

Original Research Article

DIAGNOSTIC ACCURACY OF FINE NEEDLE ASPIRATION CYTOLOGY FOR THYROID SWELLINGS COMPARED WITH HISTOPATHOLOGY

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Received : 03/08/2026
Received in revised form : 01/09/2026
Accepted : 12/09/2026

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DOI: 10.70034/ijmedph.2026.3.909

Source of Support: Nil,

Conflict of Interest: None declared

Int J Med Pub Health

2026; 16 (3); 5905-5912

ABSTRACT

Background: Thyroid swellings include non-neoplastic, benign neoplastic, and malignant lesions. Although most thyroid nodules are benign, accurate preoperative identification of malignancy is essential to avoid unnecessary surgery and ensure timely treatment. Fine-needle aspiration cytology is widely used as the initial tissue-based diagnostic investigation, while postoperative histopathological examination remains the definitive reference standard. The aim is to evaluate the diagnostic accuracy of fine-needle aspiration cytology in thyroid swellings by comparison with postoperative histopathological examination.

Materials and Methods: This hospital-based prospective observational diagnostic-accuracy study included 50 patients with thyroid swellings who underwent preoperative FNAC followed by thyroid surgery and histopathological examination. Clinical characteristics, FNAC findings and postoperative histopathological diagnoses were recorded using a structured proforma. Histopathology was considered the reference standard. The diagnostic performance of FNAC was assessed by calculating sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy with 95% confidence intervals. Agreement was assessed using Cohen's kappa, while paired disagreement was evaluated using the exact McNemar test. A p-value below 0.05 was considered statistically significant.

Results: The mean age of the patients was 38.74±12.63 years, and the mean largest nodule size was 3.42±1.57 cm. Females constituted 86.0% of the study population. Colloid or nodular goitre was the most frequent FNAC diagnosis, accounting for 56.0% of cases. FNAC classified 11 (22.0%) lesions as positive and 39 (78.0%) as negative. Histopathological examination identified 9 (18.0%) malignant and 41 (82.0%) benign lesions. FNAC correctly identified 8 malignant and 38 benign lesions, with 1 false-negative and 3 false-positive results. The observed concordance was 92.0% (95% CI: 81.2–96.8), and Cohen's kappa was 0.751 (95% CI: 0.516–0.985; p<0.001), indicating substantial agreement. The exact McNemar test showed no significant systematic disagreement (p=0.625). FNAC demonstrated sensitivity of 88.9%, specificity of 92.7%, positive predictive value of 72.7%, negative predictive value of 97.4%, and overall diagnostic accuracy of 92.0%.

Conclusion: FNAC demonstrated high sensitivity, specificity, negative predictive value, and overall accuracy in evaluating thyroid swellings. It is a reliable initial diagnostic investigation for differentiating benign from malignant lesions and may help reduce unnecessary surgery. Nevertheless, histopathological examination remains essential for definitive diagnosis, especially in suspicious, indeterminate, follicular-patterned, or clinically discordant lesions.

Keywords: Fine-needle aspiration cytology; Thyroid swelling; Histopathology.

INTRODUCTION

Thyroid swellings are common clinical findings and encompass a broad spectrum of non-neoplastic, benign neoplastic, and malignant lesions. Although most thyroid nodules are benign, the principal diagnostic challenge is to identify the comparatively small proportion of malignancies without exposing patients with benign disease to unnecessary surgery. Clinical examination and thyroid-function testing provide essential information, while ultrasonography characterizes nodule size, composition, echogenicity, margins, calcification, shape, cervical lymph nodes, and other features that influence the need for tissue sampling. Current clinical guidance recommends fine needle aspiration for nodules meeting defined sonographic and size thresholds, making cytology a central component of risk-based evaluation.^[1] Fine needle aspiration cytology (FNAC) is minimally invasive, rapid, economical, generally safe, and suitable for outpatient use. It can distinguish many benign lesions from lesions that require surgery and thereby guide the extent and timing of treatment. Standardized reporting through the Bethesda System assigns thyroid aspirates to six diagnostic categories, each linked to an estimated risk of malignancy and a recommended clinical approach. The 2023 third edition refined category terminology, malignancy-risk estimates, and alignment with the 2022 World Health Organization classification.^[2] Nevertheless, FNAC has recognized limitations. Inadequate sampling, cystic change, blood contamination, interpretive variation, and overlapping cytomorphology may produce nondiagnostic, false-negative, or false-positive results. In particular, cytology cannot reliably distinguish follicular adenoma from follicular carcinoma because capsular or vascular invasion must be demonstrated histologically. Histopathological examination of the surgically excised thyroid therefore remains the reference standard for definitive classification and allows assessment of architecture and invasion according to contemporary tumor taxonomy.^[3] Published studies have generally shown high specificity and accuracy for FNAC, but performance varies with case selection, operator technique, specimen adequacy, reporting system, and institutional expertise. An Indian cytohistological correlation study reported an overall FNAC accuracy of 95.71%,^[4] while a prospective study of thyroid swellings found that ultrasonography followed by FNAC provided reasonably good sensitivity, specificity, and diagnostic accuracy.^[5] Because diagnostic performance is context dependent, local evaluation is necessary.

Aim

To evaluate the diagnostic accuracy of fine needle aspiration cytology in thyroid swellings by comparison with postoperative histopathological examination.

Objectives

1. To describe the clinical profile and cytological spectrum of patients presenting with thyroid swellings.
2. To determine the concordance between FNAC diagnosis and postoperative histopathological diagnosis of thyroid lesions.
3. To estimate the sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy of FNAC for detecting malignant thyroid lesions.

MATERIALS AND METHODS

Source of Data: The study data were obtained from patients with clinically and/or ultrasonographically detected thyroid swellings who attended the general surgery and otorhinolaryngology outpatient departments or were admitted to the study hospital. Eligible patients who underwent preoperative FNAC followed by thyroid surgery and postoperative histopathological examination formed the study population. Information was obtained from direct clinical assessment, investigation reports, cytology records, operation notes, histopathology reports, and a structured study proforma.

Study Design: A hospital-based prospective observational diagnostic-accuracy study was conducted. FNAC was regarded as the index test and histopathological examination of the resected thyroid specimen was regarded as the reference standard.

Study Location: The study was conducted jointly in the Departments of General Surgery, Otorhinolaryngology, Radiodiagnosis, and Pathology at JIIU'S IIMSR, Warudi, Jalna, India. Clinical evaluation and surgery were performed in the concerned clinical departments; ultrasonography-guided aspiration, where indicated, was performed in the radiology department; and cytological and histopathological processing was performed in the pathology laboratory.

Study Duration: The study was conducted over 12 months. Recruitment, FNAC, surgery, specimen processing, data entry, and analysis were completed within this period.

Sample Size

The minimum sample size was calculated using the single-population-proportion formula:

$$n = Z^2 p(1 - p) / d^2$$

where n was the required sample size; Z was the standard normal deviate at the 95% confidence level (1.96); p was the anticipated proportion of neoplastic or malignant thyroid swellings (16%, or 0.16), based on previous institutional data or a pilot estimate; and d was the absolute precision (10.2%, or 0.102).

$$n = (1.96)^2 \times 0.16 \times (1 - 0.16) / (0.102)^2 = 49.62$$

The calculated sample size was rounded up to 50 patients. Consecutive eligible patients were enrolled until the required sample was achieved. This calculation corrected the earlier use of 0.95 as a Z

value; at a 95% confidence level, the appropriate two-sided Z value was 1.96.

Inclusion Criteria

- Patients of either sex and any age who presented with a palpable or ultrasonographically detected thyroid swelling.
- Patients who underwent FNAC of the thyroid lesion before definitive surgery.
- Patients who subsequently underwent thyroidectomy or excision and for whom an adequate postoperative histopathology report was available.
- Patients who provided written informed consent; for minors, consent was obtained from a parent or legally authorized representative and assent was obtained where applicable.

Exclusion Criteria

- Patients who did not undergo surgery or whose histopathological specimen was unavailable, because reference-standard verification could not be completed.
- Patients with a previously treated or recurrent thyroid malignancy, previous thyroid surgery, or prior radiotherapy to the neck when these conditions could alter cytological interpretation.
- Patients with an uncorrectable bleeding disorder or another contraindication to FNAC.
- Patients whose FNAC material remained inadequate after repeat aspiration, whose surgical specimen was inadequate for diagnosis, or whose clinical, cytological, or histopathological records were incomplete.
- Patients who declined participation or withdrew consent.

Procedure and Methodology: After approval from the Institutional Ethics Committee, potentially eligible patients were screened consecutively. Written informed consent was obtained before enrollment. A detailed history was recorded, including duration and progression of swelling, pain, dysphagia, dyspnoea, change in voice, symptoms of thyroid dysfunction, prior thyroid disease, radiation exposure, and family history of thyroid malignancy. General and systemic examinations were performed. Local examination documented the site, size, number, consistency, mobility, surface, tenderness, retrosternal extension, cervical lymphadenopathy, and movement of the swelling with deglutition. Thyroid-function tests and other routine preoperative investigations were reviewed. Ultrasonography was performed to document nodule number, size, composition, echogenicity, margins, calcification, shape, vascularity, and suspicious cervical lymph nodes. FNAC was performed using palpation guidance for readily palpable lesions or ultrasound guidance for small, deep, cystic, or nonpalpable lesions. Aseptic precautions were followed. Material was aspirated from representative solid areas, and repeat passes were made when the initial yield was inadequate. Cytological findings were recorded using the reporting terminology followed by the institution; wherever the original smears permitted, the diagnosis

was mapped to the applicable Bethesda category. The treating surgeon decided the indication and type of thyroid surgery on clinical grounds and according to cytological, radiological, and biochemical findings. The cytology result was not altered after knowledge of histopathology. Following surgery, the specimen was sent for histopathological examination. Cytological and histopathological diagnoses were subsequently paired for each participant. For the primary diagnostic analysis, malignant or suspicious-for-malignancy FNAC interpretations were treated as test-positive and benign interpretations as test-negative, according to the prespecified institutional classification. Indeterminate categories were reported separately and were included in binary analysis only according to a prespecified rule. Histopathologically malignant lesions were considered disease-positive, whereas benign/non-neoplastic lesions were considered disease-negative. A 2×2 table of true positives, false positives, false negatives, and true negatives was constructed.

Sample Processing: FNAC was performed with a sterile fine needle, usually 22-25 gauge, attached to a disposable syringe. Direct smears were prepared immediately. Air-dried smears were stained with May-Grünwald-Giemsa, and alcohol-fixed smears were stained with Papanicolaou or hematoxylin and eosin stain according to laboratory protocol. Cell-block preparation was undertaken when sufficient material was available or when ancillary assessment was required. Smears were examined for adequacy, cellularity, colloid, follicular-cell architecture, nuclear characteristics, inflammatory background, and features of malignancy. Surgically excised specimens were labeled, fixed in 10% neutral buffered formalin, and grossly examined. Representative sections were taken from the lesion, capsule, adjacent thyroid, surgical margins, and lymph nodes when submitted. Tissue was processed routinely, embedded in paraffin, sectioned at approximately 3-5 micrometres, stained with hematoxylin and eosin, and examined by a pathologist. Special stains or immunohistochemistry were used only when required for final classification. Histopathological diagnosis was made using the institutional criteria consistent with the contemporary World Health Organization classification.

Data Collection: Data were entered prospectively in a predesigned, pretested case-record form. Variables included age, sex, symptoms, clinical findings, thyroid-function status, ultrasonographic characteristics, guidance method for FNAC, specimen adequacy, cytological diagnosis, operative procedure, histopathological diagnosis, and cytohistological concordance. Each participant was assigned a unique study code. Completed forms were checked for completeness and consistency before data entry. Identifiers were kept separately from the analytical dataset, and access was restricted to the study team. Data were entered in Microsoft Excel and verified by range checks, logical checks, and comparison of a random subset with source records.

Statistical Methods: Data were analyzed using IBM SPSS Statistics version 20.0 or a later validated version. Categorical variables were summarized as frequencies and percentages. Continuous variables were assessed for distribution and were presented as mean with standard deviation when approximately normally distributed or median with interquartile range when skewed. Cytological and histopathological diagnoses were cross-tabulated. Agreement beyond chance was assessed with Cohen's kappa and interpreted with its 95% confidence interval. Using histopathology as the reference standard, sensitivity, specificity, positive predictive value, negative predictive value, false-positive rate, false-negative rate, and overall diagnostic accuracy were calculated with 95% confidence intervals. The formulas used were sensitivity = TP/(TP + FN), specificity = TN/(TN + FP), positive predictive value = TP/(TP + FP), negative predictive value = TN/(TN + FN), and accuracy = (TP + TN)/N. McNemar's test was used, when appropriate, to assess paired disagreement between the binary FNAC and histopathology classifications. Associations between categorical variables were assessed using Pearson's chi-square test or Fisher's exact test when expected cell counts were small. Independent-group continuous data were compared using the unpaired t test or Mann-Whitney U test, as appropriate. All tests were two-sided, 95% confidence intervals were

reported, and a p value below 0.05 was considered statistically significant. Nondiagnostic and indeterminate FNAC results were described explicitly and were not silently combined with benign results; sensitivity analyses were performed when their classification could materially affect diagnostic estimates.

RESULTS

[Table 1] presents the overall diagnostic profile of the 50 patients. The mean age was 38.74 ± 12.63 years (95% CI: 35.15–42.33), while the mean size of the largest thyroid nodule was 3.42 ± 1.57 cm (95% CI: 2.97–3.87). Neither mean age nor nodule size differed significantly from their respective reference values ($p=0.484$ and $p=0.064$). FNAC was test-positive in 11 (22.0%) patients and test-negative in 39 (78.0%) patients. Histopathological examination identified malignant lesions in 9 (18.0%) patients and benign lesions in 41 (82.0%) patients. The predominance of test-negative and histopathologically benign lesions was statistically significant ($p<0.001$). FNAC and histopathological classifications were concordant in 46 (92.0%; 95% CI: 81.2–96.8) cases and discordant in only 4 (8.0%; 95% CI: 3.2–18.8) cases. This high concordance was statistically significant ($\chi^2=35.28$, $p<0.001$).

Table 1: Overall diagnostic profile of FNAC compared with postoperative histopathology (N=50)

Study parameter	n (%) or Mean (SD)	95% CI	Test statistic	p-value
Age, years	38.74 (12.63)	35.15–42.33	$t = -0.71$	0.484
Largest nodule size, cm	3.42 (1.57)	2.97–3.87	$t = 1.89$	0.064
FNAC test-positive	11 (22.0)	12.8–35.2	$\chi^2 = 15.68$	<0.001
FNAC test-negative	39 (78.0)	64.8–87.2	$\chi^2 = 15.68$	<0.001
Histopathology malignant	9 (18.0)	9.8–30.8	$\chi^2 = 20.48$	<0.001
Histopathology benign	41 (82.0)	69.2–90.2	$\chi^2 = 20.48$	<0.001
Concordant FNAC–HPE classification	46 (92.0)	81.2–96.8	$\chi^2 = 35.28$	<0.001
Discordant classification	4 (8.0)	3.2–18.8	$\chi^2 = 35.28$	<0.001

Table 2: Clinical profile and FNAC cytological spectrum of patients with thyroid swellings (N=50)

Domain	Category	n (%)	95% CI	Test statistic	p-value
Age group	11–20 years	4 (8.0)	3.2–18.8	$\chi^2 = 14.60$	0.006
	21–30 years	13 (26.0)	15.9–39.6	—	—
	31–40 years	18 (36.0)	24.1–49.9	—	—
	41–50 years	11 (22.0)	12.8–35.2	—	—
	>50 years	4 (8.0)	3.2–18.8	—	—
Sex	Female	43 (86.0)	73.8–93.0	$\chi^2 = 25.92$	<0.001
	Male	7 (14.0)	7.0–26.2	—	—
Clinical feature	Dysphagia	7 (14.0)	7.0–26.2	$\chi^2 = 25.92$	<0.001
	Cervical lymphadenopathy	6 (12.0)	5.6–23.8	$\chi^2 = 28.88$	<0.001
	Hoarseness of voice	4 (8.0)	3.2–18.8	$\chi^2 = 35.28$	<0.001
	Dyspnoea	3 (6.0)	2.1–16.2	$\chi^2 = 38.72$	<0.001
	Pain or tenderness	8 (16.0)	8.3–28.5	$\chi^2 = 23.12$	<0.001
FNAC diagnosis	Colloid or nodular goitre	28 (56.0)	42.3–68.8	$\chi^2 = 57.76$	<0.001
	Lymphocytic thyroiditis	4 (8.0)	3.2–18.8	—	—
	Multinodular goitre	7 (14.0)	7.0–26.2	—	—
	Suspicious for malignancy	3 (6.0)	2.1–16.2	—	—
	Papillary carcinoma	6 (12.0)	5.6–23.8	—	—
	Follicular carcinoma	2 (4.0)	1.1–13.5	—	—

[Table 2] shows the clinical characteristics and FNAC cytological spectrum of the patients. The largest proportion belonged to the age group of 31–40 years, comprising 18 (36.0%) patients, followed

by 13 (26.0%) patients aged 21–30 years and 11 (22.0%) aged 41–50 years. Four (8.0%) patients each belonged to the 11–20-year and above-50-year groups. The age-group distribution was statistically

significant ($\chi^2=14.60$, $p=0.006$). There was a marked female predominance, with 43 (86.0%) females and 7 (14.0%) males ($\chi^2=25.92$, $p<0.001$). Pain or tenderness was reported in 8 (16.0%) patients, dysphagia in 7 (14.0%), cervical lymphadenopathy in 6 (12.0%), hoarseness of voice in 4 (8.0%), and dyspnoea in 3 (6.0%). All these clinical-feature distributions were statistically significant ($p<0.001$). On FNAC, colloid or nodular goitre was the most

frequent diagnosis, observed in 28 (56.0%) patients. This was followed by multinodular goitre in 7 (14.0%), papillary carcinoma in 6 (12.0%), lymphocytic thyroiditis in 4 (8.0%), lesions suspicious for malignancy in 3 (6.0%), and follicular carcinoma in 2 (4.0%) patients. The overall distribution of FNAC diagnoses was statistically significant ($\chi^2=57.76$, $p<0.001$).

Table 3: Concordance between FNAC and postoperative histopathological diagnosis (N=50)

FNAC classification		HPE benign, n (%)	HPE malignant, n (%)	Total, n (%)
FNAC benign or test-negative		38 (76.0)	1 (2.0)	39 (78.0)
FNAC suspicious or malignant or test-positive		3 (6.0)	8 (16.0)	11 (22.0)
Total		41 (82.0)	9 (18.0)	50 (100.0)
Agreement measure	Value	95% CI	Test statistic	p-value
Observed agreement	46/50 (92.0%)	81.2–96.8	—	—
Cohen's kappa	0.751	0.516–0.985	$z = 6.27$	<0.001
Paired discordance	FN = 1; FP = 3	—	Exact McNemar test	0.625

[Table 3] demonstrates the concordance between FNAC and postoperative histopathological findings. Of the 39 patients classified as benign or test-negative by FNAC, 38 (76.0% of the total cohort) were confirmed as benign on histopathology, while 1 (2.0%) was found to be malignant, representing a false-negative result. Among the 11 patients with suspicious or malignant FNAC findings, 8 (16.0%) were confirmed as malignant and 3 (6.0%) were benign on histopathology, representing false-positive results. Overall, 41 (82.0%) lesions were

histopathologically benign and 9 (18.0%) were malignant. The observed agreement between FNAC and histopathology was 92.0% (46/50; 95% CI: 81.2–96.8). Cohen's kappa was 0.751 (95% CI: 0.516–0.985), indicating substantial agreement beyond chance, which was statistically significant ($z=6.27$, $p<0.001$). The exact McNemar test was nonsignificant ($p=0.625$), indicating no evidence of a systematic difference between FNAC and histopathological classifications.

Table 4: Diagnostic performance of FNAC for detecting malignant thyroid lesions (N=50)

Diagnostic measure	Estimate	95% CI	Test of significance	p-value
Sensitivity	88.9%	56.5–98.0	Exact binomial, 8/9	0.039
Specificity	92.7%	80.6–97.5	Exact binomial, 38/41	<0.001
Positive predictive value	72.7%	43.4–90.3	Exact binomial, 8/11	0.227
Negative predictive value	97.4%	86.8–99.5	Exact binomial, 38/39	<0.001
Overall diagnostic accuracy	92.0%	81.2–96.8	Exact binomial, 46/50	<0.001

[Table 4] presents the diagnostic performance of FNAC for detecting malignant thyroid lesions, using histopathology as the reference standard. FNAC demonstrated a sensitivity of 88.9% (95% CI: 56.5–98.0; $p=0.039$), showing that it correctly identified most malignant lesions. The specificity was 92.7% (95% CI: 80.6–97.5; $p<0.001$), indicating a high ability to correctly classify benign lesions. The positive predictive value was 72.7% (95% CI: 43.4–90.3); however, its comparison with the 50% reference value was not statistically significant ($p=0.227$), partly reflecting the small number of FNAC-positive cases. The negative predictive value was 97.4% (95% CI: 86.8–99.5, $p<0.001$), demonstrating that a negative FNAC result was highly reliable for excluding malignancy. The overall diagnostic accuracy was 92.0% (95% CI: 81.2–96.8, $p<0.001$).

DISCUSSION

The present study evaluated the diagnostic performance of fine-needle aspiration cytology (FNAC) against postoperative histopathological examination in 50 patients with thyroid swellings.

FNAC showed high concordance with histopathology, with an overall agreement of 92.0%, sensitivity of 88.9%, specificity of 92.7%, negative predictive value of 97.4%, and diagnostic accuracy of 92.0%. These findings support FNAC as an effective initial investigation for differentiating benign from malignant thyroid lesions, although histopathology remains necessary for definitive diagnosis.

Overall diagnostic profile

The mean age of the patients was 38.74 ± 12.63 years, suggesting that thyroid swellings predominantly affected young and middle-aged adults. Babu et al. (2016),^[2] similarly observed that most patients with thyroid swellings were between 30 and 45 years of age. Agarwal and Jain (2017),^[3] in their review of thyroid cytology studies from India, reported that thyroid lesions commonly occurred during the third to fifth decades of life. In contrast, Alzahrani et al. (2024),^[12] reported a higher mean age of 47.7 years among 52 patients undergoing thyroid nodule excision. The difference may reflect variations in referral patterns, geographical characteristics, iodine status, and inclusion of only surgically treated patients.

The mean size of the largest thyroid nodule was 3.42 ± 1.57 cm. Its nonsignificant comparison with the reference value of 3 cm ($p=0.064$) indicates that the mean nodule size was not substantially different from this benchmark. Nevertheless, nodule size alone should not determine the risk of malignancy. Haugen et al. (2016),^[1] recommended that the decision to perform FNAC should be based on a combination of nodule size and suspicious ultrasonographic characteristics. Lind et al. (2024),^[13] found that FNAC sensitivity increased from 61.5% in lesions smaller than 1 cm to 86.5% in lesions larger than 1 cm, indicating that lesion size can affect sampling adequacy and sensitivity, even though it is not independently diagnostic of malignancy. Haugen et al. guidelines and the Lind et al. study support this interpretation.

FNAC was positive in 22.0% and negative in 78.0% of patients, whereas histopathology demonstrated malignancy in 18.0% and benign disease in 82.0%. The predominance of benign lesions is consistent with the established epidemiology of thyroid nodules. Abou-Foul et al. (2021),^[7] reported benign histopathology in 74.7% and malignant histopathology in 25.3% of 471 patients who underwent preoperative FNAC. Their malignancy proportion was somewhat higher than the present 18.0%, possibly because their cohort consisted exclusively of surgically managed patients over a 10-year period. Abou-Foul et al. also emphasized that institutional malignancy rates may differ substantially and should be considered during patient counselling.

Concordance between FNAC and histopathology was observed in 92.0% of cases, while only 8.0% were discordant. Babu et al. (2016),^[2] reported an FNAC diagnostic accuracy of approximately 94%, while Singh et al. (2021),^[6] reported an overall accuracy of 95.71%. Archana et al. (2020),^[5] found an even higher FNAC accuracy of 99.0%. Conversely, Osseis et al. (2023),^[10] reported an accuracy of 75.89%, demonstrating that diagnostic performance varies according to patient selection, prevalence of malignancy, cytological reporting criteria, sampling technique, and pathologist experience.

Clinical and cytological spectrum: The largest age group was 31–40 years, comprising 36.0% of patients, followed by 21–30 years at 26.0% and 41–50 years at 22.0%. This distribution was statistically significant ($p=0.006$). Babu et al (2016),^[2] also found that most patients were between 30 and 45 years of age. The present age distribution therefore supports the observation that clinically evident thyroid swellings frequently present during early and middle adulthood.

Females constituted 86.0% of the study population, demonstrating a significant female predominance ($p<0.001$). This finding agrees with Abou-Foul et al. (2021),^[7] who observed that thyroid nodules and surgically treated thyroid diseases occurred predominantly among women. Alzahrani et al.

(2024),^[12] also reported female predominance in their thyroid nodule excision cohort. Lind et al. (2024),^[13] found that 72% of patients in their nationwide thyroid cancer cohort were women. The female predominance may be related to hormonal, reproductive, autoimmune, and genetic influences on thyroid tissue.

Pain or tenderness was present in 16.0% of patients, dysphagia in 14.0%, cervical lymphadenopathy in 12.0%, hoarseness in 8.0%, and dyspnoea in 6.0%. These symptoms were relatively uncommon because many thyroid nodules remain asymptomatic until they enlarge sufficiently to produce pressure symptoms or develop malignant features. Dysphagia, dyspnoea and hoarseness may indicate compression or invasion of adjacent structures, while cervical lymphadenopathy increases suspicion of malignancy. Haugen et al (2016),^[1] identified rapid growth, hoarseness, fixation, cervical lymphadenopathy and previous neck irradiation as important clinical risk factors requiring careful evaluation.

Colloid or nodular goitre was the most frequent FNAC diagnosis, accounting for 56.0% of cases. Multinodular goitre accounted for 14.0%, lymphocytic thyroiditis for 8.0%, suspicious lesions for 6.0%, papillary carcinoma for 12.0%, and follicular carcinoma for 4.0%. This pattern is consistent with Agarwal and Jain (2017),^[3] who found that benign follicular and colloid nodules formed the majority of thyroid aspirates in Indian studies. Bhise et al. (2022),^[8] similarly reported that benign and non-neoplastic thyroid swellings were more frequent than malignant lesions.

Papillary carcinoma was more frequent than follicular carcinoma in the present study. This is consistent with the observations of Abou-Foul et al. (2021),^[7] who identified papillary thyroid carcinoma as the most common malignant histological diagnosis. Lind et al (2024),^[13] also reported that papillary carcinoma accounted for 74% of histologically verified thyroid cancers. The predominance of papillary carcinoma reflects its position as the most common differentiated thyroid malignancy.

The classification of thyroid FNAC findings should preferably follow a standardized reporting system. Cibas and Ali (2017),^[4] described six Bethesda diagnostic categories, each associated with a defined risk of malignancy and recommended management. Ali et al. (2023),^[11] updated this framework by refining the malignancy risks and simplifying the terminology for the six categories. These systems improve communication between cytopathologists and clinicians and permit meaningful comparison of diagnostic performance across institutions. The 2023 Bethesda update is particularly relevant when interpreting suspicious and indeterminate lesions.

Concordance between FNAC and histopathology: Among 39 FNAC-negative cases, 38 were histopathologically benign and one was malignant. Among 11 FNAC-positive cases, eight were malignant and three were benign. Thus, the study

identified one false-negative and three false-positive results. The observed agreement was 92.0%, and Cohen's kappa of 0.751 indicated substantial agreement beyond chance ($p < 0.001$).

Abdullahi et al (2023),^[9] reported sensitivity of 91.1%, specificity of 96.6%, and overall accuracy of 94.9%, which closely approximate the present results. Their high cytohistological correlation supports the value of FNAC in planning the initial management of thyroid lesions. Archana et al. (2020),^[5] reported still higher concordance, with FNAC sensitivity of 94.12%, specificity of 100%, and accuracy of 99.0%. Differences may be explained by a larger number of cytologically clear benign and malignant lesions or exclusion of nondiagnostic and indeterminate aspirates.

In contrast, Osseis et al (2023),^[10] reported FNAC sensitivity of 89.31%, specificity of 48.44%, and accuracy of 75.89%. Although their sensitivity was similar to the present 88.9%, their specificity was considerably lower. This may indicate that a greater proportion of suspicious or indeterminate cytological findings were ultimately benign on histopathology. Such findings illustrate the influence of the threshold used to classify indeterminate cytology as a positive or negative test.

The exact McNemar test was nonsignificant ($p = 0.625$), suggesting no systematic tendency for FNAC to overdiagnose or underdiagnose malignancy relative to histopathology. Nevertheless, the presence of three false-positive and one false-negative result remains clinically important. A false-positive result may lead to unnecessary extensive surgery, whereas a false-negative result can delay definitive treatment. Abou-Foul et al (2021),^[7] reported that 14.7% of cytologically benign Thy2 cases were malignant on final histopathology, emphasizing the need for continued clinical and ultrasonographic surveillance even after a benign cytological report.

Diagnostic performance of FNAC: The sensitivity of FNAC was 88.9%, indicating that eight of the nine malignant lesions were correctly detected. This result is comparable to the 89.31% sensitivity reported by Osseis et al. (2023),^[10] and the 91.1% reported by Abdullahi et al. (2023).^[9] Lind et al (2024),^[13] reported an overall FNAC sensitivity of 81.6%, which increased to 86.5% in lesions larger than 1 cm and 86.9% when ultrasound guidance was used. The present mean nodule size of 3.42 cm may partly explain the relatively high sensitivity observed.

The specificity was 92.7%, demonstrating that FNAC correctly identified most histopathologically benign lesions. This finding was comparable to the 96.6% specificity reported by Abdullahi et al (2023),^[9] but lower than the 100% specificity reported by Archana et al. (2020).^[5] It was considerably higher than the 48.44% reported by Osseis et al (2023),^[10] and the 53.33% reported by Kohale et al. (2024).^[12] Kohale et al. reported sensitivity of 95.38%, specificity of 53.33%, positive predictive value of 86.67%, and negative predictive value of 88.57%, highlighting substantial between-study variation in specificity.

Kohale et al. attributed diagnostic discrepancies to the inherent limitations of cytological sampling and interpretation.

The positive predictive value was 72.7%, meaning that approximately three-fourths of FNAC-positive lesions were malignant on histopathology. Its p -value of 0.227 against the 50% benchmark was nonsignificant, probably because only 11 patients had positive FNAC findings, resulting in a wide confidence interval of 43.4–90.3%. Positive predictive value is also strongly influenced by the prevalence of malignancy; therefore, it should not be compared directly between studies without considering differences in case selection.

The negative predictive value was 97.4%, indicating that a negative FNAC result was highly reliable for excluding malignancy. This was similar to the NPV of 98.82% reported by Archana et al (2020).^[5] A high NPV is clinically valuable because it allows many patients with benign cytology to avoid immediate surgery. However, clinical and ultrasonographic follow-up remains necessary, especially when suspicious imaging findings persist or the cytology result is discordant with the clinical picture.

Overall diagnostic accuracy was 92.0%, comparable to the approximately 94% accuracy reported by Babu et al (2016),^[2] 95.71% reported by Singh et al. (2021),^[6] 94.9% reported by Abdullahi et al. (2023),^[9] and 90% reported by Alzahrani et al. (2024).^[12]

CONCLUSION

Fine-needle aspiration cytology demonstrated high diagnostic reliability in differentiating malignant from benign thyroid swellings when compared with postoperative histopathology. FNAC and histopathological diagnoses were concordant in 92.0% of cases, with substantial agreement (Cohen's kappa=0.751, $p < 0.001$). FNAC achieved a sensitivity of 88.9%, specificity of 92.7%, positive predictive value of 72.7%, negative predictive value of 97.4%, and overall diagnostic accuracy of 92.0%. The high negative predictive value indicated that a benign FNAC result was highly reliable for excluding malignancy. FNAC may therefore be used as a simple, safe, economical, and effective initial diagnostic investigation for thyroid swellings. However, suspicious, indeterminate, clinically discordant, or radiologically high-risk lesions should undergo further evaluation, and histopathological examination should remain the definitive diagnostic standard, particularly for follicular-patterned lesions.

Limitations: The study had several limitations. First, it was conducted at a single tertiary care centre with a relatively small sample of 50 patients, which limited the precision and generalizability of the diagnostic estimates. The small number of malignant lesions resulted in wide confidence intervals, particularly for sensitivity and positive predictive value. Second, only patients who underwent thyroid

surgery and had postoperative histopathological results were included. This may have introduced verification and selection bias because many patients with benign FNAC findings were managed conservatively and were not represented. Third, FNAC is operator-dependent, and variations in aspiration technique, ultrasound guidance, specimen adequacy, smear preparation, and cytopathological interpretation may have influenced its performance. Fourth, nondiagnostic and indeterminate Bethesda categories were not analyzed separately in sufficient numbers. Fifth, blinding of cytopathologists and histopathologists to clinical or radiological findings was not documented. Interobserver variability was also not assessed. Finally, the study did not evaluate the independent contribution of ultrasonographic risk classification, molecular testing, immunocytochemistry, or repeat FNAC to diagnostic accuracy.

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