cases	20	31
Discordant cases	8	3
Discordance rate	28.6%	8.8%
Concordance rate	71.4%	91.2%

Interpretation: Table 4 demonstrates a clear reduction in diagnostic discordance with USG-guided FNAC. The discordance rate decreased from 28.6% with conventional FNAC to 8.8% with USG-guided FNAC, while the concordance rate increased from 71.4% to 91.2%. Although the number of HPE-correlated cases was relatively small, these findings indicate better cytology–histopathology agreement with ultrasound-guided sampling. The improvement may reflect more accurate targeting of the representative or suspicious solid component of the thyroid nodule and reduced sampling-related error.

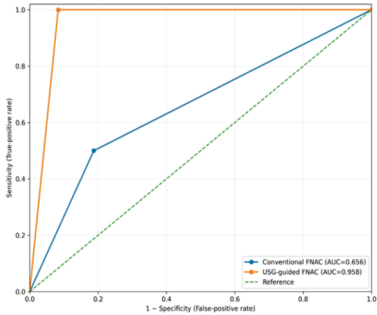


Figure 1. ROC Analysis of Cytological Category for Histological Malignancy

Table 5. ROC-derived Diagnostic Performance of Conventional and USG-guided FNAC

Parameter	Conventional FNAC	USG-guided FNAC
AUC	0.656	0.958
Sensitivity	50.0%	100.0%
Specificity	81.25%	91.67%
Overall diagnostic discrimination	Lower	Higher

ROC analysis demonstrated superior diagnostic discrimination for USG-guided FNAC compared with conventional FNAC, with an area under the curve (AUC) of 0.958 versus 0.656, respectively. USG-guided FNAC showed a sensitivity of 100% and specificity of 91.67%, compared with 50% sensitivity and 81.25% specificity for conventional FNAC.

Diagnostic discordance was substantially lower with USG-guided FNAC (8.8%) than with conventional FNAC (28.6%). The principal pitfalls involved follicular-patterned lesions and papillary carcinoma, particularly misclassification involving follicular neoplasm and adenomatoid goitre.

Microscopic Picture of Cyto-histologically Discordant Cases: -

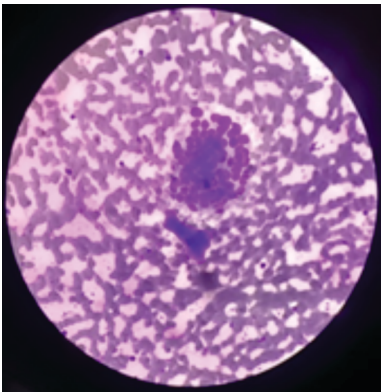


Fig.2: Cyto Diagnosis as Follicular Neoplasm

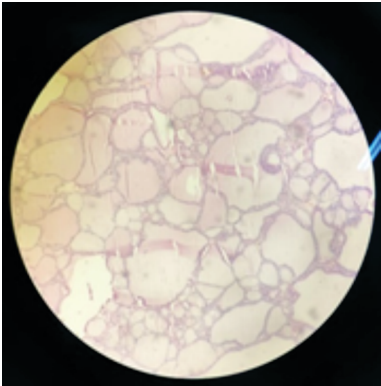


Fig.3: Hysto Diagnosis Adenomatoid Goitre

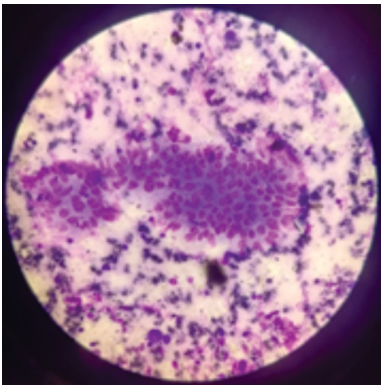


Fig.4: Cyto Diagnosis as Follicular Neoplasm

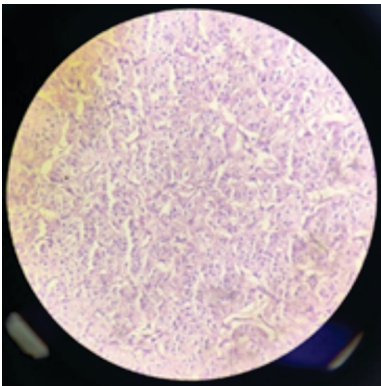


Fig. 5: Hysto Diagnosis Papillary Carcinoma

DISCUSSION

Fine Needle Aspiration Cytology (FNAC) is an established first-line investigation for evaluating thyroid nodules because it is minimally invasive, cost-effective, and provides useful information for triaging patients who require surgery from those who can be managed conservatively. The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC) has further improved the reproducibility of thyroid cytology reporting by providing standardised diagnostic categories linked to malignancy risk and corresponding clinical management. The 2023 Bethesda revision continues to recognise six diagnostic categories: nondiagnostic, benign, atypia of undetermined significance, follicular neoplasm, suspicious for malignancy and malignant ^{1,2}. However, despite standardisation, diagnostic discrepancies may occur due to sampling limitations, overlapping cytomorphological features, and the intrinsic limitations of cytology in follicular-patterned lesions.

In the present study, histopathological correlation was available for 62 cases, comprising 28 diagnosed by conventional FNAC and 34 by USG-guided FNAC. Of these, 11 cases showed cytological-histopathological discordance. The overall discordance rate was 17.7%, with discordance rates of 28.6% and 8.8% for conventional FNAC and USG-guided FNAC, respectively. Thus, these findings suggest better cytohistological concordance with USG-guided FNAC. Although the number of histologically correlated cases was relatively

limited, this observation is consistent with published evidence indicating that ultrasound guidance can improve the quality and diagnostic performance of thyroid FNAC.

A systematic review and meta-analysis comparing palpation-guided and ultrasound-guided FNAB reported higher pooled sensitivity and diagnostic performance for ultrasound-guided procedures. The pooled sensitivity was 90% for US-guided FNAB compared with 76% for palpation-guided FNAB, with corresponding area under the curve values of 0.92 and 0.827, respectively³. Previous comparative studies have similarly demonstrated a lower rate of inadequate specimens with US-guided aspiration. One study reported inadequate samples in 12.5% of US-guided aspirations compared with 27.2% of palpation-guided procedures⁴. Another prospective study reported inadequate material rates of 21.4% and 32.3% for ultrasound-guided and palpation-guided FNAB, respectively, with false-negative rates of 5.6% and 15.8%, respectively⁵. These findings plausibly explain the lower discordance observed in the USG-guided group in the present study, as real-time visualisation permits more accurate targeting of the solid or suspicious component of a nodule and may reduce sampling error.

An important finding of the present study was that most diagnostic discrepancies involved follicular-patterned lesions. Four cases diagnosed cytologically as adenomatoid goitre were reported as follicular neoplasm on histopathology, while three cases diagnosed as follicular neoplasm cytologically were found to represent papillary carcinoma on histopathological examination. Two additional cases diagnosed as adenomatoid goitre on cytology were subsequently found to be papillary carcinoma, whereas two cases interpreted as follicular neoplasm cytologically were benign adenomatoid goitre on histology. This pattern highlights the well-recognised difficulty in distinguishing benign follicular-patterned lesions from neoplastic and malignant lesions on cytological material.

The diagnostic limitation is particularly important for follicular neoplasms. FNAC evaluates individual cells and their architectural arrangement but cannot reliably assess capsular or vascular invasion, which are essential histological criteria for distinguishing follicular carcinoma from follicular adenoma. Consequently, follicular lesions are appropriately placed within the indeterminate/follicular neoplasm category in the Bethesda system rather than being definitively classified as benign or malignant on cytology alone^{1,6}. The cytological appearance of cellular follicular aspirates with microfollicular architecture and scant colloid may overlap considerably with follicular adenoma, follicular carcinoma and other follicular-patterned lesions. Recent literature also emphasises that the diagnosis of follicular neoplasm remains challenging because several benign and malignant entities share overlapping cytomorphological characteristics⁶.

The false-negative diagnoses of adenomatoid goitre in cases subsequently proven to be papillary carcinoma are also of clinical significance. Papillary thyroid carcinoma may occasionally show limited or subtle nuclear features in cytological preparations, particularly when the malignant focus is small or when the aspirate is dominated by benign follicular cells. Focal nuclear enlargement, chromatin clearing, nuclear grooves and intranuclear cytoplasmic pseudo inclusions may be sparse and therefore overlooked. In addition, cystic or degenerative change may result in suboptimal sampling of the diagnostic component. Such cases emphasise the importance of careful evaluation of nuclear morphology and correlation with ultrasound findings, particularly when cytological features are not entirely typical of a benign lesion.

The converse diagnostic pitfall, namely, interpreting a benign adenomatoid nodule as a follicular neoplasm, was also observed in the present series. This may occur when the aspirate is highly cellular and shows predominantly microfollicular architecture with relatively little colloid. The distinction between a hypercellular adenomatoid nodule and a follicular neoplasm can therefore be difficult on cytology. Studies evaluating cytological features of follicular neoplasms have shown that architectural patterns, nuclear morphology, and chromatin characteristics can help differentiate follicular neoplasms from mimicking lesions, but overlap remains an important limitation⁷.

The occurrence of papillary carcinoma among cases interpreted as follicular neoplasm is another recognised diagnostic challenge. Follicular-patterned variants of papillary thyroid carcinoma may lack prominent papillary structures and may therefore be interpreted as

follicular lesions when the characteristic nuclear changes are focal or subtle. The introduction of non-invasive follicular thyroid neoplasm with papillary-like nuclear features (NIFTP) has further complicated the cytological-histological correlation of follicular-patterned thyroid lesions because its diagnosis depends on strict histopathological criteria and its classification has implications for the estimated risk of malignancy associated with Bethesda categories^{2,8}.

The present findings are broadly comparable to previous cytohistological correlation studies, which demonstrate that the major diagnostic difficulties in thyroid FNAC occur in the follicular neoplasm and benign categories. A recent JCDR study evaluating 470 thyroid FNAs reported 50 cases with cytohistological follow-up, of which six were discordant. Five cases diagnosed as benign on cytology were subsequently diagnosed as papillary thyroid carcinoma on histopathology, while one case classified as suspicious for malignancy was diagnosed as adenomatous goitre⁹. The authors similarly highlighted the limitations of cytology in selected thyroid lesions and emphasised that TBSRTC provides an effective framework for standardised reporting but does not eliminate interpretative challenges. The relatively high specificity reported in that study further supports the usefulness of Bethesda categorisation while illustrating that false-negative diagnoses can still occur.

In the present study, the lower discordance observed with USG-guided FNAC is clinically relevant. Ultrasound not only facilitates accurate needle placement but also provides morphological information on nodule composition, margins, echogenicity, calcification, and other suspicious features. Correlation between ultrasound risk stratification and cytological classification may therefore improve the recognition of discordant cases. A recent study evaluating the relationship between ACR TIRADS and TBSRTC demonstrated a significant correlation between the two systems and significant correlations of both systems with histopathology¹⁰. Such radiological-cytological correlation is particularly useful when the cytological diagnosis appears benign but the ultrasound features remain suspicious.

The present findings should, however, be interpreted in the context of certain limitations. Histopathological follow-up was available only for a subset of the total study population, and therefore the observed discordance rates should not be extrapolated to all 124 cases. Cases undergoing surgery are also more likely to include indeterminate or clinically suspicious nodules, introducing potential selection bias into the HPE-correlated subgroup. In addition, the relatively small number of histologically correlated cases limits the statistical power of direct comparison between conventional and USG-guided FNAC. Nevertheless, the identification of specific, clinically meaningful diagnostic pitfalls provides useful information about areas where greater cytomorphological vigilance and radiological correlation may improve diagnostic accuracy.

Overall, the findings demonstrate that although FNAC using the Bethesda framework provides a reliable approach to evaluating thyroid nodules, diagnostic pitfalls persist, particularly in follicular-patterned lesions and in cases of papillary carcinoma with subtle nuclear features. The substantially lower discordance observed with USG-guided FNAC in the present study supports the value of ultrasound guidance in thyroid aspiration. Accurate targeting, adequate sampling, careful assessment of nuclear features, and integration of cytological findings with ultrasound characteristics are important measures to reduce false-negative and false-positive interpretations. Where cytomorphological findings remain indeterminate, histopathological assessment and, where available and appropriate, ancillary or molecular testing may help resolve difficult cases. The 2023 Bethesda System also recognises the increasing role of ancillary testing and integration of imaging findings in the contemporary evaluation of thyroid nodules¹.

Strengths

A major strength of the present study is the comparative evaluation of conventional FNAC and USG-guided FNAC for assessing thyroid nodules within the same study population. The study incorporated the Bethesda System for Reporting Thyroid Cytopathology (TBSRTC), thereby providing a standardised framework for cytological categorisation and facilitating comparison with histopathological findings. An additional strength was the availability of histopathological correlation in a substantial subset of cases, allowing assessment of cytological-histopathological concordance and identification of specific diagnostic pitfalls. The study also highlights the practical

value of image guidance in improving sampling adequacy and reducing diagnostic discordance, particularly in lesions with a follicular pattern or heterogeneous sonographic appearance. Identifying these specific pitfalls may help improve cytological interpretation and guide appropriate clinical management.

Limitations

The study has certain limitations. First, it was conducted at a single centre and involved a relatively limited number of cases, which may restrict the generalisability of the findings to other populations and healthcare settings. Second, histopathological correlation was available only in a subset of the total study cohort; therefore, definitive assessment of diagnostic accuracy, sensitivity and specificity was restricted to the HPE-correlated cases. Third, the decision to proceed with surgery and obtain histopathology was influenced by clinical and radiological factors and was not uniform across patients, introducing potential selection bias in the HPE-correlated subgroup. Fourth, the study was observational, and the choice between conventional and USG-guided FNAC was not necessarily randomised; hence, differences between the groups may partly reflect case selection and lesion characteristics. Finally, interobserver variability in cytological interpretation and the influence of operator experience were not formally assessed. Larger, prospective, multicentric studies with uniform histopathological follow-up and standardised assessment of sampling adequacy would help validate the present findings.

CONCLUSION

The present study demonstrates that both conventional FNAC and USG-guided FNAC are useful modalities for the cytological evaluation of thyroid nodules, with USG guidance showing a higher cytology-histopathology concordance in the HPE-correlated subset. The diagnostic discordance was lower with USG-guided FNAC than with conventional FNAC, particularly for lesions exhibiting follicular-patterned morphology. The principal diagnostic pitfalls involved distinguishing adenomatoid goitre, follicular neoplasm, and papillary carcinoma, emphasising the recognised limitations of cytomorphology in these diagnostically challenging lesions. Integration of ultrasound findings with targeted image-guided sampling and careful application of TBSRTC may improve diagnostic confidence and reduce sampling-related errors. Nevertheless, the findings should be interpreted in view of the limited histopathological follow-up and scope: The present study highlights the potential role of USG-guided FNAC in reducing cytology-histopathology discordance and provides a basis for further development of precision thyroid management. Future studies should evaluate larger prospective cohorts incorporating ultrasound risk stratification, TBSRTC, molecular alterations and long-term histopathological outcomes. Integrating these modalities with artificial intelligence, intraoperative nerve monitoring, and parathyroid-preservation technologies may facilitate patient-specific selection of the extent of thyroid surgery. Such an approach could minimise diagnostic uncertainty, reduce unnecessary thyroidectomy and simultaneously ensure timely treatment of clinically significant malignancies. The future of thyroid surgery therefore lies not merely in detecting malignancy, but in accurately defining its biological risk and tailoring the extent of surgery to the individual patient.

The present study highlights the potential role of USG-guided FNAC in reducing cytology-histopathology discordance and provides a basis for further development of precision thyroid management. Future studies should evaluate larger prospective cohorts incorporating ultrasound risk stratification, TBSRTC, molecular alterations and long-term histopathological outcomes. Integrating these modalities with artificial intelligence, intraoperative nerve monitoring, and parathyroid-preservation technologies may facilitate patient-specific selection of the extent of thyroid surgery.

Future Research Scope

Future studies should evaluate larger prospective cohorts incorporating ultrasound risk stratification and long-term histopathological outcomes. Integrating these modalities with artificial intelligence, intraoperative nerve monitoring, and parathyroid-preservation technologies may facilitate patient-specific selection of the extent of thyroid surgery. Such an approach could minimise diagnostic uncertainty, reduce unnecessary thyroidectomy and simultaneously ensure timely treatment of clinically significant malignancies. The future of thyroid surgery therefore lies not merely in

detecting malignancy, but in accurately defining its biological risk and tailoring the extent of surgery to the individual patient.

REFERENCES

1. Ali SZ, Baloch ZW, Cibas ES, Faquin WC, et al. The 2023 Bethesda System for Reporting Thyroid Cytopathology. *J Am Soc Cytopathol.* 2023;12(5):319-334. doi:10.1016/j.jasc.2023.06.001.
2. Cibas ES, Ali SZ. The 2017 Bethesda System for Reporting Thyroid Cytopathology. *Thyroid.* 2017;27(11):1341-1346. doi:10.1089/thy.2017.0500.
3. Nugraha A, et al. Diagnostic accuracy of palpation versus ultrasound-guided fine needle aspiration biopsy for diagnosis of malignancy in thyroid nodules: a systematic review and meta-analysis. *J Med Ultrasound.* 2022.
4. Carmeci C, Jeffrey RB, McDougall IR, Nowels KW, Weigel RJ. Ultrasound-guided fine-needle aspiration biopsy of thyroid masses. *Thyroid.* 1998;8:283-289.
5. Danese D, Sciacchitano S, Farsetti A, Andreoli M, Pontecorvi A. Diagnostic accuracy of conventional versus ultrasound-guided fine-needle aspiration biopsy of thyroid nodules. [Comparative evidence demonstrating improved adequacy and lower false-negative rate with ultrasound guidance.]
6. Baloch ZW, LiVolsi VA, Asa SL, et al. Cytopathology of follicular and oncocytic follicular thyroid neoplasms: a Bethesda System perspective. *J Am Soc Cytopathol.* 2025.
7. Kim JY, et al. Cytological features that differentiate follicular neoplasm from mimicking lesions. *J Pathol Transl Med.* 2018.
8. Layfield LJ, Baloch ZW, Esebua M, Kannuswamy R, Schmidt RL. Impact of the reclassification of the non-invasive follicular variant of papillary carcinoma as benign on the malignancy risk of the Bethesda System for Reporting Thyroid Cytopathology: a meta-analysis study. *Acta Cytol.* 2017;61(3):187-193. doi:10.1159/000469654.
9. [JCDR study] Cytological diagnosis, cytohistological correlation, thyroid carcinoma. *J Clin Diagn Res.* 2024;18(8):EC29-EC35. doi:10.7860/JCDR/2024/19794.
10. Correlation of ultrasound-based TIRADS and the Bethesda system for reporting of thyroid cytopathology: a study in a tertiary care centre. *J Clin Pathol / related publication,* 2023.