RESEARCH PAPER

Diagnostic Accuracy of Fine Needle Aspiration Cytology in Thyroid Lesions Using the Bethesda System (2023): A Prospective Cyto-Histopathological Correlation Study

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Abstract

Background: Fine needle aspiration cytology (FNAC) is a cornerstone in the evaluation of thyroid nodules. The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC 2023) provides a standardized framework for diagnosis and management.

Aim: To evaluate the diagnostic accuracy of FNAC in thyroid lesions using the Bethesda system (2023) and correlate cytological findings with histopathology.

Methods: A prospective study was conducted over 18 months including 72 patients presenting with thyroid swelling at NIMS hospital, Jaipur, Rajasthan. FNAC was performed and categorized using the Bethesda system. Histopathological examination was used as the gold standard for correlation. Diagnostic parameters including sensitivity, specificity, and accuracy were calculated.

Results: Females constituted 84.7% of cases, with the majority of patients belonging to the 31–50-year age group. Bethesda Category II was the most common cytological diagnosis (68.1%), with colloid goitre representing the most frequent non-neoplastic lesion. Histopathological examination revealed that non-neoplastic lesions accounted for 65.27% of cases, while papillary carcinoma was the most common malignant lesion (19.44%). Cyto-histological concordance was observed in 87.5% of cases. Fine-needle aspiration cytology (FNAC) demonstrated high specificity (94.6%) and overall diagnostic accuracy (88.9%), with a sensitivity of 68.8%.

Conclusion: FNAC using the Bethesda system is a reliable and effective diagnostic tool for thyroid lesions. However, histopathological confirmation remains essential in indeterminate categories.

Keywords: FNAC, Thyroid nodules, Bethesda system 2023, Cytopathology, Histopathology, Diagnostic accuracy

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Introduction

Thyroid nodules represent one of the most frequent indications for cytopathological evaluation in clinical practice. Although the majority of thyroid nodules are benign, a small but clinically significant proportion harbor malignancy. The primary objective of thyroid cytology is therefore to accurately identify lesions requiring surgical intervention while avoiding unnecessary thyroidectomy in patients with benign disease. Fine Needle Aspiration Cytology (FNAC) has become the cornerstone of preoperative assessment owing to its simplicity, safety, rapid turnaround time, and high diagnostic accuracy (1,4).

The cytological spectrum of thyroid lesions encompasses a wide range of non-neoplastic, benign neoplastic, and malignant conditions. Non-neoplastic lesions constitute the majority of thyroid aspirates and include nodular colloid goiter, hyperplastic nodules, multinodular goiter, Hashimoto thyroiditis, lymphocytic thyroiditis, and granulomatous thyroiditis. These lesions typically demonstrate characteristic cytomorphological features such as abundant colloid, benign follicular epithelial cells, Hurthle cell change, inflammatory infiltrates, and multinucleated giant cells depending on the underlying pathology (7,8).

Neoplastic lesions of the thyroid comprise both benign and malignant tumors. Follicular adenoma is the most common benign neoplasm and often presents cytologically as a follicular-patterned lesion. However, distinguishing follicular adenoma from follicular carcinoma remains a significant challenge because the diagnosis of carcinoma requires demonstration of capsular and/or vascular invasion, features that cannot be assessed on cytological specimens. Consequently,

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follicular-patterned lesions continue to represent one of the most important diagnostic limitations of FNAC (3,7).

Among malignant thyroid neoplasms, papillary thyroid carcinoma (PTC) is the most prevalent, accounting for approximately 80–85% of thyroid cancers. Cytologically, PTC is characterized by distinctive nuclear features including enlargement, overlapping, nuclear grooves, chromatin clearing, and intranuclear pseudoinclusions. These characteristic findings often allow a definitive preoperative diagnosis. Other malignant tumors include follicular carcinoma, medullary thyroid carcinoma, poorly differentiated thyroid carcinoma, anaplastic carcinoma, and metastatic tumors involving the thyroid gland. Each exhibits unique cytomorphological characteristics that contribute to diagnostic categorization and subsequent clinical management (7,8). To standardize reporting and improve communication between cytopathologists and clinicians, The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC) was introduced in 2007 and subsequently revised in 2017 and 2023. The Bethesda system categorizes thyroid FNAC findings into six diagnostic categories: Category I (Non-diagnostic/Unsatisfactory), Category II (Benign), Category III (Atypia of Undetermined Significance/Follicular Lesion of Undetermined Significance), Category IV (Follicular Neoplasm/Suspicious for Follicular Neoplasm), Category V (Suspicious for Malignancy), and Category VI (Malignant). Each category is associated with an estimated risk of malignancy and recommended clinical management strategy (1,2).

The 2023 Bethesda update incorporates recent advances in molecular diagnostics, risk stratification, and emerging pathological entities. It provides refined diagnostic criteria for indeterminate categories and emphasizes integration of cytomorphology with radiological and molecular findings. This updated classification has enhanced reproducibility and improved patient-specific clinical decision-making (1).

Category II (Benign) remains the largest diagnostic group and includes nodular goiter and thyroiditis, exhibiting a very low risk of malignancy. Categories III and IV represent indeterminate lesions and continue to pose significant diagnostic challenges because of overlapping cytological features between benign and malignant follicular-patterned lesions. These categories often require repeat aspiration, molecular testing, or diagnostic lobectomy for definitive evaluation. Categories V and VI are associated with progressively increasing risks of malignancy and usually warrant surgical management (1,2,6).

Histopathological examination remains the gold standard for definitive diagnosis of thyroid lesions. It provides architectural details, assessment of capsular and vascular invasion, evaluation of extrathyroidal extension, lymphovascular involvement, and accurate tumor classification. Histopathology is particularly indispensable in differentiating follicular adenoma from follicular carcinoma and in identifying specific variants of papillary thyroid carcinoma that may have prognostic significance (3,8).

Correlation of cytological findings with subsequent histopathological diagnosis serves as an essential quality assurance measure in thyroid pathology. Such correlation enables assessment of sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of FNAC. Furthermore, it facilitates identification of false-positive and false-negative cases, highlights areas of diagnostic difficulty, and contributes to continuous improvement in cytological interpretation (4,6).

Recent studies have demonstrated that the implementation of the Bethesda system significantly improves interobserver agreement and diagnostic reproducibility while providing reliable estimates of malignancy risk across different categories. Nevertheless, challenges remain in the evaluation of indeterminate lesions, sampling adequacy, cystic lesions, and follicular-patterned neoplasms. The incorporation of ultrasound-guided aspiration, cell block techniques, immunocytochemistry, and molecular testing has further enhanced the diagnostic performance of thyroid cytopathology (5,6).

Therefore, a comprehensive cytohistopathological correlation is crucial not only for validating cytological diagnoses but also for optimizing patient management, reducing unnecessary surgeries, and ensuring early detection of thyroid malignancies. In this context, the present study was undertaken to evaluate the role of FNAC in thyroid lesions using the Bethesda System for Reporting Thyroid Cytopathology (2023) and to correlate cytological findings with histopathological diagnosis, thereby assessing its diagnostic accuracy and clinical utility.

Aim

To evaluate thyroid gland lesions using fine needle aspiration cytology (FNAC) in accordance with the Bethesda System for Reporting Thyroid Cytopathology (2023), and to assess its diagnostic accuracy through histopathological correlation.

Objectives

1. To categorize thyroid lesions cytologically based on the Bethesda System for Reporting Thyroid Cytopathology (2023).
2. To conduct a detailed histopathological examination of the corresponding surgical specimens for definitive diagnosis.
3. To establish cytological–histopathological concordance and evaluate the diagnostic performance of FNAC in thyroid lesions.

Materials and Methods

Study Design and Setting

This prospective observational study was conducted over a period of 18 months in the Departments of Pathology, Department of ENT, and General Surgery at National Institute of Medical Sciences and Research, Jaipur. The study was designed to evaluate the

diagnostic utility of fine needle aspiration cytology (FNAC) in thyroid lesions and to correlate cytological findings with histopathological diagnosis.

Study Population
The study included patients presenting with thyroid gland lesions who were admitted to the Departments of General Surgery and ENT. Individuals of all age groups and both genders were considered eligible, provided they fulfilled the inclusion and exclusion criteria.

Inclusion Criteria
- Patients presenting with clinically palpable thyroid gland lesions and advised for FNAC.
- Patients who provided written informed consent for participation in the study.

Exclusion Criteria
- Medically unfit patients, including those with coagulation disorders, uncontrolled thyrotoxicosis, or chronic liver disease.
- Patients who had received prior chemotherapy.
- Cases in which corresponding histopathological specimens were unavailable or deemed unsuitable due to improper labelling, inadequate fixation, autolysis, or insufficient tissue as per standard pathological protocols.

Sample Size and Sampling Technique
A total of 72 cases were included in the study. The sample size was calculated using the standard formula for estimating proportions:

$$n = \frac{(Z_{\alpha/2})^2 \times p \times (1-p)}{d^2}$$

where:
- $Z_{\alpha/2} = 1.96$at a 95% confidence interval
- $p = 0.86$(expected diagnostic accuracy)
- $d = 0.08$(margin of error)

The calculated sample size was approximately 72, which was adopted for the study.

Data Collection and Statistical Analysis
Clinical, cytological, and histopathological data were systematically recorded and tabulated. Statistical analysis was performed using SPSS and Microsoft Excel. Diagnostic performance parameters, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy, were calculated where applicable.

FNAC Procedure and Cytological Evaluation
Fine needle aspiration cytology was performed under aseptic precautions using 22–25 gauge needles. Both direct and image guided procedures were used as and where required. Patients were positioned supine with slight neck extension. The nodule was localized, and aspiration was carried out using standard techniques.
The aspirated material was expelled onto clean glass slides, and both air-dried and alcohol-fixed smears prepared. Cytological evaluation was performed using the Bethesda System for Reporting Thyroid Cytopathology (2023), categorizing cases into six diagnostic groups.

Cytological Staining Techniques
To ensure optimal cytomorphological assessment, multiple staining methods were employed:

Papanicolaou (PAP) Stain
Alcohol-fixed smears were stained using the PAP technique to evaluate nuclear morphology. The procedure involved hematoxylin staining for nuclear detail, followed by cytoplasmic counterstaining with Orange G and Eosin Azure.

May–Grünwald–Giemsa (MGG) Stain
Air-dried smears were stained using MGG stain, a Romanowsky-type stain that provides excellent cytoplasmic and background detail.

Diff-Quik Stain
A rapid modified Romanowsky stain was used for immediate assessment of smear adequacy, particularly useful during on-site evaluation.

Histopathological Examination
Surgically excised thyroid specimens were received in the Department of Pathology and processed according to standard protocols.

Gross Examination
Specimens were carefully examined for size, weight, external appearance, nodularity, capsular integrity, and presence of lesions. Serial sectioning was performed to assess tumor characteristics, including size, consistency, circumscription, and relation to surrounding thyroid tissue**(Figure 1a, 1b).** Representative sections were taken from tumor, adjacent thyroid tissue, isthmus, and other relevant areas.

Tissue Processing
Specimens were fixed in 10% neutral buffered formalin. Following fixation, tissues were processed in an automated tissue processor through dehydration in graded alcohol, clearing in xylene, and paraffin embedding. Sections of 3–5 µm thickness were obtained using a rotary microtome.

Histopathological Staining
Sections were stained with Hematoxylin and Eosin (H&E). Hematoxylin stained nuclei blue-purple, while eosin stained cytoplasmic components pink, allowing detailed evaluation of tissue architecture.

Diagnostic Criteria
Histopathological diagnosis was established according to the World Health Organization (WHO) Classification of Tumours of Endocrine Organs.

Cytological–Histopathological Correlation
Cytological findings were correlated with corresponding histopathological diagnoses wherever surgical

specimens were available. This correlation was used to assess concordance and evaluate the diagnostic accuracy of FNAC across different Bethesda categories.

Ethical Considerations

The study was conducted in accordance with ethical standards. Written informed consent was obtained from all participants prior to inclusion in the study. Patient confidentiality was strictly maintained throughout the study.

Results

The present study included 72 patients with thyroid gland lesions evaluated by fine needle aspiration cytology (FNAC). A marked female predominance was observed, with females accounting for 61 cases (84.7%) and males for 11 cases (15.3%). The most commonly affected age group was 31–40 years (27.8%), followed closely by 41–50 years (26.4%), while patients aged ≤20 years constituted only 2.8% of cases. These findings indicate that thyroid lesions were predominantly encountered in middle-aged females.

With regard to anatomical distribution, involvement of the whole thyroid gland or isthmus was the most common presentation, observed in 36.1% of cases, followed by the right lobe (33.3%) and left lobe (30.6%). This suggests that thyroid lesions may involve any region of the gland, with a slight predominance of diffuse or central gland involvement.

Clinically, the majority of patients presented with non-tender midline neck swelling (88.9%), whereas only 11.1% had tender swelling, indicating that most lesions were chronic and non-inflammatory in nature. The duration of swelling was ≤6 months in 52.8% of patients and 7–12 months in 29.2% of cases, while only two patients presented after more than 24 months of symptom duration. These findings suggest that most patients sought medical attention within the first year of noticing thyroid enlargement.

Assessment of lesion size demonstrated that nodules measuring ≤2 cm were identified in only 4 cases (5.56%). Lesions measuring 2.1–4 cm were observed in 25 cases (34.72%), while nodules measuring 4.1–6 cm constituted the largest group, accounting for 31 cases (43.06%). Lesions larger than 6 cm were present in 12 cases (16.67%). Overall, moderately sized nodules (2.1–6 cm) represented the predominant clinical presentation, although a considerable proportion of patients had large lesions, suggesting delayed consultation or progressive enlargement before presentation.

Evaluation using The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC) demonstrated that Bethesda Category II**(Figure 2,3),** lesions predominated, accounting for 68.1% of cases, indicating a high prevalence of benign thyroid lesions. Bethesda Category III (AUS/FLUS) comprised 6.9% of cases, while Bethesda Category IV (follicular neoplasm/suspicious for follicular neoplasm) accounted for 5.6%. Bethesda Categories V and VI **(Figure 4,5),** each constituted 9.7% of cases, reflecting a significant proportion of lesions with suspicious or confirmed malignant potential. No cases were reported under Bethesda Category I.

FNAC was found to be a safe and minimally invasive diagnostic procedure. No complications were observed in 91.7% of patients, while mild transient pain was reported in only 8.3% of cases. No significant bleeding, hematoma, infection, or other serious adverse effects were encountered.

Histopathological examination revealed that non-neoplastic benign lesions formed the majority of cases, accounting for 65.27% (n = 47). These included colloid goitre, multinodular goitre, lymphocytic thyroiditis **(Figure 6),** Hashimoto's thyroiditis, and follicular nodular disease. Among malignant lesions, papillary carcinoma and its variants were the most common, constituting 19.44% (n = 14) of cases. Other lesions included follicular neoplasm (5.56%), non-invasive follicular thyroid neoplasm with papillary-like nuclear features (NIFTP) (4.17%), poorly differentiated thyroid carcinoma (2.77%)**(Figure 7),** and differentiated high-grade carcinoma (1.39%).

Table 1. Demographic Profile of Patients gender and age

Variable	Number	Percentage
Male	11	15.3%
Female	61	84.7%
≤20 years	2	2.8%
21-30 years	9	12.5%
31–40 years	20	27.8%
41–50 years	19	26.4%
51-60 years	11	15.3%
>60 years	11	15.3%

Table 2. Clinical Characteristics, Duration and Involvement of Thyroid Lesions

Clinical Variable	Number	Percentage
Non-tender swelling	64	88.9%
Tender swelling	8	11.1%
Duration ≤6 months	38	52.8%
Duration 7–12 months	21	29.2%
Right lobe involvement	24	33.3%

Left lobe involvement	22	30.6%
Whole gland/isthmus	26	36.1%

Table 3. Distribution of Lesion Size

Lesion Size	Number	Percentage
≤2 cm	4	5.56%
2.1–4 cm	25	34.72%
4.1–6 cm	31	43.06%
>6 cm	12	16.67%

Table 4. Bethesda Category Distribution

Bethesda Category	Diagnosis	Number	Percentage
I	Non-diagnostic	0	0%
II	Benign	49	68.1%
III	AUS/FLUS	5	6.9%
IV	FN/SFN	4	5.6%
V	Suspicious for malignancy	7	9.7%
VI	Malignant	7	9.7%

Table 5. Histopathological Spectrum of Thyroid Lesions

Diagnosis	Number	Percentage
Benign non-neoplastic lesions	47	65.27%
Papillary carcinoma	14	19.44%
Follicular neoplasm	4	5.56%
NIFTP	3	4.17%
Poorly differentiated carcinoma	2	2.77%
Differentiated high-grade carcinoma	1	1.39%

Cytology and Histopathological Correlation

Cyto-histopathological correlation between FNAC diagnosis based on the Bethesda System and final histopathological examination demonstrated concordance in 87.5% of cases, indicating a high degree of reliability of FNAC as a preoperative diagnostic modality. Discordance was observed in 12.5% of cases, which may be attributed to sampling error, interpretative difficulties, technical limitations, and tumor heterogeneity. Most discordant cases were seen in Bethesda Categories II and III. In Category II, lesions initially interpreted as benign follicular nodules or follicular nodular disease were later diagnosed on histopathology as papillary carcinoma **(Figure 9),** follicular variant of papillary carcinoma **(Figure 8),** or NIFTP, highlighting the potential for malignant lesions to mimic benign follicular patterns on cytology. In Category III, lesions categorized as AUS/FLUS were subsequently identified as benign entities such as colloid goitre, multinodular goitre, follicular adenoma with lymphocytic thyroiditis, and follicular nodular disease, reflecting the inherent diagnostic uncertainty associated with indeterminate cytological categories. One false-positive case was observed in Bethesda Category V, where cytology was suspicious for malignancy but histopathology confirmed follicular adenoma. These findings reinforce that although FNAC is an effective first-line diagnostic investigation, histopathological examination remains the gold standard for definitive diagnosis, particularly in indeterminate and follicular-patterned lesions.

Table 6. Diagnostic Performance of FNAC

Parameter	Value
Sensitivity	68.8%
Specificity	94.6%
Positive Predictive Value	78.6%
Negative Predictive Value	91.4%
Diagnostic Accuracy	88.9%

Discussion

The present study was undertaken to evaluate the diagnostic utility of fine needle aspiration cytology (FNAC) in thyroid gland lesions, with particular emphasis on the **Bethesda System for Reporting Thyroid Cytopathology (TBSRTC 2023)**, and to correlate cytological findings with histopathological diagnosis. Thyroid nodules represent one of the most common endocrine abnormalities encountered in clinical practice, and distinguishing benign from malignant lesions preoperatively remains crucial for optimal patient management. FNAC has emerged as a cost-effective, minimally invasive, and reliable diagnostic modality, and the findings of the present study

further substantiate its clinical value while highlighting its limitations.

Demographic Profile of Patients

A marked female predominance (84.7%) was observed in the present study, with males accounting for only 15.3% of cases. This finding is consistent with the well-established epidemiological pattern of thyroid disorders, which are significantly more prevalent in females due to hormonal influences, increased susceptibility to autoimmune diseases, and differences in iodine metabolism. Similar observations were reported by Gupta et al., who documented a female predominance exceeding 75% in patients with thyroid lesions [9].

The mean age of patients was 43.9 ± 13.3 years, with the highest incidence in the 31–40 and 41–50 years age groups. This indicates that thyroid lesions are most frequently encountered in middle-aged individuals. Comparable findings were reported by Handa et al., who also demonstrated peak incidence in the fourth and fifth decades of life [10]. However, certain Western studies have reported a relatively older age distribution, which may be attributed to differences in healthcare access and screening practices [11].

Anatomical Distribution of Lesions

In the present study, the entire gland or isthmus was involved in 36.1% of cases, followed by the right lobe (33.3%) and left lobe (30.6%). The near-equal distribution between the lobes suggests that thyroid lesions may arise in any anatomical region. The relatively higher proportion of diffuse gland involvement may be explained by the prevalence of multinodular goiter and inflammatory conditions. Sengupta et al. similarly reported frequent bilateral or diffuse thyroid involvement in benign lesions [12]. Conversely, some studies have suggested a slight right lobe predominance, possibly due to anatomical asymmetry [13].

Clinical Presentation and Duration of Swelling

The majority of patients presented with non-tender midline neck swelling (88.9%), indicating that most lesions were chronic, slowly progressive, and non-inflammatory. Thyroid nodules are often asymptomatic and are frequently detected incidentally or due to cosmetic concerns. Similar findings were reported by Yassa et al., who noted that most patients presented with painless swelling [14].

More than half of the patients (52.8%) sought medical attention within six months of symptom onset, reflecting increasing awareness and improved healthcare accessibility. In contrast, studies from resource-limited settings have reported delayed presentation with long-standing goiter [15].

Nodule Size Distribution

The majority of nodules measured 4.1–6 cm (43.06%), followed by 2.1–4 cm (34.72%), while smaller nodules (≤2 cm) were relatively uncommon. This suggests that many patients presented only after nodules became clinically apparent. Kamran et al. reported similar findings, noting that larger nodules are more likely to undergo FNAC compared to subclinical micro-nodules [16]. However, in settings with widespread imaging, smaller nodules are increasingly detected and evaluated [17].

Cytological Diagnosis According to Bethesda System

Bethesda Category II (benign) constituted the majority of cases (68.1%), reflecting the predominance of non-neoplastic thyroid lesions. This is consistent with the findings of Bongiovanni et al., whose meta-analysis demonstrated that benign lesions represent the largest proportion of thyroid FNAC diagnoses globally [18].

Indeterminate categories (Category III and IV) accounted for 12.5% of cases. The relatively low proportion of AUS/FLUS (6.9%) suggests judicious use of this category, which is important to avoid unnecessary diagnostic ambiguity. Cibas and Ali emphasized that Category III should be reserved for select cases with limited atypia [19].

Categories V and VI each comprised 9.7% of cases, indicating a significant proportion of lesions with high malignant potential. This proportion may be slightly elevated due to inclusion of surgically managed cases, which often represent a more selective population [20].

Post-FNAC Complications

FNAC was found to be a safe and well-tolerated procedure, with no complications in 91.7% of cases. Only mild, transient pain was reported in a small proportion of patients (8.3%). No major complications such as hemorrhage, infection, or hematoma were observed. These findings are in agreement with Gharib and Goellner, who reported FNAC as a safe outpatient procedure with minimal complications [21].

Histopathological Diagnosis

Histopathological examination revealed that the majority of lesions (65.27%) were non-neoplastic benign conditions, including colloid goiter, multinodular goiter, and thyroiditis. This correlates well with the predominance of Bethesda Category II lesions. Similar observations were reported by Hegedüs, who emphasized that most thyroid nodules are benign [22].

Among malignant lesions, papillary thyroid carcinoma and its variants were the most common (19.44%), consistent with global trends. Davies and Welch also reported papillary carcinoma as the most prevalent thyroid malignancy worldwide [23]. Other lesions such as follicular neoplasm and NIFTP were observed in smaller proportions, reflecting evolving classification systems and recognition of low-risk neoplasms [24].

Cytohistopathological Correlation

A high concordance rate of 87.5% was observed between FNAC and histopathology, demonstrating the reliability of FNAC when interpreted using standardized Bethesda criteria. Similar concordance rates ranging from 80% to 90% have been reported in previous studies [25].

The discordance rate of 12.5% in the present study is within acceptable limits and reflects inherent limitations of cytology, particularly in follicular-patterned lesions and sampling-dependent conditions.

Analysis of Discordant Cases

Most discordant cases were observed in Bethesda Categories II and III. Some lesions initially diagnosed as benign were later confirmed as papillary carcinoma or its variants, likely due to sampling error, cystic degeneration, or subtle nuclear features. Jo et al. reported similar diagnostic challenges, particularly in follicular variants of papillary carcinoma [26].

Category III cases demonstrated variability, with several lesions proving benign on histopathology. This highlights the indeterminate nature of this category and the need for repeat FNAC or further evaluation. A single false-positive case in Category V underscores the possibility of overinterpretation in cases with overlapping cytological features.

Diagnostic Accuracy of FNAC

The sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy of FNAC in the present study were 68.8%, 94.6%, 78.6%, 91.4%, and 88.9%, respectively. The relatively lower sensitivity reflects the presence of false-negative cases, whereas the high specificity indicates excellent ability to correctly identify benign lesions.

These findings are comparable to those reported by Baloch et al. and Handa et al., who demonstrated high specificity and overall diagnostic accuracy of FNAC in thyroid lesions [27,10]. The high negative predictive value further supports the reliability of FNAC in ruling out malignancy.

Summary

The present study confirms that FNAC, when used in conjunction with the Bethesda System (2023), is an effective first-line diagnostic tool for thyroid lesions. It provides accurate risk stratification and guides clinical management. However, limitations persist in indeterminate and follicular-patterned lesions, where histopathological examination remains essential for definitive diagnosis.

Conclusion

The present study demonstrates that fine needle aspiration cytology (FNAC) is a safe, simple, minimally invasive, and highly effective first-line diagnostic modality for the evaluation of thyroid gland lesions. The implementation of the **Bethesda System for Reporting Thyroid Cytopathology (2023)** provides a standardized and clinically relevant framework for categorizing thyroid lesions, thereby facilitating risk stratification and guiding appropriate clinical management.

The findings of this study indicate that the majority of thyroid lesions are benign, with a pronounced female predominance and peak incidence in the fourth and fifth decades of life. Bethesda Category II constituted the largest proportion of cases, while papillary thyroid carcinoma emerged as the most common malignant lesion.

A high cytohistopathological concordance rate (87.5%) and overall diagnostic accuracy (88.9%) were observed, underscoring the reliability of FNAC in distinguishing benign from malignant thyroid lesions. The high specificity and negative predictive value further highlight its clinical utility in minimizing unnecessary surgical interventions in patients with benign conditions.

However, diagnostic challenges persist in follicular-patterned lesions, cystic nodules, and indeterminate categories, where cytological interpretation may be limited. Therefore, histopathological examination remains indispensable as the gold standard for definitive diagnosis, particularly in cases with suspicious, indeterminate, or discordant findings.

In conclusion, FNAC, when combined with the Bethesda 2023 classification, serves as an invaluable diagnostic tool in thyroid pathology, contributing to accurate diagnosis, rational treatment planning, reduction of avoidable surgeries, and overall improvement in patient care.

Strengths and Limitations

Strengths

The present study possesses several methodological and clinical strengths. It was conducted as a prospective study with clearly defined inclusion and exclusion criteria, ensuring systematic and unbiased data collection. The use of the **Bethesda System (2023)** for cytological reporting provided a standardized and reproducible framework, enhancing diagnostic consistency and clinical applicability.

A key strength of the study is the comprehensive cytohistopathological correlation performed in all cases, which enabled accurate assessment of the diagnostic performance of FNAC and validation of cytological findings. The study reflects real-world clinical practice in a tertiary care setting, thereby increasing the external validity and applicability of the results to similar healthcare environments.

Furthermore, the use of multiple staining techniques and adherence to standardized histopathological processing protocols contributed to improved cytomorphological assessment and diagnostic accuracy.

Limitations

Despite its strengths, the study has certain limitations that should be acknowledged. The sample size was relatively small (n = 72), which may limit the generalizability of the findings to larger populations. Additionally, selection bias may have been introduced, as only cases with available histopathological correlation were included.

FNAC, by its nature, has inherent diagnostic limitations, particularly in follicular-patterned lesions, where evaluation of capsular and vascular invasion is not possible. Sampling errors, cystic degeneration, and tumor heterogeneity may contribute to false-negative or false-positive interpretations.

Interobserver variability in cytological interpretation may also influence diagnostic categorization, especially

in indeterminate categories such as AUS/FLUS. Moreover, advanced ancillary techniques, including molecular testing, were not utilized in the present study, which could have enhanced diagnostic precision, particularly in borderline or indeterminate lesions.

Conflict of interest: There is no conflict of interest.
Ethical statement: Informed consent was obtained from the patient prior to all clinical investigations and procedures. All efforts have been made to ensure patient anonymity and confidentiality.
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Author Contributions:
Kinjal Patel: Conceptualization, data collection, cytological and histopathological evaluation, manuscript preparation and literature review.
Sima Chauhan: Study supervision, histopathological evaluation, data interpretation, manuscript review and final approval.
Natasha Modi: Cytopathological correlation, data interpretation, revision of manuscript and final approval.
Monika Yadav: Revision of manuscript and final approval.

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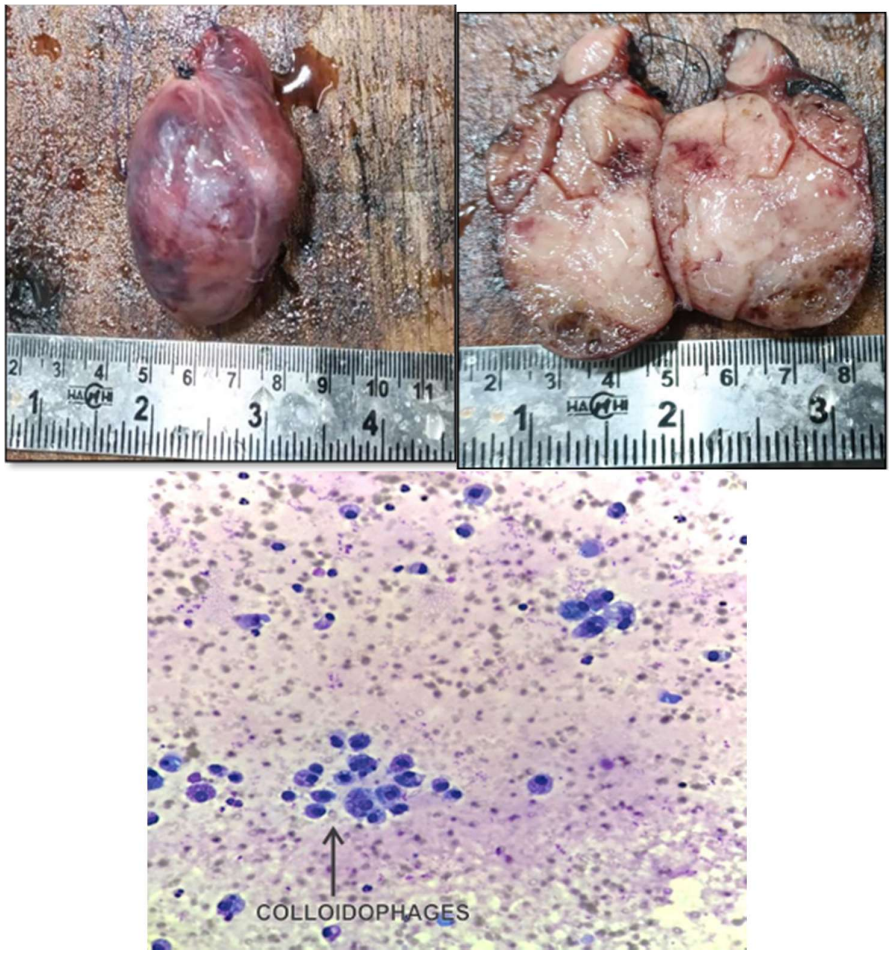
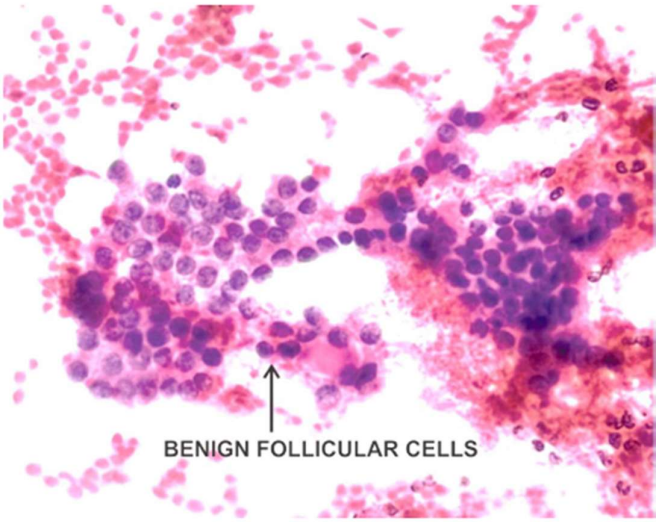
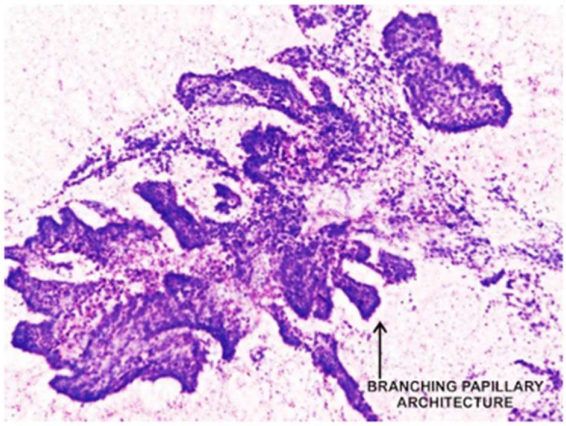
Figure legends:
Figure 1a,1b. Gross specimen and cut section of thyroid shows nodular area with normal thyroid parenchyma in lower end.
Figure 2. Follicular nodular disease. Microphotograph showing abundant colloidophages in a background of thin colloid (Leishman stain,400X)
Figure 3. Benign follicular nodular disease. Microphotograph showing benign sheets of follicular cells. (H&E stain,400X)
Figure 4. Papillary carcinoma of thyroid. Microphotograph demonstrating multiple branching papillary fragments with well-defined fibrovascular cores, lined by crowded follicular epithelium cells, in a haemorrhagic background (H&E stain, 100X)

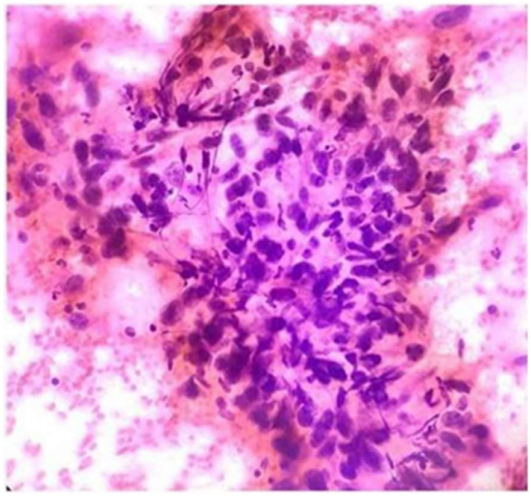
Figure 5. Anaplastic carcinoma thyroid. Microphotograph showing highly pleomorphic malignant cells, a few spindle and multinucleated giant forms, with marked nuclear atypia in a necrotic background (H&E stain,400X)
Figure 6. Lymphocytic thyroiditis. Microphotograph showing dense lymphocytic infiltration and follicles filled with colloidal material (H&E stain, 400X)
Figure 7. Anaplastic carcinoma of thyroid -Microphotograph showing sheets of highly pleomorphic spindle cells with marked nuclear atypia and brisk mitotic activity (H&E stain,400x)

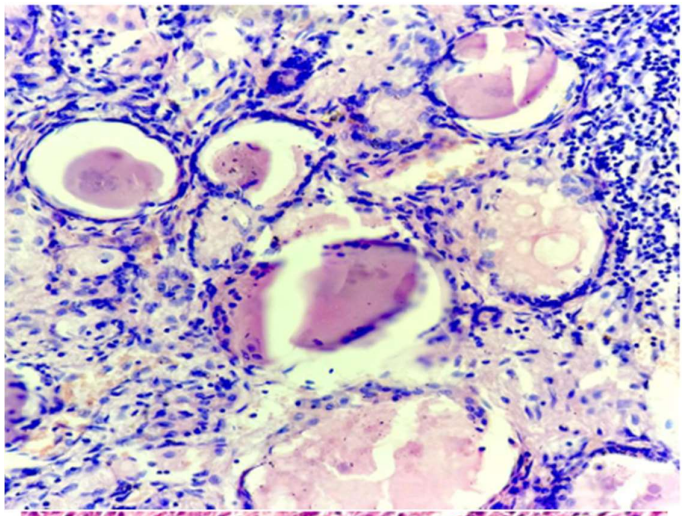
Figure 8. IFVPTC (Infiltrative follicular variant of Papillary Thyroid Carcinoma)- Microphotograph showing infiltrative tumor arranged predominantly in follicles. Tumor cells have clear to eosinophilic cytoplasm, pleomorphic nuclei showing elongation, overlapping, overcrowding, nuclear clearing with chromatin margination and nuclear grooves (H&E stain, 400X).
Figure 9. Papillary carcinoma of thyroid -Microphotograph showing papillary architecture lined by tumor cells with nuclear enlargement, overlapping, clearing, grooves, and occasional inclusions (H&E stain, 400X)

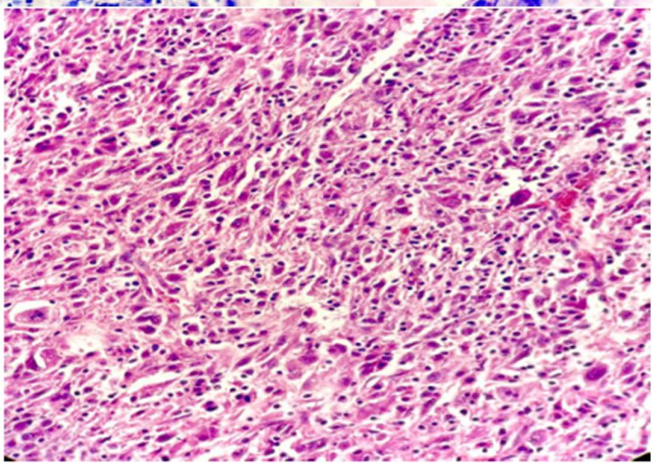


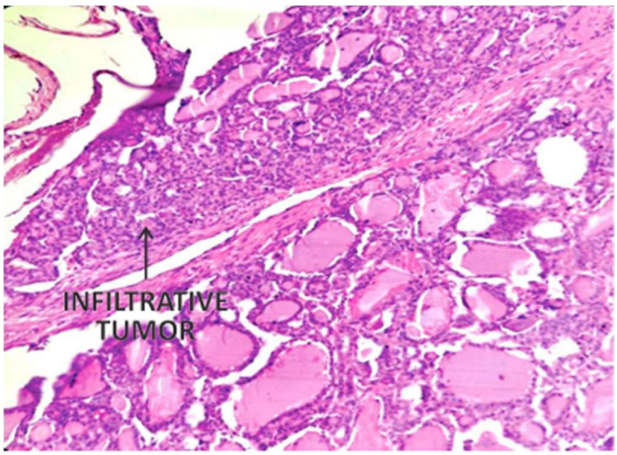

BENIGN FOLLICULAR CELLS

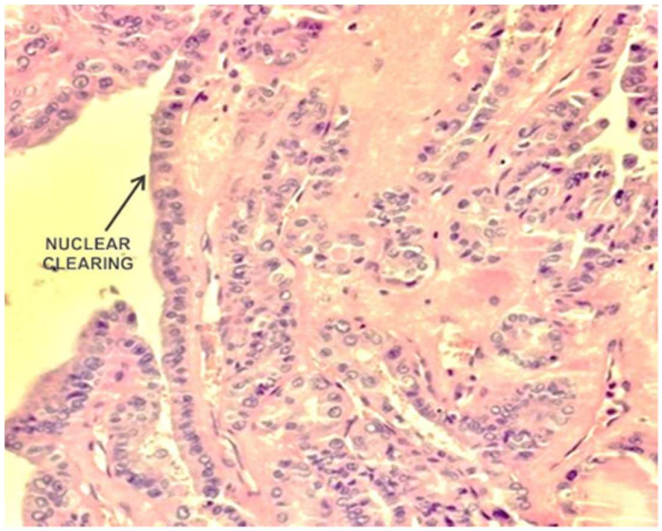

BRANCHING PAPILLARY
ARCHITECTURE








INFILTRATIVE
TUMOR


NUCLEAR
CLEARING