e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2026; 17(7); 100-111

Original Research Article

A Study is to Ensure that Samples are Adequate, Handled Properly for Satisfactory Morphological Study and that They Meet all Pre-Analytical Requirements for Specific Diagnostic Tests by Performing RAPID ON-SITE EVALUATION (ROSE)

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Received: 15-05-2026 / Revised: 17-06-2026 / Accepted: 06-07-2026
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Conflict of interest: Nil

Abstract:
Fine-needle aspiration cytology (FNAC) is widely used for the stratification of thyroid nodules Results of FNAC were reported as per the Bethesda System for Reporting of Thyroid Cytopathology Rapid on-site evaluation (ROSE) has been proposed to improve the overall adequacy of FNA. ROSE is a simple technique, which helps in the immediate assessment of sample adequacy. This reduces the turnaround time for reporting the cases. And hence, in turn, allowing early intervention and treatment of the patient.
Keywords: FNAC, ROSE.
DOI: 10.25258/ijpqa.17.7.15

Introduction

The term "thyroid" is derived from the Greek word "thyreos, " meaning "shield." It was first introduced by Thomas Wharton (1614-1673), a London-based

anatomist, who coined the term Glandularis thyroideis in his 1656 book Adenographia [1]. Historically, the thyroid gland was referred to by various names, including struma (the Latin term for a swollen gland), bronchocele (a cystic mass in the neck), and goiter (derived from the Latin word gutter, meaning throat), with the latter still in use today [2].

In 1927, Dudgeon and Patrick in the United Kingdom proposed the use of needle biopsy for rapid microscopic diagnosis of tumors. The fine needle aspiration technique for thyroid diagnosis was further developed in Sweden in the 1950s, at the Rudinhelment Hospital of Stockholm [3]. By 1983, Frable W. J. advocated the use of FNAC for diagnosing most thyroid masses, classifying them as either neoplasms or goiter nodules [4].

Fine-needle aspiration cytology (FNAC) is widely used for the stratification of thyroid nodules [1]. Results of FNAC were reported as per the Bethesda System for Reporting of Thyroid Cytopathology [1]. Rapid on-site evaluation (ROSE) has been proposed to improve the overall adequacy of FNA. ROSE is a simple technique, which helps in the immediate assessment of sample adequacy. This reduces the turnaround time for reporting the cases. And hence, in turn, allowing early intervention and treatment of the patient [12].

Methodology

The present study deals with FNAC of 120 cases of thyroid swellings referred to cytology lab over a period from March 2023 To August 2024 in the Department of Pathology, Ballari Medical College and Research Centre, Ballari

The FNAC was done as an outpatient procedure after explaining the details of the procedure to the patient and taking an informed written consent. Prior to aspiration a local examination was carried out to locate and identify the site of the swelling, shape, size, and consistency. The patient is made to lie supine with the neck extended, a 21-23 G needle attached to a 10ml disposable syringe is taken and 2-3 passes made in each case. When material starts to collect in the needle hub, the syringe is withdrawn and the aspirate is transferred to clean glass slides and smears are prepared. In the case of a fluid aspirate, the aspirate is centrifuged, and slides are made from the sediment. Several smears are made in each case and smears are fixed in 95% ethyl alcohol and then rapid onsite evaluation was done on one slide using the toluidine stain and examined for the presence of six clusters of thyroid follicular

cells and at least ten cells in each cluster[3]. If the smears stained by toluidine are adequate, then the other slides are stained bythe routine H & E method and a cytological diagnosis were given and categorized according to the Bethesda system of reporting the thyroid.

If there were no adequate follicles in the toluidine-stained slide then the FNAC is repeated again , FNAC is repeated for a maximum of 3 times and if still no adequate follicles present in the slide then the it is considered as inadequate.

Inclusion Criteria

Fine needle aspiration cytology of clinically palpable thyroid lesion referred to cytology Laboratory

Exclusion Criteria

Non-cooperative patient.
Neck swellings other than thyroid

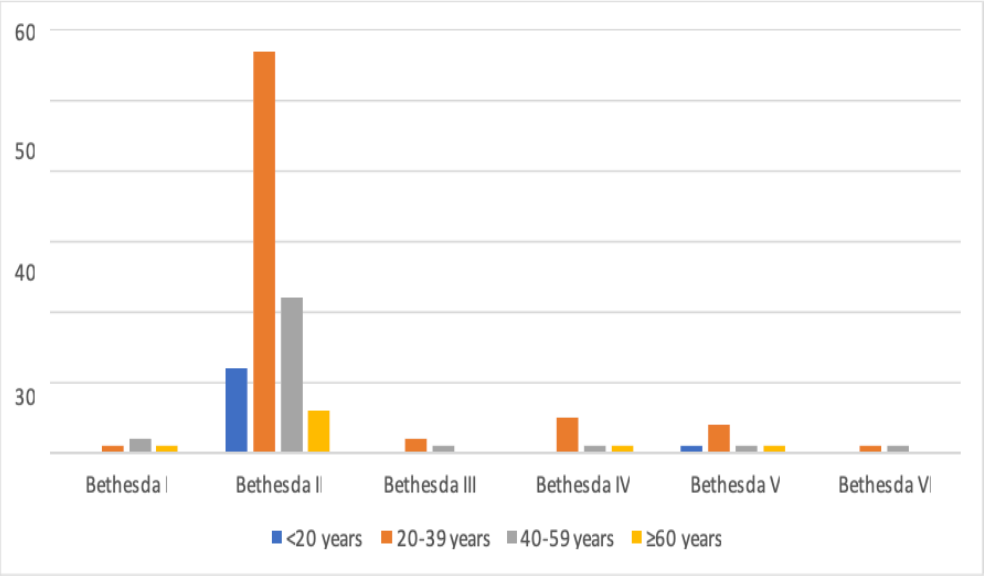
Results

The present study was conducted at Ballari Medical College & Research Centre, Ballari, over a period of March 2023 To August 2024 and deals with the FNAC of thyroid swellings and rapid onsite evaluation of FNAC sample for sample adequacy. A total of 120 patients with thyroid swellings were taken for the study

Table 1: Association between age groups and Bethesda categories

Age Group	Bethesda I	Bethesda II	Bethesda III	Bethesda IV	Bethesda V	Bethesda VI	Total
<20 Years	0 (0.0%)	12 (92.3%)	0 (0.0%)	0 (0.0%)	1 (7.7%)	0 (0.0%)	13 (100%)
20-39 Years	1 (1.4%)	57 (81.4%)	2 (2.9%)	5 (7.1%)	4 (5.7%)	1 (1.4%)	70 (100%)
40-59 Years	2 (7.1%)	22 (78.6%)	1 (3.6%)	1 (3.6%)	1 (3.6%)	1 (3.6%)	28 (100%)
≥60 years	1 (11.1%)	6 (66.7%)	0 (0.0%)	1 (11.1%)	1 (11.1%)	0 (0.0%)	9 (100%)
Total	4 (3.3%)	97 (80.8%)	3 (2.5%)	7 (5.8%)	7 (5.8%)	2 (1.7%)	120 (100%)

Chi-square statistic: 12.48, p-value: 0.41



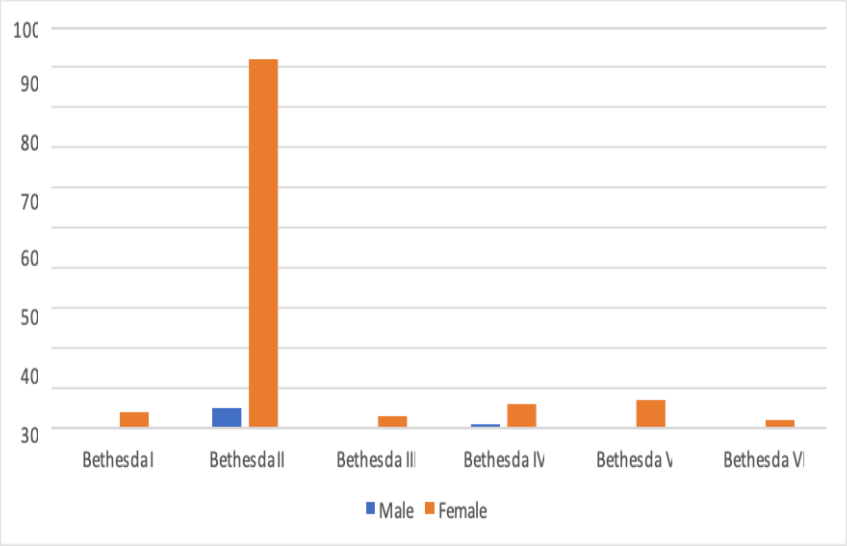
Graph 1: Distribution of Association between age groups and Bethesda categories

In patients <20 years, 12 of 13 cases (92.3%) were Bethesda II, with 1 case (7.7%) being Bethesda V. In the 20-39 years group, 57 of 70 cases (81.4%) were Bethesda II, with other categories represented in smaller numbers. Among 40-59year patients, 22 of 28 cases (78.6%) were Bethesda II, with the rest distributed across other categories. The chi-square value was 12.48 with a p-value of 0.41, which is not statistically significant, indicating no strong association between age group and Bethesda category.

Table 2: Association between gender and Bethesda categories

Gende r	Bethesd a I	Bethesd a II	Bethesd a III	Bethesd a IV	Bethesd a V	Bethesd a VI	Total
Male	0 (0.0%)	5 (83.3%)	0 (0.0%)	1 (16.7%)	0 (0.0%)	0 (0.0%)	6(100%)
Female	4 (3.5%)	92 (80.7%)	3 (2.6%)	6 (5.3%)	7 (6.1%)	2 (1.8%)	114(100%)
Total	4 (3.3%)	97 (80.8%)	3 (2.5%)	7 (5.8%)	7 (5.8%)	2 (1.7%)	120(100%)

Chi-square statistic: 2.09, p-value: 0.84



Graph 2: Distribution of Association between gender and Bethesda categories

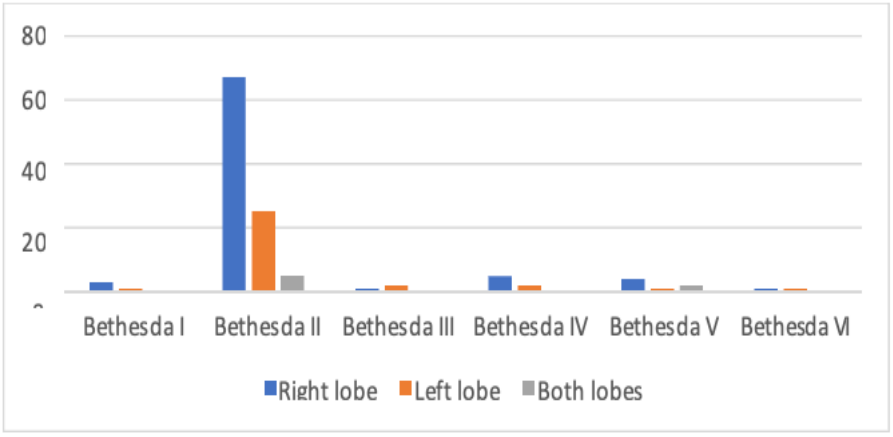
Among the 6 male patients, 5 (83.3%) were Bethesda II and 1 (16.7%) was Bethesda

IV. For the 114 female patients, distribution spanned all categories, with 80.7% being Bethesda II. The chi-square value was 2.09 with a p-value of 0.84, which is not statistically significant, suggesting gender does not significantly influence the Bethesda category distribution

Table 3: Association between thyroid swelling location and Bethesda categories

Locatio n	Bethesd a I	Bethesd a II	Bethesd a III	Bethesd a IV	Bethesd a V	Bethesd a VI	Total
Right Lobe	3 (3.7%)	67 (82.7%)	1 (1.2%)	5 (6.2%)	4 (4.9%)	1 (1.2%)	81(100%)
Left lobe	1 (3.1%)	25 (78.1%)	2 (6.3%)	2 (6.3%)	1 (3.1%)	1 (3.1%)	32(100%)
Both Lobes	0 (0.0%)	5 (71.4%)	0 (0.0%)	0 (0.0%)	2 (28.6%)	0 (0.0%)	7(100%)
Total	4 (3.3%)	97 (80.8%)	3 (2.5%)	7 (5.8%)	7 (5.8%)	2 (1.7%)	120(100%)

Chi-square statistic: 6.91, p-value: 0.73



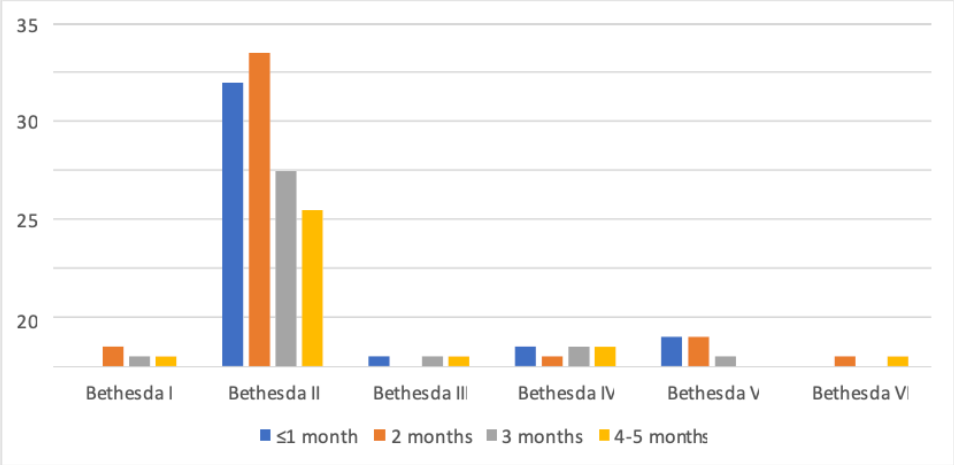
Graph 3: Distribution of Association between thyroid swelling location and Bethesda categories

No significant association was found between thyroid swelling location and Bethesda categories (chi-square 6.91, p-value 0.73). However, bilateral involvement had a higher proportion of Bethesda V cases (28.6%) compared to unilateral involvement, though this did not reach statistical significance.

Table 4: Association between thyroid swelling duration and Bethesda categories

Duratio n	Bethesd a I	Bethesd a II	Bethesd a III	Bethesd a IV	Bethesd a V	Bethesd a VI	Total
≤1 Month	0 (0.0%)	29 (82.9%)	1 (2.9%)	2 (5.7%)	3 (8.6%)	0 (0.0%)	35(100%)
2 months	2 (5.1%)	32 (82.1%)	0 (0.0%)	1 (2.6%)	3 (7.7%)	1 (2.6%)	39(100%)
3 months	1 (4.0%)	20 (80.0%)	1 (4.0%)	2 (8.0%)	1 (4.0%)	0 (0.0%)	25(100%)
4-5 Months	1 (4.8%)	16 (76.2%)	1 (4.8%)	2 (9.5%)	0 (0.0%)	1 (4.8%)	21(100%)
Total	4 (3.3%)	97 (80.8%)	3 (2.5%)	7 (5.8%)	7 (5.8%)	2 (1.7%)	120(100%)

Chi-square statistic: 10.66, p-value: 0.83



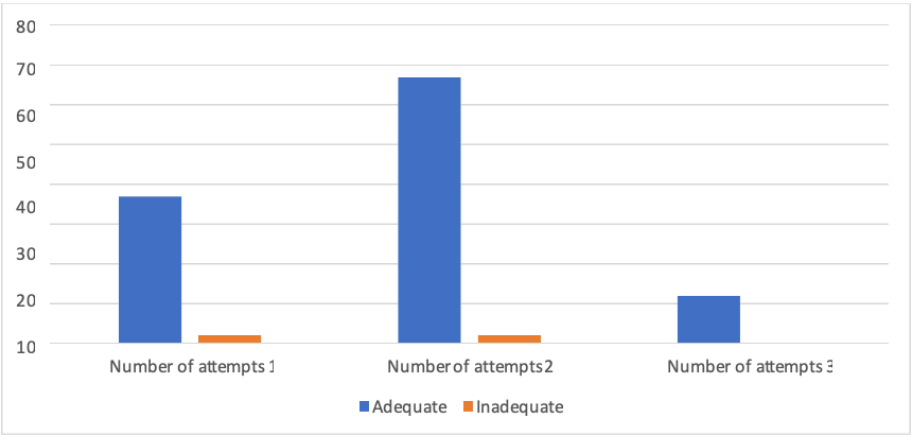
Graph 4: Association between thyroid swelling duration and Bethesda categories

The chi-square value was 10.66 with a p-value of 0.83, indicating no significant association between duration of thyroid swelling and Bethesda category. This suggests that the length of time a patient has had a thyroid swelling does not significantly predict the cytological outcome.

Table 5: Association between number of FNAC attempts and adequacy of sample

Number of attempts	Adequate	Inadequate	Total
1	37 (94.9%)	2 (5.1%)	39 (100%)
2	67 (97.1%)	2 (2.9%)	69 (100%)
3	12 (100.0%)	0 (0.0%)	12 (100%)
Total	116 (96.7%)	4 (3.3%)	120 (100%)

Chi-square statistic: 1.85, p-value: 0.40



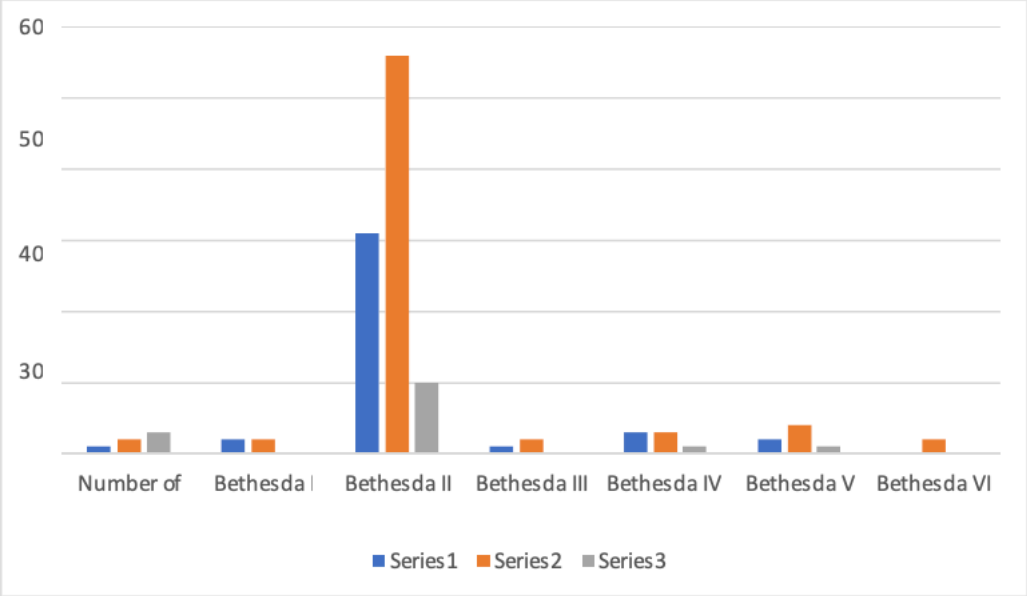
Graph 5: Association between number of FNAC attempts and adequacy of sample

The chi-square value was 1.85 with a p-value of 0.40, which is not statistically significant. This indicates that the number of FNAC attempts did not significantly affect the ultimate adequacy of the sample in this study.

Table 6: Association between number of FNAC attempts and Bethesda categories

Number of attempt s	Bethesd a I	Bethesd a II	Bethesd a III	Bethesd a IV	Bethesd a V	Bethesd a VI	Total
1	2 (5.1%)	31 (79.5%)	1 (2.6%)	3 (7.7%)	2 (5.1%)	0 (0.0%)	39(100%)
2	2 (2.9%)	56 (81.2%)	2 (2.9%)	3 (4.3%)	4 (5.8%)	2 (2.9%)	69(100%)
3	0 (0.0%)	10 (83.3%)	0 (0.0%)	1 (8.3%)	1 (8.3%)	0 (0.0%)	12(100%)
Total	4 (3.3%)	97 (80.8%)	3 (2.5%)	7 (5.8%)	7 (5.8%)	2 (1.7%)	120(100%)

Chi-square statistic: 7.31, p-value: 0.70



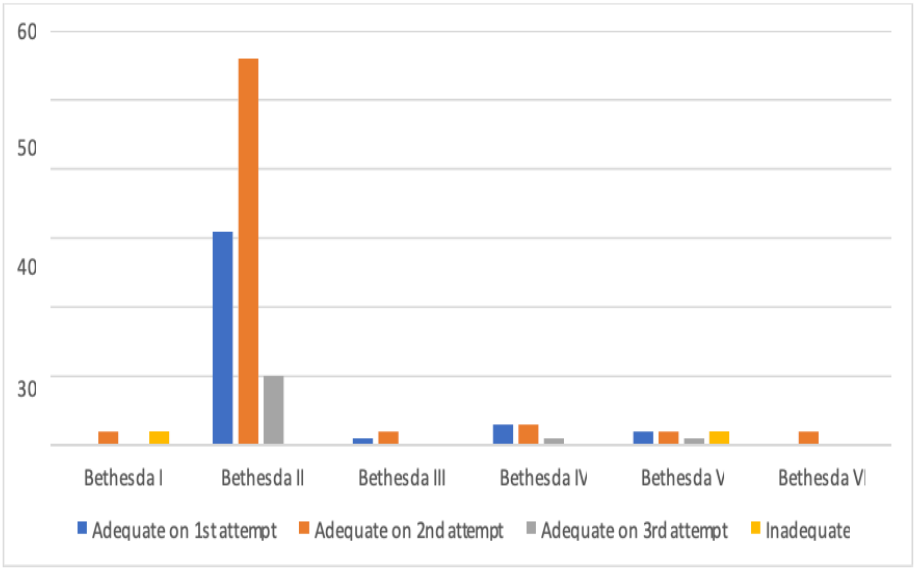
Graph 6: Association between number of FNAC attempts and Bethesda categories

The chi-square value was 7.31 with a p-value of 0.70, indicating no significant association between the number of FNAC attempts and Bethesda category. This suggests that the cytological diagnosis is not significantly influenced by the number of passes required to obtain an adequate sample.

Table 7: Association between ROSE Adequacy Assessment and Final Diagnosis

ROSE Assessment	Bethesd a I	Bethesd a II	Bethesd a III	Bethesd a IV	Bethesd a V	Bethesd a VI	Total
Adequate on1st Attempt	0 (0%)	31 (83.8%)	1 (2.7%)	3 (8.1%)	2 (5.4%)	0 (0%)	37(100%)
Adequate on 2nd Attempt	2 (3.0%)	56 (83.6%)	2 (3.0%)	3 (4.5%)	2 (3.0%)	2 (3.0%)	67(100%)
Adequate On 3rd Attempt	0 (0%)	10 (83.3%)	0 (0%)	1 (8.3%)	1 (8.3%)	0 (0%)	12(100%)
Inadequate	2 (50%)	0 (0%)	0 (0%)	0 (0%)	2 (50%)	0 (0%)	4(100%)

Chi-square value = 52.84, p-value < 0.001 (Statistically significant)



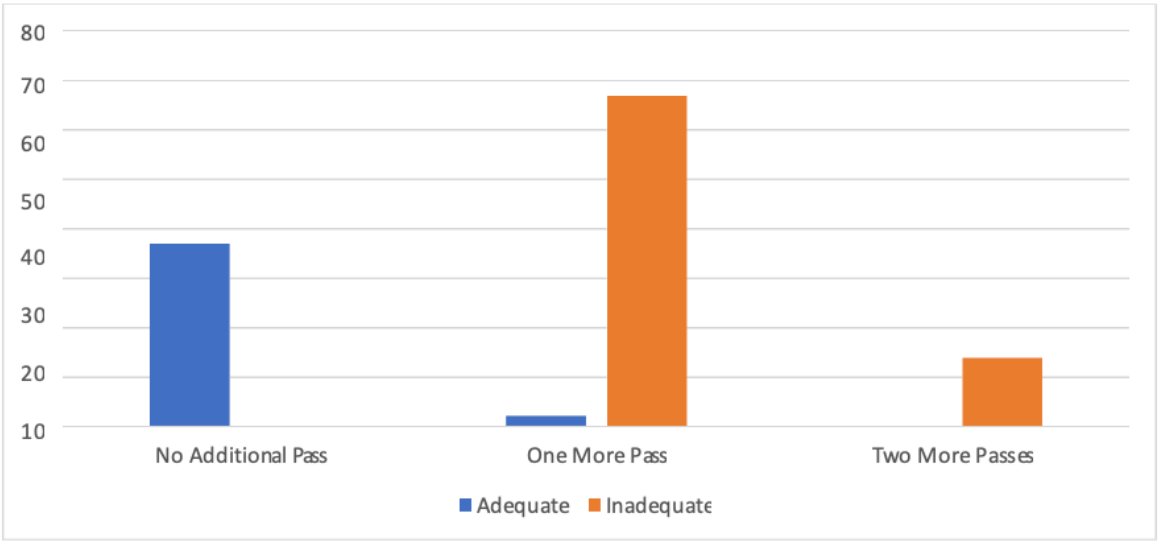
Graph 7: Association between ROSE Adequacy Assessment and Final Diagnosis

Of note, 50% of cases deemed inadequate by ROSE were later classified as Bethesda V (suspicious formalignancy) on H and E stained scantly cellular smear .The chi-square value was 52.84 with a p-value < 0.001, which is highly statistically significant. This demonstrates a strong association between ROSE adequacy assessment and final Bethesda diagnosis.

Table 8. Association between ROSE First Assessment and Number of Additional Passes Required

Initial ROSE Assessment	No Additional Pass	One More Pass	Two More Passes	Total
Adequate	37 (94.9%)	2 (5.1%)	0 (0%)	39 (100%)
Inadequate	0 (0%)	67 (82.7%)	14 (17.3%)	81 (100%)

Chi-square value = 108.92, p-value < 0.001 (Statistically significant)



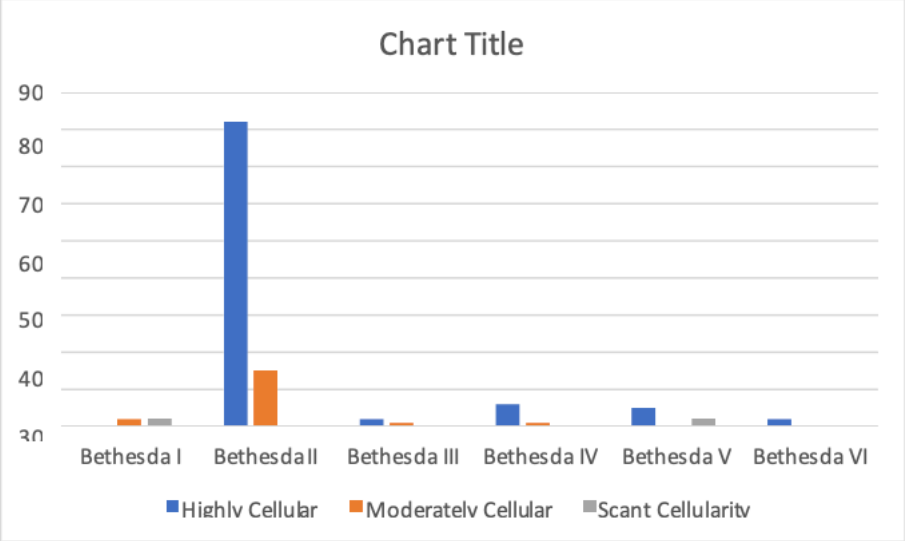
Graph 8: Association between ROSE First Assessment and Number of Additional Passes Required

The chi-square value was 108.92 with a p-value < 0.001, which is highly statistically signific
significant. This demonstrates that the initial ROSE assessment strongly predicts the need for additional sampling, validating its utility in guiding the FNA procedure.

Table 9: Association between ROSE Cellularity Assessment and Final Bethesda Categories

ROSE Cellularity	Non-diagnostic (I)	Benign (II)	AUS/FLUS (III)	FN/SFN (IV)	Suspicious (V)	Malignant (VI)
Highly Cellular	0 (0%)	82 (84.5%)	2 (2.1%)	6 (6.2%)	5 (5.2%)	2 (2.1%)
Moderately Cellular	2 (11.8%)	15 (88.2%)	1 (5.9%)	1 (5.9%)	0 (0%)	0 (0%)
Scant Cellularity	2 (50%)	0 (0%)	0 (0%)	0 (0%)	2 (50%)	0 (0%)

Chi-square value = 45.67, p-value < 0.001 (Statistically significant)



Graph 9: Association between ROSE Cellularity Assessment and Final Bethesda Categories

The chi-square value was 45.67 with a p-value < 0.001, which is highly statistically significant. This indicates a strong association between ROSE cellularity assessment and final Bethesda categorization. Interestingly, specimens with scant cellularity were either non-diagnostic (Bethesda I) or suspicious for malignancy (Bethesda V).

This analysis of 120 thyroid FNAC cases reveals a predominantly female population (95%) with most patients in the 20-39 age group (58.3%). Right lobe involvement (67.5%) was most common, and the majority of cases (80.8%) were benign (Bethesda II). While demographic and clinical variables showed no significant associations with Bethesda categories, the ROSE technique demonstrated highly significant associations ($p < 0.001$) with final outcomes.

The ROSE adequacy assessment strongly predicted both final diagnosis and need for additionalpasses, while ROSE cellularity assessment significantly correlated with final diagnostic categories. These findings highlight ROSE's value in optimizing FNAC procedures by ensuring adequate sampling and potentially reducing unnecessary passes. The high sample adequacy rate (96.7%) and strong concordance between ROSE assessments and final diagnoses support its implementation in routine clinical practice for thyroid swelling evaluation.

Discussion

This pattern differs from several published series, which typically report colloid or nodular goiter as the predominant diagnoses. The high prevalence of lymphocytic thyroiditis in our cohort may reflect regional variations in the epidemiology of autoimmune thyroid disease or differences in referral patterns. Unnikrishnan et al. documented significant geographical variations in the prevalence of thyroid disorders across India, with certain regions showing higher rates of autoimmune thyroiditis. The findings in the present study may thus reflect the specific disease pattern in our geographical area.

When classified according to the Bethesda system, the vast majority of the cases (80.8%) fell into Category II (benign), with the remaining cases distributed across the other categories.

Table 10: Comparison of Cytological Diagnoses with Other Studies

Diagnosis	Present Study (%)	Sikder et al. [13] (%)	Chandanwale et al. [14] (%)	Mangshetty et al. [15] (%)	Sharma et al. [16] (%)	Abdullah et al. [17] (%)
Lymphocytic thyroiditis	34.2	8.3	9.2	13.5	16.5	10.8
Colloid goiter	15.0	42.8	77.0	54.5	36.7	61.2
Nodular goiter	13.3	30.4	*	11.8	22.5	*
Adenomatous hyperplasia	10.8	2.8	4.6	5.6	7.8	6.4
Follicular neoplasm	5.8	4.6	3.2	6.2	6.9	5.3
Suspicious for malignancy	5.8	3.7	2.4	3.4	2.8	4.6
Malignant	1.7	6.5	2.2	3.9	6.4	5.7
Inadequate	3.3	10.6	9.5	9.6	7.3	6.0

*Included in colloid goiter category

Table 11: Comparison of Bethesda Categories Distribution

Bethesda Category	Present Study (%)	Mehra & Verma [6] (%)	Theoharis et al. [18] (%)	Bongiovanni et al. [19] (%)	Krauss et al. [20] (%)	Wong et al. [21] (%)
I(Non - diagnostic)	3.3	7.7	11.1	13.0	11.6	9.8
II (Benign)	80.8	75.8	73.8	59.3	65.3	72.6
III (AUS/FLUS)	2.5	4.2	3.0	9.6	9.5	4.9
IV (FN/SFN)	5.8	9.3	5.5	10.1	5.4	4.7
V (Suspicious)	5.8	1.9	1.3	2.7	2.9	2.1
VI (Malignant)	1.7	1.1	5.2	5.4	5.3	5.9

This distribution is broadly comparable to that reported in other studies, though with some notable differences. The higher proportion of benign cases (80.8%) compared to the meta-analysis by Bongiovanni et al. (59.3%) might reflect differences in referral patterns or the prevalence of thyroid pathologies in the study population.

The combined proportion of potentially neoplastic categories (Bethesda III through VI) in the present study was 15.8%, with suspicious for malignancy (Bethesda V) and follicular neoplasm (Bethesda IV) each accounting for 5.8% of cases. This is broadly consistent with findings by Mehra and Verma, who reported a combined proportionof 16.5% for these categories in their two-year prospective study. However, our proportion of malignant cases (Bethesda VI, 1.7%) is lower than the 5-10% typically reported in the literature. The lower rate in the series of the present study may reflect variations in the prevalence of thyroid malignancy across different geographical regions or differences in the threshold for classifying cases as frankly malignant rather than suspicious.

ROSE Implementation and Impact

One of the most significant findings in this study was the strong association between ROSE parameters and final cytological outcomes. The ROSE adequacy assessment showed a highly significant correlation with final Bethesda diagnosis ($p < 0.001$), and the initial ROSE assessment strongly predicted the need for additional passes ($p < 0.001$).

Table 12: Comparison of ROSE Impact on FNAC Outcomes

Study	Year	Sample Size	Post-ROSE Inadequacy (%)	Statistical Significance
Present study	2024	120	3.3	$p < 0.001$
Witt and Schmidt [22]	2013	834	8.6	$p < 0.001$
Zhu and Michael [23]	2013	1,024	7.0	$p < 0.01$
Yang et al. [24]	2001	1,135	7.0	$p < 0.001$
Collins et al. [25]	2013	1,412	5.5	$p < 0.01$
Da Cunha Santos et al. [26]	2013	940	13.0	$p < 0.001$

The utility of ROSE in thyroid FNAC has been increasingly recognized in recent years, with multiple studies demonstrating significant improvements in sample adequacy rates after implementing this technique.

A particularly noteworthy finding in this study was that 50% of cases deemed inadequate by ROSE were ultimately classified as Bethesda V (suspicious for malignancy). This observation suggests that some malignant or suspicious lesions may be inherently difficult to sample adequately, possibly due to fibrosis, necrosis, or cystic change. Similar observations have been made by other investigators

Table 13: Comparison of Inadequacy Rates in Malignant vs. Benign Lesions

Study	Year	Sample Size	Inadequacy in Benign Lesions (%)	Inadequacy n Malignant/ Suspicious Lesions (%)	p-value
Present Study	2024	120	0	50.0	< 0.001
Schmidt et al. [27]	2012	674	7.2	23.0	< 0.01
Wu et al. [28]	2012	1,382	15.1	22.6	< 0.05
Olson et al. [29]	2013	423	8.9	18.7	< 0.05
Renshaw et al. [30]	2006	1,147	10.2	20.1	< 0.05
Krauss et al. [31]	2016	21,272	9.4	17.3	< 0.01

These findings highlight the importance of clinical correlation and potential repeat sampling in cases where ROSE suggests inadequacy despite strong clinical suspicion of malignancy.

The significant association between ROSE cellularity assessment and final Bethesda categories ($p < 0.001$) in the present study further validates the predictive value of ROSE

Interestingly, specimens with scant cellularity showed a bimodal distribution, being either non-diagnostic (Bethesda I) or suspicious for malignancy (Bethesda V). This pattern has been observed by other investigators. Olson et al. noted that scant samples from papillary thyroid carcinoma often contained diagnostic nuclear features despite limited cellularity, while Renshaw et al. described the characteristic finding of "thyroid paucicellular atypical cells" in some malignant lesions. These observations emphasize that cellularity alone is an imperfect predictor of finaldiagnosis and that careful cytomorphologic examination is essential even in specimens with limited cellularity.

The present study demonstrated no significant associations between Bethesda categories and variables such as age group, gender, thyroid swelling location, or duration of swelling. This finding suggests that clinical and demographic factors have limited predictive value for cytological outcomes. Similar conclusions were reached by Kaliszewski et al. who found no significant correlations between clinical features and cytological results in their analysis of 1,424 thyroid FNACs. These observations highlight the limitations of clinical assessment alone in predicting thyroid pathology and underscore the importance of cytological evaluation in all thyroid nodules, regardless of clinical characteristics.

Comparison with Other Thyroid FNAC Studies

When comparing the present study with those of similar studies, several points of concordance and divergence emerge. The overall Bethesda category distribution in the present study shows some variations from the distributions reported in other studies, as shown in .

The lower rate of non-diagnostic samples (Category I, 3.3%) compared to many published series is likely attributable to the implementation of ROSE, which has been shown to reduce inadequacy rates in multiple studies. The relatively low proportion of Bethesda III cases (atypia of undetermined significance, 2.5%) in the present study suggests a conservative approach to the diagnostic category, which is consistent with recommendations to limit its use to minimize diagnostic uncertainty. The Bethesda consensus document suggests that this category should ideally be used in less than 7% of all thyroid FNACs [8], and our rate falls well within this guideline

The proportion of potentially neoplastic categories (Bethesda IV-VI) in the series of present study (13.3%) is comparable to the range of 10-20% typically reported in the literature. Hambleton and Kandil reported a range of 15-30% for these categories in their review, while Abdullah et al. found a combined proportion of 14.3% in their analysis of 1,385 thyroid FNACs. The fact that the findings in the present study align with these established ranges supports the validity of cytological assessments and suggests that the study population is representative of the broader spectrum of thyroid pathology.

Bethesda System and Risk of Malignancy

While the present study did not include

histopathological correlation to determine the actual risk of malignancy (ROM) for each Bethesda category, it is worth discussing the established ROM for these categories based on the literature

Table 14: Comparison of Risk of Malignancy (ROM) in Bethesda Categories

Bethesda Category	Bethesda System 2017 [8] (%)	Krauss et al. [31] (%)	Wong et al. [21] (%)	Bongiovanni et al. [19] (%)	Theoharis et al. [18] (%)	Nayar & Ivanovic [Meta-analysis] (%)
I (Non-diagnostic)	5-10	12.0	10.7	16.8	9.0	20.0
II (Benign)	0-3	4.5	4.2	3.7	2.0	2.5
III (AUS/FLUS)	10-30	19.2	12.8	15.9	24.0	14.0
IV (FN/SFN)	25-40	26.6	29.6	26.1	28.0	34.0
V (Suspicious)	50-75	75.0	79.2	75.2	87.0	70.0
VI (Malignant)	97-99	97.8	97.3	98.6	100.0	99.0

These established risk profiles guide clinical management decisions for each Bethesda category, with benign cases (Category II) typically managed conservatively, indeterminate categories (III and IV) often subjected to molecular testing or diagnostic lobectomy, and suspicious or malignant categories (V and VI) generally proceeding to definitive surgical management. The distribution of Bethesda categories in our series, with the majority falling into Category II (80.8%), suggests that most of our patients would be candidates for conservative management. However, the 15.8% of cases in Categories III through VI represent a significant proportion requiring further evaluation or intervention

ROSE Technique:

Advantages and Limitations: The significant associations between ROSE parameters and final outcomes in the present study highlight the advantages of this technique in thyroid FNAC. ROSE offers several benefits, including immediate assessment of sample adequacy, reduction in inadequacy rates, decreased need for repeat procedures, and optimization of specimen collection for ancillary studies.

Table 15: Comparison of ROSE Advantages and Implementation

Study	Year	Sample Size	Main Advantage of ROSE	Concordance with Final Diagnosis (%)	Cost-Effective
Present study	2024	120	Improved adequacy	96.7	Yes
Nasuti et al. [32]	2011	182	Fewer passes	87.0	Yes
Da Cunha Santos et al. [26]	2013	940	Improved adequacy	82.0	Yes
Schmidt et al. [27]	2012	674	Better triage	95.0 (major), 58.0 (complete)	*
Zanocco et al. [33]	2013	1,502	Fewer procedures	*	Yes, if baseline inadequacy >17%
Collins et al. [25]	2013	1,412	Reduced repeats	90.2	Yes

Despite these advantages, ROSE is not universally implemented due to certain limitations, including the need for on-site cytopathology expertise, time constraints, potential discordance between preliminary and final interpretations, and additional cost. Schmidt et al. noted that ROSE interpretations were fully concordant with final diagnoses in only 58% of thyroid FNACs, with minor discrepancies in 37% and major discrepancies in 5%. However, most discrepancies involved refinement of diagnoses rather than complete changes in diagnostic category.

The resource implications of ROSE must also be considered. A cost-effectiveness analysis by Zanocco et al. found that ROSE was cost-effective for thyroid FNAC when the baseline inadequacy rate exceeded 17%. Given the high adequacy rate (96.7%) and the significant associations between ROSE parameters and final outcomes, the experience suggests that ROSE provides substantial clinical value that may justify the additional resources required for its implementation.

Clinical Implications and Future Directions: The findings in the present study have several important clinical implications. First, the high adequacy rate achieved with ROSE supports its routine implementation in thyroid FNAC practice. Second, the strong association between ROSE parameters and final outcomes validates the reliability of preliminary on-site assessments and their utility in

guiding further management. Third, the absence of significant associations between clinical features and cytological outcomes underscores the limitations of clinical assessment alone and the importance of cytological evaluation in all thyroid nodules.

Looking to the future, several avenues for further research emerge from the present study . Molecular testing of thyroid FNAC specimens has emerged as a valuable adjunct to cytomorphologic evaluation, particularly for indeterminate categories (Bethesda III and IV). Nikiforov et al. [104] demonstrated that molecular testing could refine the risk assessment for these categories, with a negative predictive value of 94-95% and a positive predictive value of 37-38% for their gene expression classifier. Investigation of how ROSE might optimize specimen collection for molecular testing represents an important area for future research.

The integration of ROSE with ultrasound guidance is another promising direction. Ultrasound guidance has been shown to improve the accuracy of thyroid FNAC, with Cesur et al. reporting an increase in sensitivity from 85% to 98% with its use. The combined implementation of ultrasound guidance and ROSE might further enhance the diagnostic yield of thyroid FNAC, particularly for small or deep-seated nodules.

Finally, the potential role of artificial intelligence in ROSE deserves exploration. Automated image analysis systems are being developed for cytological interpretation, with Wang et al. reporting a diagnostic accuracy of 92.8% for their deep learning algorithm in thyroid cytology. Such systems might eventually support or partially replace human interpretationin ROSE, potentially expanding its accessibility in resource-limited settings.

Conclusion

This comprehensive analysis of 120 thyroid Fine-Needle Aspiration Cytology (FNAC) cases demonstrates the effectiveness and reliability of FNAC with Rapid On-Site Evaluation (ROSE) for evaluating thyroid swellings. The demographic profile of our cohort shows a striking female predominance (95.0%) and peak incidence in young to middle-aged adults (58.3% in 20-39 years), consistent with established epidemiological patterns of thyroid disorders.

The implementation of ROSE significantly enhanced the diagnostic yield of FNAC, as evidenced by the high sample adequacy rate (96.7%) and the highly significant associations between ROSE parameters and final outcomes ($p<0.001$). The initial ROSE assessment strongly predicted the need for additional sampling, potentially reducing patient discomfort and procedure time by minimizing unnecessary passes. The strong correlation between ROSE cellularity assessment and final Bethesda categories validates the reliability of preliminary on-site assessments.

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