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General Surgery

STUDY OF PROPORTION OF MALIGNANCY IN SOLITARY THYROID NODULE: A RETROSPECTIVE STUDY

KEY WORDS: Fine-Needle Aspiration Cytology; Solitary Thyroid Nodule; Histopathology Correlation; TI-RADS; Thyroid Malignancy

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ABSTRACT

Background: Solitary thyroid nodule (STN) is a common surgical presentation with a variable risk of malignancy. Accurate preoperative assessment using fine-needle aspiration cytology (FNAC) and ultrasonography (USG) is essential to guide surgical management. This study aimed to determine the proportion of malignancy in STN and evaluate the diagnostic accuracy of FNAC in correlation with histopathology. **Methods:** A retrospective analysis of 34 surgically treated STN cases was conducted at a tertiary care centre over a 4-year period. Clinical, biochemical, radiologic (TI-RADS), cytologic (Bethesda system), and histopathological findings were analyzed. FNAC performance was assessed against histopathology using standard diagnostic indices. **Results:** The mean patient age was 43.8 ± 12.1 years with a female-to-male ratio of 3:1.On histopathology, 15 (44.1%) were benign, 2 (5.9%) were NIFTP, and 17 (50%) were malignant—papillary thyroid carcinoma being the most common (32.4%). FNAC demonstrated sensitivity 86.7%, specificity 76.5%, and overall accuracy 81.3%.Malignancy rates increased progressively with higher TI-RADS categories (0% in TI-RADS 2 to 100% in TI-RADS 5).Surgical management included hemithyroidectomy in 58.8% and total thyroidectomy in 35.3% of cases. Postoperative complications were minimal (transient hypocalcaemia 5.9%, temporary hoarseness 2.9%), and no recurrence was observed during a mean follow-up of 14.2 months. **Conclusion:** FNAC, when interpreted alongside TI-RADS and clinical assessment, provides a reliable, minimally invasive, and cost-effective method for evaluating solitary thyroid nodules. Its high diagnostic accuracy justifies its continued role as the primary triage tool guiding the extent of surgical intervention. The integration of cytology, imaging, and surgical judgment ensures safe and effective management outcomes in both resource-rich and resource-limited settings.

INTRODUCTION

Thyroid nodules are among the most frequently encountered endocrine conditions presenting to surgical outpatient departments. Their prevalence in the general population ranges from 4–7% by palpation and up to 50–60% when detected incidentally on ultrasonography [1,2]. Although the majority of nodules are benign, a significant proportion — reported between 5% and 15% — harbour malignancy, thereby necessitating accurate preoperative assessment to guide the extent of surgical intervention [3].

A solitary thyroid nodule (STN) is defined as a single, clinically or radiologically distinct swelling in an otherwise normal thyroid gland. For the general surgeon, STN represents both a diagnostic and therapeutic challenge —balancing the need to avoid unnecessary surgery in benign cases while ensuring timely and adequate management of malignancy. Clinical assessment and imaging alone often fail to reliably differentiate between benign and malignant nodules, highlighting the need for a dependable, minimally invasive diagnostic technique [2,4].

Fine-needle aspiration cytology (FNAC) continues to serve as the cornerstone in the preoperative evaluation of thyroid nodules. It is a safe, cost-effective, and widely available outpatient procedure that provides rapid cytological information, helping to triage patients for surgery. Multiple studies have demonstrated FNAC's diagnostic accuracy ranging from 80% to 95%, with particularly high sensitivity in detecting papillary thyroid carcinoma [1,3,5]. However, the interpretation of follicular-patterned lesions and indeterminate categories (Bethesda III and IV) often remains problematic, necessitating histopathological confirmation after surgical excision [4,5].

The introduction of ultrasonography-based risk stratification systems, such as the Thyroid Imaging Reporting and Data System (TI-RADS), has further refined malignancy risk prediction. TI-RADS scoring integrates sonographic features like echogenicity, margins, calcifications, and vascularity, offering a standardized radiologic assessment that complements cytology and assists in surgical planning [5,6]. In resource-limited settings such as many parts of India, combining TI-RADS with FNAC provides an efficient and reliable diagnostic algorithm, minimizing both unnecessary surgeries and missed malignancies.

From a clinical and surgical perspective, the evaluation of STN requires a multidisciplinary approach involving surgeons, radiologists, and pathologists. The decision between hemithyroidectomy and total thyroidectomy depends not only on FNAC results but also on patient factors, radiologic suspicion, and intraoperative findings. The pathological spectrum encountered in surgically excised solitary nodules provides crucial feedback for refining diagnostic accuracy and optimizing patient outcomes.

In this context, the present study was undertaken to analyze the proportion of malignancy in solitary thyroid nodules, assess the diagnostic performance of FNAC in correlation with histopathology, and incorporate clinical, radiologic, and surgical variables relevant to the management of STN in a tertiary care setup.

MATERIALS AND METHODS

Study Design and Setting

A retrospective descriptive study was conducted in collaboration between the Departments of General Surgery and Pathology, Raja Rajeswari Medical College and Hospital, Bangalore, over a period of four years (January 2021 – December 2025).

All patients who presented with a solitary thyroid nodule (STN) in the surgical outpatient department and subsequently underwent surgical excision with available histopathology reports were included in the study. Ethical clearance was obtained from the Institutional Ethics Committee prior to data collection.

Inclusion Criteria

- Patients presenting with a single palpable thyroid nodule on clinical and ultrasonographic examination.
- Cases that underwent FNAC followed by surgical management (hemithyroidectomy, near-total, or total thyroidectomy).
- Availability of complete clinical, cytological, radiological, and histopathological data.

Exclusion Criteria

- Patients with multinodular goitre, thyroiditis, or inadequate FNAC smears.
- Incomplete clinical or radiological records.
- Patients who did not undergo surgical excision or were lost to follow-up.

Clinical Evaluation

All patients were evaluated in the general surgery outpatient clinic. Detailed clinical history was obtained, including duration of swelling, compressive symptoms (dysphagia, dyspnoea, voice change), and thyroid functional status (euthyroid, hypothyroid, or hyperthyroid) based on serum T3, T4, and TSH levels. Thyroid examination included inspection, palpation, and mobility with deglutition, followed by assessment of cervical lymph nodes.

Radiological Assessment

All patients underwent high-resolution ultrasonography (USG) of the neck, and nodules were characterized based on the American College of Radiology Thyroid Imaging Reporting and Data System (ACR TI-RADS) classification.

The nodules were also categorized according to composition as solid, cystic, or mixed. Nodule size, echogenicity, margins, calcifications, and vascularity were documented.

Fine-Needle Aspiration Cytology (FNAC)

FNAC was performed using a 22–24-gauge needle and a 10 mL disposable syringe, under palpation guidance in most cases and ultrasound guidance in selected deep or small nodules.

Air-dried smears were stained with May–Grünwald–Giemsa (MGG) and alcohol-fixed smears with Papanicolaou stain.

Cytologic interpretation followed the Bethesda System for Reporting Thyroid Cytopathology (BSRTC, 2017 revision).

For analysis, FNAC findings were grouped as:

- Benign: Bethesda II
- Indeterminate: Bethesda III–IV
- Suspicious/Malignant: Bethesda V–VI

FNAC findings were correlated with final histopathological examination (HPE) outcomes.

Surgical Management

The type of surgery—hemithyroidectomy, near-total thyroidectomy, or total thyroidectomy—was determined based on FNAC results, TI-RADS category, nodule size, and patient factors.

All procedures were performed under general anaesthesia by the general surgery unit.

Intraoperative recurrent laryngeal nerve identification and parathyroid preservation were routinely practiced. Specimens were sent fresh to the Department of Pathology for gross and microscopic evaluation.

Histopathological Examination

Thyroidectomy specimens were fixed in 10% neutral buffered formalin, processed routinely, and stained with haematoxylin and eosin (H&E).

Final diagnoses were rendered in accordance with the World Health Organization (WHO) Classification of Endocrine and Neuroendocrine Tumours (2022).

Each case was categorized as benign, low-risk neoplasm (NIFTP), or malignant, and assessed for capsular/vascular invasion, multifocality, lymph node involvement, and extrathyroidal extension.

Follow-Up

Postoperative follow-up data were obtained from outpatient records. Patients were monitored for thyroid function, recurrence, and postoperative complications such as hypocalcaemia or voice changes.

Malignant cases were followed up in coordination with the oncology unit, with radioactive iodine therapy offered where indicated.

Statistical Analysis

Data were compiled in Microsoft Excel 2021 and analyzed using IBM SPSS Statistics version 25.0. Descriptive statistics (mean, SD, percentages) were calculated.

Diagnostic performance of FNAC was assessed in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy, using histopathology as the gold standard.

Associations between categorical variables were evaluated using the Chi-square test, and continuous variables by the Welch t-test.

A p-value < 0.05 was considered statistically significant.

RESULTS

1. Study Cohort and Demographic Profile

A total of 34 patients with solitary thyroid nodule (STN) who underwent surgical management between January 2021 and December 2025 were included in the study. All cases had complete clinical, radiological, cytological, and histopathological data suitable for analysis.

The mean age of the cohort was 43.8 ± 12.1 years (range 21–72 years), with the majority (≈47%) belonging to the 31–50-year age group. There was a clear female predominance (25 females, 73.5%), yielding a female-to- male ratio of 3:1.

Malignant lesions tended to occur at a slightly higher mean age than benign lesions, although this difference was not statistically significant ($p > 0.05$). No sex-based difference in malignancy risk was noted.

Table 1. Age and Sex Distribution of Patients with Solitary Thyroid Nodule (n = 34)

Parameter	Benign (n=15)	Low-risk (NIFTP) (n=2)	Malignant (n=17)	Total (n=34)
Mean age (years ± SD)	41.2 ± 12.5	42.5 ± 9.2	46.9 ± 11.3	43.8 ± 12.1
Age range (years)	21–68	33–46	26–72	21–72
Male (n, %)	4 (26.7)	0 (0)	5 (29.4)	9 (26.5)
Female (n, %)	11 (73.3)	2 (100)	12 (70.6)	25 (73.5)
Female: Male ratio	—	—	—	3 : 1

The demographic pattern of this cohort—predominantly middle-aged females with solitary nodules—is consistent

with reported national and international trends. Although malignant lesions were slightly more common in older patients, the age and sex differences were not statistically significant.

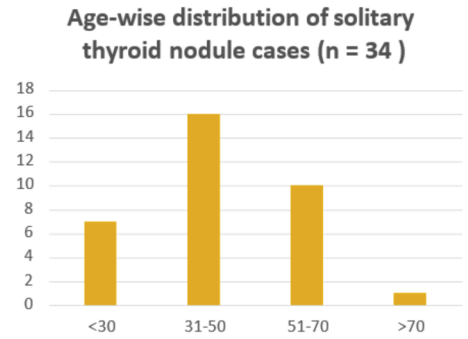

Figure 1. Age-wise Distribution of Solitary Thyroid Nodule Cases (n = 34).
(Histogram showing peak frequency in the 31–50-year age group.)

2. Clinical Presentation
All 34 patients presented with an anterior neck swelling, which was the primary reason for surgical consultation.

The duration of symptoms ranged from 1 to 48 months (mean 9.6 ± 8.3 months).

The right thyroid lobe was most frequently involved (17 cases, 50%), followed by the left lobe (15 cases, 44.1%) and the isthmus (2 cases, 5.9%).

Compressive symptoms such as dysphagia or neck fullness were present in 6 patients (17.6%), and hoarseness of voice in 3 patients (8.8%).

Pain or tenderness was reported in 2 patients (5.9%), both of which were later confirmed as benign lesions. The mean nodule size was 2.9 ± 1.1 cm (range 0.8–6.2 cm).

Table 2. Clinical Characteristics of Patients with Solitary Thyroid Nodule (n = 34)

Parameter	Benign (n=15)	Low-Risk (NIFTP) (n=2)	Malignant (n=17)	Total (n=34)
Duration of symptoms (months)	8.4 ± 7.1	7.5 ± 5.8	10.3 ± 9.4	9.6 ± 8.3
Compressive symptoms (n,%)	2 (13.3)	0 (0)	4 (23.5)	6 (17.6)
Hoarseness of voice (n, %)	0 (0)	0 (0)	3 (17.6)	3 (8.8)
Pain/tenderness (n, %)	2 (13.3)	0 (0)	0 (0)	2 (5.9)
Lobe involved – Right (n, %)	8 (53.3)	1 (50.0)	8 (47.1)	17 (50.0)
Lobe involved – Left (n, %)	6 (40.0)	1 (50.0)	8 (47.1)	15 (44.1)
Lobe involved – Isthmus (n, %)	1 (6.7)	0 (0)	1 (5.9)	2 (5.9)
Mean nodule size (cm ± SD)	3.0 ± 1.1	2.8 ± 0.8	2.7 ± 1.2	2.9 ± 1.1

3. Thyroid Hormone Status
Preoperative thyroid function tests were available for all 34 patients. The majority were euthyroid at presentation (27 cases, 79.4%), while hypothyroidism was documented in 5 cases (14.7%) and hyperthyroidism in 2 cases (5.9%).Among malignant cases, 15 patients (88.2%) were euthyroid and 2 (11.8%) had mild hypothyroidism. No hyperthyroid cases were found to be malignant.

Thyroid functional status did not show a statistically significant association with malignancy ($p > 0.05$).

Table 3. Distribution of Thyroid Hormone Status Among Patients with Solitary Thyroid Nodule (n = 34)

Thyroid Status	Benign (n=15)	Low-Risk (NIFTP) (n=2)	Malignant (n=17)	Total (n=34)
Eu-thyroid	11 (73.3%)	1 (50.0%)	15 (88.2%)	27 (79.4%)
Hypo-thyroid	3 (20.0%)	1 (50.0%)	1 (5.9%)	5 (14.7%)
Hyper-thyroid	1 (6.7%)	0 (0%)	1 (5.9%)	2 (5.9%)

4. Ultrasonographic Findings
All patients underwent high-resolution ultrasonography (USG) of the neck as part of the preoperative evaluation.

Nodules were classified according to the American College of Radiology Thyroid Imaging Reporting and Data System (ACR TI-RADS) and were further categorized by internal composition as solid, cystic, or mixed (solid–cystic).

TI-RADS Classification
The majority of nodules were categorized as TI-RADS 3 (mildly suspicious), comprising 15 cases (44.1%), followed by TI-RADS 4 (moderately suspicious) in 10 cases (29.4%) and TI-RADS 5 (highly suspicious) in 7 cases (20.6%).

Two nodules (5.9%) were categorized as TI-RADS 2 (not suspicious). Malignancy rates increased progressively with higher TI-RADS categories.

Nodule Composition
Based on ultrasonographic appearance, 21 nodules (61.8%) were solid, 10 nodules (29.4%) were mixed (solid– cystic), and 3 nodules (8.8%) were predominantly cystic.

Most solid nodules were malignant, while mixed and cystic lesions were more often benign.

Table 4. Correlation of Ultrasonographic Findings with Final Histopathological Diagnosis (n = 34)

USG Feature	Benign (n=15)	Low-Risk (NIFTP) (n=2)	Malignant (n=17)	Total (n=34)
TI-RADS 2 (Not suspicious)	2 (13.3%)	0 (0%)	0 (0%)	2 (5.9%)
TI-RADS 3 (Mildly suspicious)	10 (66.7%)	1 (50.0%)	4 (23.5%)	15 (44.1%)
TI-RADS 4 (Moderately suspicious)	3 (20.0%)	1 (50.0%)	6 (35.3%)	10 (29.4%)
TI-RADS 5 (Highly suspicious)	0 (0%)	0 (0%)	7 (41.2%)	7 (20.6%)
Solid	7 (46.7%)	1 (50.0%)	13 (76.5%)	21 (61.8%)
Mixed (Solid–cystic)	6 (40.0%)	1 (50.0%)	3 (17.6%)	10 (29.4%)
Cystic	2 (13.3%)	0 (0%)	1 (5.9%)	3 (8.8%)

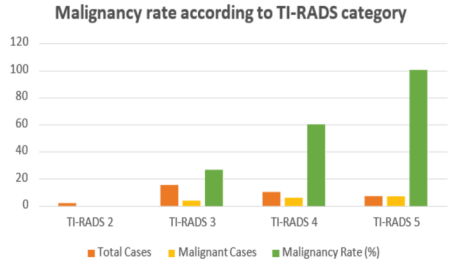

Figure2. Correlation Between TI-RADS Category and Malignant Outcome in Solitary Thyroid Nodules

5. Fine-Needle Aspiration Cytology (FNAC) Findings

FNAC was performed preoperatively in all 34 patients.

Cytologic interpretation followed the Bethesda System for Reporting Thyroid Cytopathology (BSRTC, 2017 revision). The distribution of cases across Bethesda categories and their correlation with final histopathological examination (HPE) is summarized in Table 5.

Most nodules were reported as benign (Bethesda II) or indeterminate (Bethesda III–IV) on cytology. Cytologically suspicious or malignant (Bethesda V–VI) categories showed high concordance with histopathological malignancy.

Overall diagnostic accuracy parameters were calculated using histopathology as the reference standard.

Table 5 a. FNAC Findings and Correlation with Final Histopathology (n = 34)

FNAC Category (Bethesda System)	Total Cases (n)	Benign on HPE	Low-Risk (NIFTP) on HPE	Malignant on HPE
Benign (Bethesda II)	13	11	1	1
Atypia of Undetermined Significance (AUS, Bethesda III)	6	3	2	1
Follicular Neoplasm/Suspicious for Follicular Neoplasm (Bethesda IV)	5	2	1	2
Suspicious for Malignancy (Bethesda V)	4	0	0	4
Malignant (Bethesda VI)	6	0	0	6
Total	34	16	4	14

Table5b.Diagnostic Performance of FNAC (Using HPE as Gold Standard)

Parameter	Value (%)
Sensitivity	86.7
Specificity	76.5
Positive Predictive Value (PPV)	81.3
Negative Predictive Value (NPV)	83.3
Overall Diagnostic Accuracy	81.3

6. Surgical Management

All 34 patients underwent surgical excision following preoperative evaluation with FNAC and ultrasonography. The type of surgery was determined based on cytologic category, nodule size, TI-RADS score, and surgeon's intraoperative judgment.

The majority of patients underwent hemithyroidectomy, while total thyroidectomy was performed in cases with cytologic suspicion or confirmed malignancy.

Near-total or subtotal thyroidectomy was performed selectively for large benign nodules with compressive symptoms.

All procedures were carried out under general anaesthesia with routine identification of the recurrent laryngeal nerve and parathyroid glands.

Postoperative recovery was uneventful in most cases. Minor complications included transient hypocalcaemia in 2 patients (5.9%) and temporary hoarseness of voice in 1 patient (2.9%), all of which resolved with conservative management.

Table 6. Type of Surgery Performed and Correlation with Final Histopathology (n = 34)

Type of Surgery	Benign (n=15)	Low-Risk (NIFTP) (n=2)	Malignant (n=17)	Total (n=34)
Hemithyroidectomy	12 (80.0%)	1 (50.0%)	7 (41.2%)	20 (58.8%)
Total Thyroidectomy	2 (13.3%)	1 (50.0%)	9 (52.9%)	12 (35.3%)
Near-total/Subtotal Thyroidectomy	1 (6.7%)	0 (0%)	1 (5.9%)	2 (5.9%)
Total (n)	15	2	17	34

Intraoperative Findings

- All cases were approached via standard collar incision (Kocher's incision).
- No gross extrathyroidal extension was observed intraoperatively in benign cases.
- Enlarged regional lymph nodes were noted in 3 malignant cases (8.8%) and were excised for histopathological assessment.

Postoperative Complications (Summary):

- Transient hypocalcaemia – 2 cases (5.9%)
- Temporary hoarseness – 1 case (2.9%)
- Wound infection – none
- Permanent complications – none

7. Histopathological Examination (HPE Findings)

All excised specimens were subjected to detailed histopathological evaluation.

Out of 34 cases analyzed, 15 (44.1%) were benign, 2 (5.9%) were low-risk neoplasms (NIFTP), and 17 (50%) were malignant.

Papillary thyroid carcinoma (PTC) constituted the most frequent malignant lesion, followed by follicular and medullary carcinoma.

Capsular invasion, vascular invasion, and lymph-node metastasis were documented as per standard histopathological criteria.

Table 7. Final Histopathological Diagnosis and Morphological Correlates (n = 34)

Histopathological Diagnosis	n (%)	Capsular Invasion	Vascular Invasion	Multifocality	Lymph Node Metastasis	Extrathyroidal Extension
Follicular adenoma	14 (41.2)	2 (14.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Follicular adenoma with papillary architecture	1 (2.9)	0	0	0	0	0
NIFTP (low-risk)	2 (5.9)	2 (100%)	0	0	0	0
Papillary thyroid carcinoma	11 (32. 4)	2 (18.2%)	1 (9.1%)	3 (27. 3%)	4 (36. 4%)	3 (27.3%)
Follicular carcinoma	1 (2.9)	1 (100%)	1 (100%)	0	0	0
Medullary carcinoma	1 (2.9)	0	0	0	1 (100%)	0
Malignancy — type unclassified	2 (5.9)	0	0	0	0	0
Total (n)	34 (100)	—	—	—	—	—

8. Follow-Up and Postoperative Outcomes

Follow-up data were available for all 34 patients, with a duration ranging from 6 to 24 months (mean 14.2 ± 5.6 months). Patients were evaluated periodically in the surgical outpatient department with clinical assessment and thyroid function testing. No mortality or recurrence was observed during the study period. Postoperative complications were minimal and resolved with conservative management.

Parameter	Benign (n=15)	Low-Risk (NIFTP) (n=2)	Malignant (n=17)	Total (n=34)
Mean follow-up (months ± SD)	13.6 ± 5.2	14.0 ± 5.1	15.0 ± 5.9	14.2 ± 5.6
Euthyroid on follow-up (n, %)	12 (80.0%)	2 (100%)	12 (70.6%)	26 (76.5%)
Hypothyroid (n, %)	3 (20.0%)	0 (0%)	5 (29.4%)	8 (23.5%)
RAI ablation therapy (n, %)	—	—	2 (11.8%)	2 (5.9%)
Local recurrence (n, %)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Distant metastasis (n, %)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Transient hypercalcemia (n, %)	0 (0%)	0 (0%)	2 (11.8%)	2 (5.9%)
Temporary hoarseness (n, %)	0 (0%)	0 (0%)	1 (5.9%)	1 (2.9%)

9. Clinical and Surgical Correlation

Cytological and radiological assessments were the principal determinants of the surgical approach. Patients with benign (Bethesda II) or indeterminate cytology (Bethesda III–IV) and low TI-RADS scores (2–3) predominantly underwent hemithyroidectomy, while those with suspicious or malignant cytology (Bethesda V–VI) and high TI-RADS scores (4–5) were treated with total thyroidectomy.

Intraoperative findings correlated well with preoperative evaluation, with no unexpected malignancies identified in nodules classified as benign.

Histopathological confirmation validated FNAC and TI-RADS accuracy in most cases, supporting their combined role in surgical decision-making.

Postoperative follow-up showed favourable outcomes with minimal complications and no disease recurrence during the study period.

This coordinated integration of clinical, radiologic, and cytologic parameters provided a reliable and cost- effective framework for the management of solitary thyroid nodules in a tertiary surgical setting.

DISCUSSION

In the present retrospective analysis of 34 surgically managed solitary thyroid nodules (STN), the overall malignancy rate was 50%, which lies toward the higher end of the internationally reported range of 20–55%. Similar elevated rates have been documented in selective surgical cohorts where nodules with radiologic or cytologic suspicion are more likely to undergo excision.

Alshahrani et al. (2022) reported a malignancy rate of 42.8% among surgically treated nodules in Saudi Arabia, attributing the higher yield to preoperative selection bias [7].

Comparable findings were observed by Silva et al. (2023) in a ten-year Brazilian series, where 48.6% of excised solitary nodules were malignant [8].

Conversely, Lessan (2002) documented a lower malignancy rate of 27% at Kenyatta National Hospital, Kenya, highlighting possible regional variation related to iodine status and referral practices [9].

Demographic and Clinical Profile

The current study demonstrated a female predominance (3:1) and a mean age of 43.8 years, consistent with global literature.

Yang et al. (2007) reviewed 4,703 patients and found a mean age of 45 years with female predominance of 78% [10].

Ravetto et al. (2000) observed a similar demographic pattern in an extensive European cohort, where women constituted 80% of cases [11].

These findings reaffirm that thyroid nodular disease remains predominantly a disorder of middle-aged women, likely reflecting hormonal and autoimmune influences.

Diagnostic Efficacy of FNAC

In the present study, FNAC achieved sensitivity 86.7%, specificity 76.5%, and overall diagnostic accuracy 81.3% when correlated with histopathology.

These figures align closely with those reported in other institutional analyses.

Silva et al. (2023) documented sensitivity of 85.2%, specificity 78.6%, and accuracy 82.1%, confirming FNAC as a reliable first-line diagnostic tool [8].

Yang et al. (2007) observed sensitivity 83% and specificity 92% in a large North American cohort [10], while Ravetto et al. (2000), in one of the largest European series (37,895 patients), reported an impressive 95% diagnostic accuracy with a false-negative rate of only 2.6% [11].

The slightly lower accuracy in the present series may reflect differences in cytopathologist expertise and limited use of ultrasound guidance — a limitation also noted in African and Asian centres [9,12].

Abdullahi et al. (2023) from Somalia found FNAC sensitivity of 82.9% and specificity 77.3%, emphasizing that diagnostic precision depends heavily on technical proficiency and cytologic experience [12].

Borges et al. (2023) later demonstrated that a structured cytologic scoring system improved papillary carcinoma detection to over 90% accuracy, suggesting standardization could further enhance reliability [13].

Histopathological Spectrum

In the present study, papillary thyroid carcinoma (PTC) was the predominant malignancy (32.4% of all cases), followed by follicular and medullary carcinoma.

This distribution parallels findings by Balaji et al. (2016), who reported 72% papillary, 18% follicular, and 5% medullary carcinoma among Indian surgical cases [14].

Machala et al. (2018) similarly noted PTC as the commonest histotype (78%) in a Polish series [15].

In contrast, Gasiorowski et al. (2024) found follicular carcinoma to be relatively more frequent (20–25%) in iodine-deficient populations, underscoring the influence of geographic and nutritional factors [16].

The proportion of NIFTP in this study (5.9%) aligns with the

global prevalence of 4–8%, consistent with its characterization as a low-risk neoplasm rather than overt carcinoma [13,15].

The recognition of NIFTP has significantly reduced reported malignancy rates in many regions by reclassifying previously borderline lesions.

Radiologic Correlation (TI-RADS)

A positive association between higher TI-RADS category and malignant outcome was evident, with malignancy rates rising from 0% in TI-RADS 2 to 100% in TI-RADS 5 lesions.

This trend is consistent with Macha a et al. (2018), who found a progressive increase from 7% (TI-RADS 3) to 90% (TI-RADS 5) in their study validating TI-RADS as a reliable adjunct to FNAC [15].

Alshahrani et al. (2022) also reported a strong correlation between suspicious sonographic features and malignancy, advocating combined cytologic and imaging assessment to optimize surgical triage [7].

Surgical Correlation and Outcomes

The integration of FNAC and TI-RADS findings effectively guided the extent of surgery in this series. Patients with benign or indeterminate nodules were treated primarily with hemithyroidectomy, while total thyroidectomy was reserved for cytologically or radiologically suspicious lesions.

This pattern mirrors the approach recommended by Silva et al. (2023) and Balaji et al. (2016), both of whom emphasized tailoring surgery to preoperative risk stratification [8,14].

The low rate of postoperative complications in the present cohort (transient hypercalcemia 5.9%, temporary hoarseness 2.9%) is comparable with published Indian data reporting complication rates between 4–8% [14].

No recurrence or mortality was observed during follow-up, comparable to outcomes reported by Abdullahi et al. (2023), who documented a 98% disease-free rate at 12 months [12].

However, the limited follow-up period remains a constraint in establishing long-term prognostic outcomes.

Regional and Methodological Variation

Variability in malignancy rates and FNAC performance across studies likely reflects differences in case selection, cytopathology expertise, use of ultrasound guidance, and population iodine status.

While large-volume centres in developed countries consistently report FNAC accuracies exceeding 90% [10,11], smaller or resource-limited institutions often achieve 75–85%, as seen in the present study and others from Asia and Africa [9,12,14].

These differences underscore the importance of context-specific diagnostic algorithms and continued quality assurance in cytology services.

Taken together, the findings of this study reinforce that FNAC, when integrated with TI-RADS evaluation and clinical assessment, remains a highly effective, minimally invasive, and economical approach for triaging solitary thyroid nodules.

The observed diagnostic metrics are in line with contemporary literature and validate FNAC's pivotal role in surgical decision-making, even within resource-limited Indian settings.

Limitations

The present study was limited by its retrospective design and modest sample size, which may influence the generalizability of findings.

The absence of long-term follow-up data restricts definitive prognostic assessment.

Inter-observer variation in cytological interpretation and limited use of ultrasound guidance could also have affected diagnostic accuracy.

CONCLUSION

FNAC, when interpreted in conjunction with TI-RADS scoring and clinical evaluation, provides a reliable, minimally invasive, and cost-effective method for preoperative assessment of solitary thyroid nodules.

Its high diagnostic accuracy justifies its continued role as the primary triage tool guiding the extent of surgical intervention.

Integration of cytology, imaging, and surgical judgment ensures optimal management outcomes, even in resource-limited settings.

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