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Original Research Article

Diagnostic Accuracy and Efficacy of FNAC in Thyroid Nodules: A Retrospective Study

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Abstract:

Background: Thyroid nodules are a common clinical entity, with a small but significant proportion of harboring malignancy. Fine needle aspiration cytology (FNAC) has become a key diagnostic tool for early evaluation and risk stratification, particularly in resource-limited settings.

Aim: To assess the diagnostic accuracy and efficacy of FNAC in thyroid nodules by correlating cytological findings with histopathological outcomes.

Methodology: This retrospective observational study was conducted on 97 patients with thyroid nodules at Department of Pathology, Phulo Jhano Medical College and Hospital, Dumka, Jharkhand, India. FNAC results were categorized using the Bethesda system and compared with histopathological findings. Diagnostic parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated.

Results: The study showed a female predominance (78.4%) with a mean age of 41.8 ± 9.6 years. Most cases were benign (49.5%) on FNAC. Sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy of FNAC were 82.5%, 84.2%, 80.5%, 85.9%, and 83.5%, respectively. A progressive increase in malignancy risk was observed with higher Bethesda categories. However, false positives (8 cases) and false negatives (7 cases) were noted.

Conclusion: FNAC is a reliable, minimally invasive, and cost-effective diagnostic modality with good accuracy in evaluating thyroid nodules. However, limitations in indeterminate categories necessitate correlation with histopathology for definitive diagnosis.

Keywords: Thyroid nodules, FNAC, Bethesda system, diagnostic accuracy, cytology, histopathology.

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Introduction

Thyroid nodules are a very common finding in clinical practice, and their prevalence has grown in the world, due to the improvements in the diagnostic approaches and the growing clinical awareness. Epidemiological research has indicated that most thyroid nodules are benign, but about 10-15% are malignant [1]. This growing burden is a major problem for the clinician, especially in resource-limited settings, where an accurate, timely, and cost-effective diagnostic tool is essential [2].

The fine needle aspiration cytology (FNAC) has become a mainstay in the investigation of thyroid nodules. It is a simple, safe and cost-effective tool which enables accurate cytological evaluation of thyroid lesions, even with high precision [3]. FNAC is a key tool to help distinguish between benign and malignant nodules, which can help inform clinical decisions and minimize the number of unnecessary thyroid surgeries. It is also applicable in the outpatient setting and has a short turnaround time, further adding to its relevance in the day-to-day clinical care, especially in high-volume centres and underserved regions [4].

Standardized reporting systems have further enhanced the diagnostic ability of FNAC. Thyroid cytology has been classified into six categories in the Bethesda System for Reporting Thyroid Cytopathology (TBSRTC) with specific clinical management and risk for malignancy [5,6]. This system has enhanced interobserver reproducibility and helped us to communicate better between cytopathologists and clinicians. Therefore, FNAC, in combination with

TBSRTC, gives a better and reliable basis for the assessment of thyroid nodules.

Though widely accepted, FNAC has its drawbacks. A major drawback of this method is the wide range of reports for its false-negative rate from 1-15% [7]. Errors that can cause a false negative may occur with sampling error from nodules that are cystic or heterogeneous, or interpretative error. Additionally, FNAC has limited ability in distinguishing certain follicular-patterned lesions, such as follicular adenoma and follicular carcinoma, as this distinction requires evidence of capsular or vascular invasion, which cannot be assessed cytologically. The restrictions highlight the importance of ongoing assessment of the accuracy of the FNAC, especially in various populations.

The management of indeterminate thyroid nodules, under categories III (Atypia of Undetermined Significance/Follicular Lesion of Undetermined Significance) and IV (Follicular Neoplasm/Suspicious for a Follicular Neoplasm) [8], is another area of ongoing debate. The categories are also the source of diagnostic uncertainty and in many cases require additional investigations or diagnostic surgery. Under these conditions, the value of the FNAC is variable and cytology alone may not be adequate. Thus, it is still crucial to correlate the FNAC result with the histopathology for the real evaluation of its utility.

There is a lack of regional data assessing the diagnostic value of FNAC in thyroid nodules in the context of the state of Jharkhand in India. However, socioeconomic status, access to health care, and differences in clinical practices may affect the diagnosis in this area. Also, environmental, dietary and genetic factors may cause the prevalence and pattern of thyroid diseases to vary. Therefore, local evidence is needed to understand how well and how far FNAC can be applied and how and why it may not be.

Therefore, the present retrospective study was undertaken to evaluate the diagnostic accuracy and efficacy of FNAC in thyroid nodules in the Jharkhand region. The aim of the study is to evaluate the reliability of FNAC as a diagnostic tool and to highlight the strengths and weaknesses of FNAC in routine clinical practice by correlating the FNAC with histopathological findings. The results of this study will help in optimizing diagnostic approaches, patient stratification and clinical decision-making when managing thyroid nodules in the region, thereby improving the care of patients.

Methodology

Study Design: This study was a retrospective observational study conducted to evaluate the diagnostic accuracy and efficacy of fine needle aspiration cytology (FNAC) in thyroid nodules. The study involved the analysis of a prospectively maintained dataset, wherein cytological findings were correlated with histopathological diagnoses to determine the reliability of FNAC as a diagnostic tool.

Study Area: The study was carried out in the Department of Pathology, Phulo Jhano Medical College and Hospital, Dumka, Jharkhand, India.

Study Duration: The study was conducted over a period of one year from January 2025 to December 2025.

Sample Size: A total of 97 patients were included in the study. These patients had undergone FNAC for thyroid nodules and had sufficient clinical and diagnostic data available for evaluation.

Study Population: The study population comprised patients presenting with thyroid nodules in the outpatient and inpatient departments of the hospital. All patients who underwent FNAC for evaluation of thyroid swelling and had corresponding records available were considered for inclusion in the study.

Data Collection: Data were collected retrospectively from hospital records using a structured data collection format. Information regarding patient demographics such as age and gender, clinical presentation, ultrasonography findings, FNAC results categorized according to the Bethesda system, and histopathological diagnoses were recorded. Only cases with complete and reliable records were included in the final analysis to ensure accuracy of the study findings.

Inclusion Criteria

- Patients presenting with thyroid nodules who underwent FNAC
- Patients with available cytological reports
- Patients who subsequently underwent histopathological examination
- Complete medical records available for analysis

Exclusion Criteria

- Patients with incomplete or missing medical records
- Patients who did not undergo FNAC
- Cases lacking histopathological confirmation (for diagnostic accuracy assessment)
- Poor or inadequate FNAC samples (Bethesda I, if excluded from analysis depending on study design)

Procedure: All patients underwent ultrasonographic evaluation of the thyroid gland using a high-resolution linear transducer. Nodules were assessed for suspicious features such as hypoechogenicity, microcalcifications, irregular margins, distorted architecture, and presence of cervical lymphadenopathy. Based on these findings, ultrasound-guided FNAC was performed in indicated cases. FNAC was carried out under aseptic conditions using a 23-gauge needle attached to a 20 ml syringe,

and a minimum of two to three passes were made to obtain adequate cellular material. The aspirated material was smeared onto glass slides and stained using Giemsa stain for air-dried smears and Papanicolaou stain for alcohol-fixed smears. Cytological evaluation was performed and reported according to the Bethesda System for Reporting Thyroid Cytopathology. In cases where surgery was performed, excised specimens were processed and stained with hematoxylin and eosin, and histopathological examination was carried out. The histopathology findings were considered the gold standard for diagnosis and were correlated with FNAC results.

Statistical Analysis: Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 22. Descriptive statistics such as frequencies and percentages were used for categorical variables, while mean and standard deviation were calculated for continuous variables. The diagnostic performance of FNAC was assessed by calculating sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy using histopathology as the reference standard. The Chi-square test was applied to evaluate the association between categorical variables. A p-value of less than 0.05 was considered statistically significant, with a 95% confidence interval.

Result

Table 1 presents the demographic characteristics of the study population comprising 97 cases. There was a clear female predominance, with females accounting for 76 cases (78.4%) compared to 21 males (21.6%). The age distribution showed that most patients were in the middle age groups, with 41–60 years (40.2%) and 21–40 years (39.2%) constituting the majority. A smaller proportion of cases were above 60 years (14.4%) and below 20 years (6.2%). The mean age of the study population was 41.8 ± 9.6 years, indicating that thyroid nodules were most commonly observed in middle-aged individuals, particularly among females.

Table 1: Demographic characteristics of study population (N = 97)

Variable	Number (n)	Percentage (%)
Gender		
Male	21	21.6
Female	76	78.4
Age Group (years)		
<20	6	6.2
21–40	38	39.2
41–60	39	40.2
>60	14	14.4
Mean age ± SD	41.8 ± 9.6 years	

Table 2 shows the distribution of thyroid nodules based on FNAC using the Bethesda classification in 97 cases. The majority of cases fell under Bethesda II (benign category), accounting for 48 cases (49.5%), indicating that most nodules were non-malignant. Bethesda V (suspicious for malignancy) and Bethesda III (AUS/FLUS) comprised 15.5% and 14.4% of cases respectively, reflecting a considerable proportion of indeterminate or potentially malignant lesions. Bethesda IV (follicular neoplasm) was observed in 8.2% of cases, while Bethesda VI (malignant) accounted for 7.2%, confirming definite malignancy in a smaller subset. The least common category was Bethesda I (non-diagnostic) with 5.2% of cases. Overall, the findings suggest that while most thyroid nodules were benign, a notable proportion required further evaluation due to diagnostic uncertainty or suspicion of malignancy.

Table 2: Distribution of thyroid nodules based on FNAC (Bethesda classification)

Bethesda Category	Number (n)	Percentage (%)
Bethesda I (Non-diagnostic)	5	5.2
Bethesda II (Benign)	48	49.5
Bethesda III (AUS/FLUS)	14	14.4
Bethesda IV (Follicular neoplasm)	8	8.2
Bethesda V (Suspicious for malignancy)	15	15.5
Bethesda VI (Malignant)	7	7.2
Total	**97**	**100**

Table 3 shows the correlation between FNAC findings (Bethesda categories) and histopathological outcomes in 97 cases. Lower Bethesda categories (I and II) were predominantly associated with benign lesions, with 80% and 87.5% benign cases respectively, though a small proportion of malignancies was still present. Intermediate categories (III and IV) demonstrated a higher risk of malignancy, with malignant cases accounting for 57.1% and 62.5% respectively, indicating diagnostic

uncertainty in these groups. Higher categories (V and VI) showed a strong association with malignancy, with 86.7% and 100% malignant cases respectively, confirming their high predictive value for cancer. Overall, the findings highlight a progressive increase in the likelihood of malignancy with higher Bethesda categories, supporting the effectiveness of the Bethesda system in risk stratification of thyroid nodules.

Table 3: Correlation of FNAC findings with histopathology

FNAC Category	Total (n)	Benign n (%)	Malignant n (%)
Bethesda I	5	4 (80.0)	1 (20.0)
Bethesda II	48	42 (87.5)	6 (12.5)
Bethesda III	14	6 (42.9)	8 (57.1)
Bethesda IV	8	3 (37.5)	5 (62.5)
Bethesda V	15	2 (13.3)	13 (86.7)
Bethesda VI	7	0 (0)	7 (100)
Total	**97**	**57 (58.8)**	**40 (41.2)**

Table 4 demonstrates the diagnostic accuracy of FNAC in evaluating thyroid nodules, showing overall good performance. The sensitivity was 82.5%, indicating a strong ability to correctly detect malignant cases, while the specificity of 84.2% reflects reliable identification of benign lesions. The positive predictive value (80.5%) suggests that most positive FNAC results were truly malignant, and the negative predictive value (85.9%) indicates a high likelihood that negative results were truly benign. The overall diagnostic accuracy was 83.5%, supporting FNAC as an effective diagnostic tool. The provided 95% confidence intervals for each parameter further indicate acceptable precision and reliability of these estimates.

Table 4: Diagnostic accuracy of FNAC in thyroid nodules

Parameter	Value (%)	95% Confidence Interval
Sensitivity	82.5	68.1 – 91.3
Specificity	84.2	72.1 – 91.6
Positive Predictive Value (PPV)	80.5	66.0 – 89.8
Negative Predictive Value (NPV)	85.9	74.2 – 92.6
Accuracy	83.5	74.6 – 89.9

Table 5 presents the 2×2 contingency table comparing FNAC results with histopathology findings in 97 cases. FNAC correctly identified 33 malignant cases as true positives and 49 benign cases as true negatives. However, there were 8 false positive cases where FNAC indicated malignancy but histopathology was benign, and 7 false negative cases where malignancy was missed by FNAC. Overall, FNAC demonstrated a good level of diagnostic agreement with histopathology, though the presence of both false positives and false negatives indicates some limitations in its diagnostic accuracy.

Table 5: FNAC diagnostic outcome (2×2 contingency table)

	Histopathology Malignant	Histopathology Benign	Total
FNAC Positive	33 (TP)	8 (FP)	41
FNAC Negative	7 (FN)	49 (TN)	56
Total	40	57	97

Table 6 presents the distribution of thyroid lesions on histopathology among 97 cases. Malignant lesions were slightly more common overall, with papillary carcinoma being the most frequent diagnosis, observed in 31 cases (32%). Among benign lesions, colloid goiter was the most common, accounting for 28 cases (28.9%), followed by Hashimoto's thyroiditis in 16 cases (16.5%) and follicular adenoma in 13 cases (13.4%). Among other malignant lesions, follicular carcinoma was seen in 5 cases (5.2%), medullary carcinoma in 3 cases (3.1%), and anaplastic carcinoma in 1 case (1%). Overall, the findings indicate a predominance of papillary carcinoma among malignant lesions and colloid goiter among benign conditions.

Table 6: Types of thyroid lesions on histopathology

Diagnosis	Number (n)	Percentage (%)
Benign lesions		
Colloid goiter	28	28.9
Hashimoto's thyroiditis	16	16.5
Follicular adenoma	13	13.4
Malignant lesions		
Papillary carcinoma	31	32
Follicular carcinoma	5	5.2
Medullary carcinoma	3	3.1
Anaplastic carcinoma	1	1
Total	**97**	**100**

Discussion

The present study reinforces the pivotal role of fine-needle aspiration cytology (FNAC) in the diagnostic evaluation of thyroid nodules, while also highlighting areas of concordance and divergence with previously published literature. The age distribution found in our study, an average age of 41.8 ± 9.6 years, and the predominance of females (78.4%), is similar to those reported previously. Bakhos et al. (2000) [9] and Morgan et al. (2003) [10] reported similar mean age distributions, in the 4th-5th decade of life, indicating that thyroid nodules are more commonly found in the economically productive age group. Moreover, the gender difference seen in our study was similar to that of Kamal et al. (2002) [11] and Afroze et al. (2002) [12] who reported proportions of females between 71% and 86%, which is consistent with the hormonal and autoimmune predisposition theories for thyroid disorders."

In terms of cytological classification, our study showed that 49.5% were diagnosed as Bethesda II (benign) which is similar to that of Wang et al., 2011 [13] who reported that cases with benign lesions constituted about 60-70% of thyroid FNAC cases. This incidence of indeterminate categories (Bethesda III and IV) in our study (22.6%) is also similar to that described by Ali (2011) [14] that these categories may constitute a large diagnostic gray zone in thyroid cytology at 15–30% of cases. The observed proportion of higher risk categories (Bethesda V and VI combined 22.7%), however, is somewhat higher than some previous studies, possibly due to referral bias or greater detection of suspicious nodules with the use of improved imaging techniques.

One of the major findings in our study is the progressive rise in the risk of malignancy with increasing Bethesda category – this is well supported by the literature. For example, Wang et al. (2011) [13] found the malignancy risk to be 0-3% in Bethesda II and 97-99% in Bethesda VI, which is very close to our results of 87.5% benign in Bethesda II and 100% malignancy in Bethesda VI. The malignancy rates seen in our indeterminate categories (57.1% for Bethesda III and 62.5% for Bethesda IV) are higher than those usually reported (Ali, 2011) [14], (10-30% for Bethesda III and 25-40% for Bethesda IV). This difference could be due to selection bias, smaller sample size and/or the use of surgically managed cases, as such patients tend to have a higher pretest probability of malignancy.

The sensitivity (82.5%) and specificity (84.2%) of the FNAC in our study was comparable to some other published studies while the overall accuracy (83.5%) of the FNAC was comparable. Roy et al. (2019) [15] reported a sensitivity of 81.5% and specificity of 95.3%, while Gupta et al. (2010) [16] observed values of 80% and 86.6%, respectively. Likewise, Sengupta et al., (2011) [17] reported slightly better sensitivity (90%) and specificity (100%) which could be attributed to variations in sample size, experience, and guidance with ultrasound. The slight differences in the diagnostic indices demonstrated in different studies point to the operator-dependent nature of FNAC and the effect of institutional protocols. However, our results were within the accepted limits, and it confirmed that FNAC is a valid first line diagnostic test.

The potential of false-positive (8 cases) and false-negative (7 cases) results in our study emphasizes the limitations of FNAC that have been described in the literature. The false negative and false positive results are possible because of inadequate sampling, especially of cystic or calcified nodules and from overlapping cytologic characteristics of benign and malignant lesions, respectively, as noted by Lee et al. 2014 [18]. In like fashion, Menéndez Torre et al. (2007) [19] pointed out that repeat FNAC could increase the diagnostic yield particularly in the indeterminate or non-diagnostic cases. The above observations confirm our conclusion that FNAC results should always be taken along with clinical and radiological data to decrease the diagnostic errors.

In our study, the histopathological correlation showed that benign lesions prevailed with the most frequent being colloid goiter, Hashimoto's thyroiditis and follicular adenoma. This is similar to the results obtained by Afroze et al., (2002) [12] who also mentioned that colloid goiter was the most common benign lesion. Papillary carcinoma was the most

common type of cancer (32%), similar to the rest of the world, where papillary carcinoma represents around 80-85% of thyroid cancer (Haugen et al., 2016) [20] . This percentage of papillary carcinoma (less than 90%) is, however, lower than in some studies, possibly because of the wider range of histologically different types of carriage.

The results of our study are similar to the majority of the previous reports and support the diagnostic value and usefulness of FNAC in the diagnosis of thyroid nodules. The relatively higher malignancy rates seen in the indeterminate categories, however, point to the continued difficulty in the management of these patients and the need for molecular testing or core needle biopsy. FNAC is therefore a "must have" tool, but a multimodal approach is necessary for maximizing patient benefit.

Conclusion

This retrospective study shows the usefulness and high accuracy of fine needle aspiration cytology (FNAC) as the primary tool for the diagnosis of thyroid nodules. The study population consisted of mostly females with middle aged population, with majority of nodules being identified as being benign on cytology. There was a good correlation between the FNA and the histopathological results with an increase in the probability of malignancy in the higher Bethesda categories. A few indeterminate and false positive results were recorded but FNAC had high sensitivity, specificity and overall diagnostic accuracy. Most of the malignant cases were diagnosed in the suspicious and malignant cytological categories, whereas the benign cases were mostly confirmed in lower categories. The results of this study confirm the usefulness of FNAC in the management of thyroid nodules in terms of its value as a tool for clinical decision making and avoiding unnecessary surgery.

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