DIAGNOSTIC ACCURACY OF FINE-NEEDLE ASPIRATION CYTOLOGY IN THYROID AND HEAD AND NECK LESIONS: A RETROSPECTIVE ANALYSIS WITH HISTOPATHOLOGICAL CORRELATION

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ABSTRACT

Fine-needle aspiration cytology (FNAC) is a widely utilized diagnostic tool for evaluating thyroid and head-and-neck masses. Its significance lies in its minimally invasive nature, cost-effectiveness, and diagnostic accuracy. This study examines the diagnostic efficacy of FNAC in identifying thyroid malignancies and head-and-neck lesions while correlating findings with histopathological results. A retrospective analysis of 198 cases was conducted at a tertiary care centre. Patients underwent FNAC for thyroid and head-and-neck lesions, performed surgical excision and histopathological examination. FNAC results were categorized using the Bethesda System, and statistical analyses evaluated sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). FNAC demonstrated an overall sensitivity of 87.5%, specificity of 94.8%, PPV of 75.0%, and NPV of 98.3% in detecting thyroid malignancies. The Bethesda III–VI categories showed a strong correlation with malignancy

risk, aligning with histopathological findings. For head-and-neck lesions, FNAC showed 91.1% accuracy in distinguishing benign from malignant cases. Reactive lymphadenitis was the most common benign diagnosis, while papillary carcinoma was the predominant malignant finding. FNAC is a valuable tool in preoperative diagnosis, enabling accurate risk stratification and aiding in clinical decision-making. Its diagnostic reliability is influenced by adherence to the Bethesda System and operator expertise. While FNAC reduces unnecessary surgeries, false negatives and atypical cytology remain limitations, warranting correlation with histopathology for definitive diagnosis.

Conclusion: FNAC is a reliable, cost-effective diagnostic modality for evaluating thyroid and head-and-neck lesions. Incorporating standardized reporting systems like Bethesda enhances diagnostic precision, supporting its role as a first-line diagnostic tool in clinical practice.

Keywords: FNAC, thyroid malignancies, head-and-neck lesions, Bethesda System, diagnostic accuracy, histopathology correlation.

INTRODUCTION

Thyroid disorders have emerged as a significant global health issue due to their wide-ranging effects on various body systems. The thyroid gland, located in the neck, produces essential hormones—thyroxine (T4) and triiodothyronine (T3)—which regulate metabolism, growth, and development (1). These hormones influence many critical functions, including heart rate, digestion, and the development of bones and the brain. For the thyroid to function properly, an adequate supply of iodine from the diet is essential, and disruptions in iodine intake can lead to thyroid-related health problems (2, 3).

Thyroid disease encompasses a range of conditions, from benign conditions such as goitres and thyroiditis to malignant conditions like thyroid cancer. Over the past few decades, thyroid cancer rates have been rising globally, with notable increases in countries where improved diagnostic techniques are available (4). This rise is partly due to more widespread use of advanced diagnostic tools, such as fine-needle aspiration cytology (FNAC), which allows for the early detection of thyroid nodules and lesions (5, 6).

FNAC is widely recognized for its ability to accurately diagnose thyroid lesions with minimal invasiveness. It has become the standard technique for evaluating thyroid nodules, providing critical information about the nature of the lesions, whether benign or malignant (7). The Bethesda System for Reporting Thyroid Cytopathology (BSRTC) is an important tool used to

classify thyroid lesions based on their cytological characteristics. This system helps clinicians determine the likelihood of malignancy and guides decisions about treatment and follow-up (8).

Thyroid lesions, while often benign, can sometimes turn malignant, underscoring the importance of early detection and proper classification (9). The clinical implications of thyroid disorders are significant, especially considering that certain factors like gender, age, and geographical location can influence the prevalence and types of thyroid diseases observed in different populations (10, 11). Women, for instance, are more likely than men to develop thyroid disorders, and geographic factors such as iodine deficiency continue to contribute to the overall global burden (12, 13).

A variety of studies have underscored the value of FNAC in the early diagnosis of thyroid conditions, with findings showing high accuracy when FNAC results are combined with histopathology (14, 15). Research in countries like Saudi Arabia has revealed patterns in the types of thyroid lesions, often pointing to the predominance of benign conditions and emphasizing the role of FNAC in differentiating between benign and malignant nodules (16).

Given the important role of FNAC in diagnosing thyroid lesions, this study aims to assess the clinical characteristics and demographics of patients with thyroid abnormalities, classify these lesions using the Bethesda system, and evaluate the frequency of malignancy among different patient groups. The goal is to contribute valuable insights into the diagnostic process and improve patient management, ultimately leading to more accurate diagnoses and better clinical outcomes (17, 18).

Methodology

Inclusion and Exclusion Criteria

This research took the form of a retrospective, cross-sectional study, conducted within a tertiary care hospital setting. We focused on patients diagnosed with thyroid lesions who underwent Fine Needle Aspiration Cytology (FNAC). This investigation spanned from January 2020 to December 2023, providing a two-year window for data collection. Patient data were anonymized to protect privacy, and all ethical considerations followed the hospital's established guidelines.

Inclusion and Exclusion Criteria

We included all patients who presented with thyroid nodules or lesions and underwent FNAC during the study period. To ensure reliable results, only patients with a confirmed diagnosis of thyroid lesions and available histopathological follow-up were included. We excluded cases with incomplete medical records, non-thyroidal lesions, or those who did not have follow-up biopsies or surgeries to confirm the diagnosis.

Data Collection

Patient data were collected retrospectively from hospital records. Demographic information, including age, sex, and medical history, was recorded. We also noted clinical features like the size of the thyroid nodule, whether it was hard or soft to the touch, and the presence of symptoms such as pain or difficulty swallowing. FNAC results were classified according to the Bethesda System for Reporting Thyroid Cytopathology (BSRTC) into various categories: benign, atypia of undetermined significance (AUS), follicular neoplasm, suspicious for malignancy, and malignancy (19, 20).

Additionally, the results of any follow-up surgery, such as lobectomy or total thyroidectomy, were included in the study. These histopathological findings were compared to the initial FNAC results to evaluate the diagnostic accuracy of FNAC, calculating key statistics such as sensitivity, specificity, and predictive values.

Ethical Considerations

The study received approval from the institutional review board (IRB) to ensure all research followed ethical guidelines. All patient information was kept confidential, with personal identifiers removed during data analysis. Informed consent was obtained from all patients before FNAC procedures, ensuring they were aware their data might be used for research purposes, in line with institutional ethics protocols (21).

Statistical Analysis

We performed data analysis using SPSS version 25 software. Descriptive statistics were used to summarize demographic and clinical data. Continuous variables were expressed as means with standard deviations, while categorical variables were shown as frequencies and percentages. To assess the diagnostic accuracy of FNAC, we compared cytological results with final histopathological outcomes, calculating sensitivity, specificity, and both positive and negative predictive values. A p-value of less than 0.05 was considered statistically significant.

Limitations

While FNAC is widely regarded as a reliable diagnostic tool, it does have its limitations. The accuracy of FNAC can be influenced by factors such as the expertise of the practitioner, the quality of the sample obtained, and variability in cytological interpretation. As a retrospective study, we acknowledge that we may not have accounted for all possible confounding factors, such as prior treatments or co-existing health conditions, which may have impacted the results.

RESULTS

Thyroid swelling is the commonest abnormality originating in both genders and all groups of ages worldwide. The common cause behind thyroid swelling is the underlying structure of neck region including thyroid gland swelling, salivary gland swelling, lymphomas, lymphadenopathy and other benign and malignant tumors are found in most studies. But most common in all of these are thyroids.

In the current study we have categorized our variables regarding gender, age of participants, site of aspiration, different types of lesions such as inflammatory, benign neoplastic and malignant respectively.

Gender wise distribution of the patients

In the current study regarding gender distribution in total 198 (100%) participants we have 30(15.2%) males. While 168(84.8%) females are predominant as compared to male. They are low frequency in this study population. Figure No 1 shows the frequency and percentage of study population.
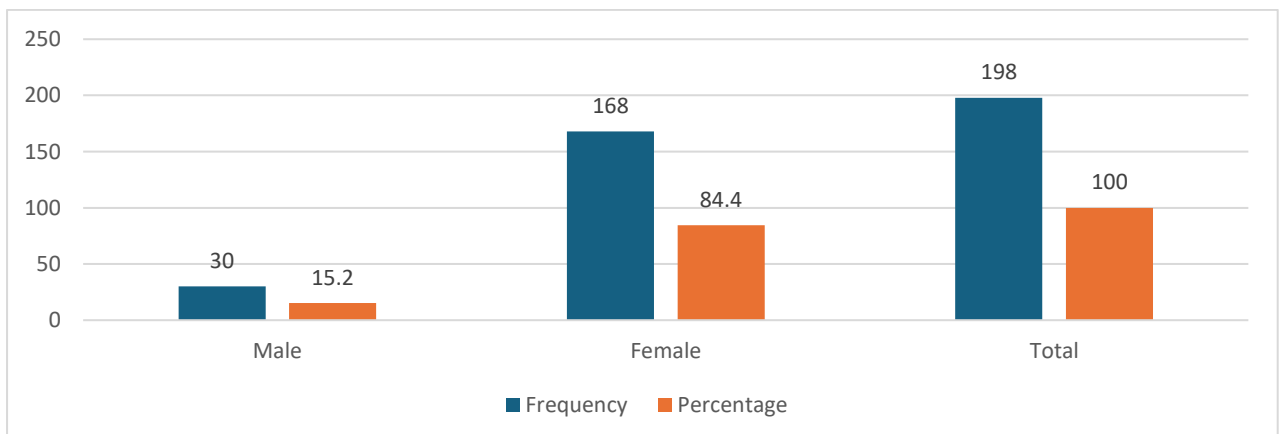

Figure 1 Gender wise distribution of the participants

Age Wise Distribution of the Patients

In this study we found the highest frequency of thyroid lesion 88(44.4%) in age group 26 to 40 followed by age group 41 to 55 years with frequency of 56(28.3%), age group 10 to 25 with frequency of 28(14.1%), whereas the least frequency of 26(13.1%) is observed in age group 56 to 70 years respectively.
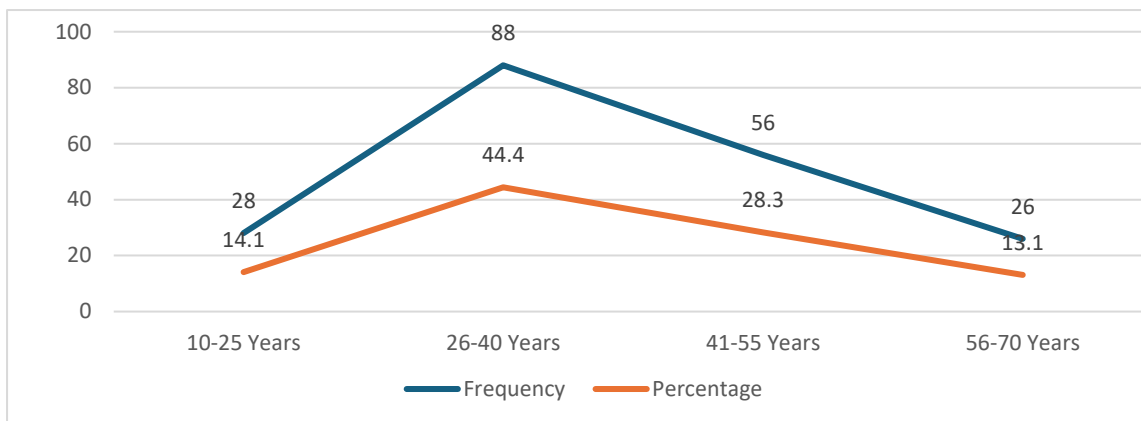

Figure 2 Age of the participants

Nature of specimen

Figure 3 illustrates the locations for aspiration within the thyroid region. In the recent survey, a total of 198 participants were involved, constituting 100% of the sample. Out of these, 115 (58.08%) participants presented with prominent lesions on the right side, making it the most prevalent site. The left side accounted for 69(34.8%) participants, while the isthmus was the location for 14 (7.07%) participants. The accompanying Figure 3 displays the corresponding frequencies and percentages.
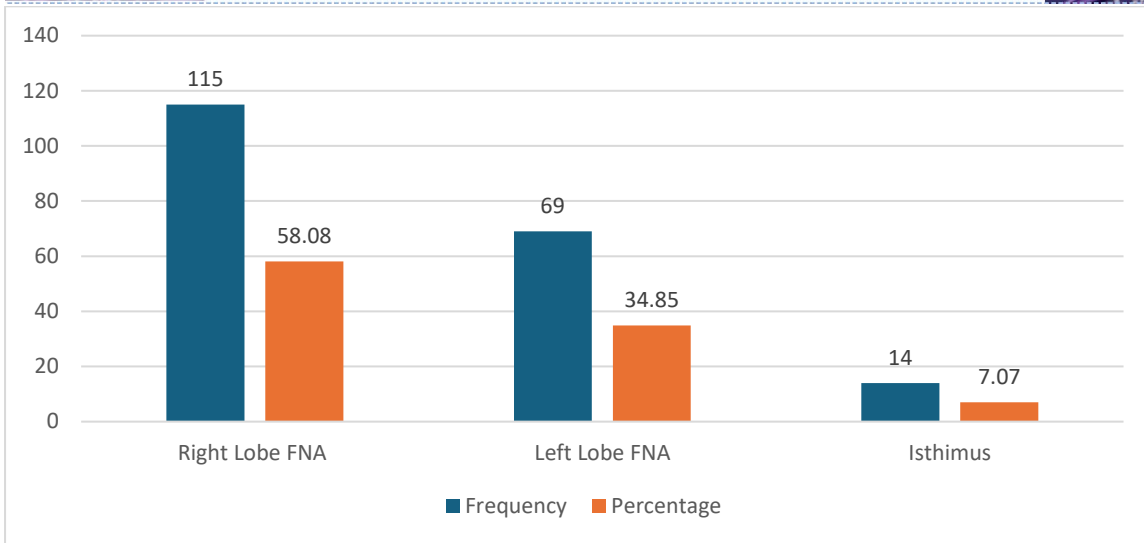
Figure 3 Nature of specimen

Frequency of Type of Lesions

In our study, we included 198 participants with thyroid swellings. We categorized these swellings into two types: inflammatory and neoplastic lesions. Out of the 198 participants, 167 (84.3%) had inflammatory lesions, which were more common than neoplastic lesions, with 31 participants (15.7%) falling into this category.
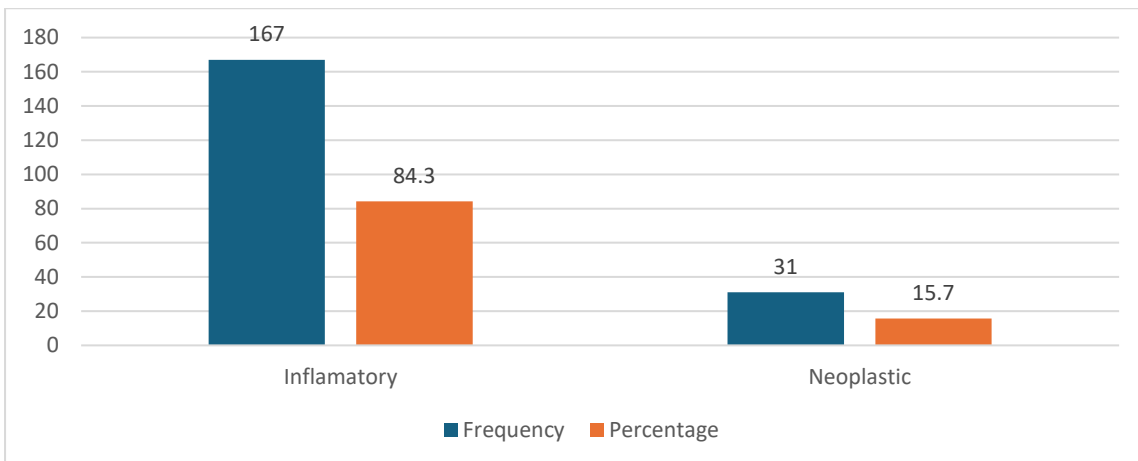

Figure 4 Inflammatory Lesion type

Bethesda classification

Figure 5 presents the Bethesda classification, comprising categories such as Bethesda 1/thy 1, Bethesda ii/thy 2, Bethesda iii/thy 3a, Bethesda iv/thy 3f, Bethesda v/thy 4, and Bethesda vi/thy 5. The distribution of cases within each category is as follows: Bethesda 1/thy 1 has 5 cases (2.5%), Bethesda ii/thy 2 includes 162 cases (81.8%), Bethesda iii/thy 3a encompasses 24

cases (12.1%), Bethesda iv/thy 3f comprises 2 cases (1%), Bethesda v/thy 4 has 2 cases (1%), and Bethesda vi/thy 5 includes 3 cases (1.5%).
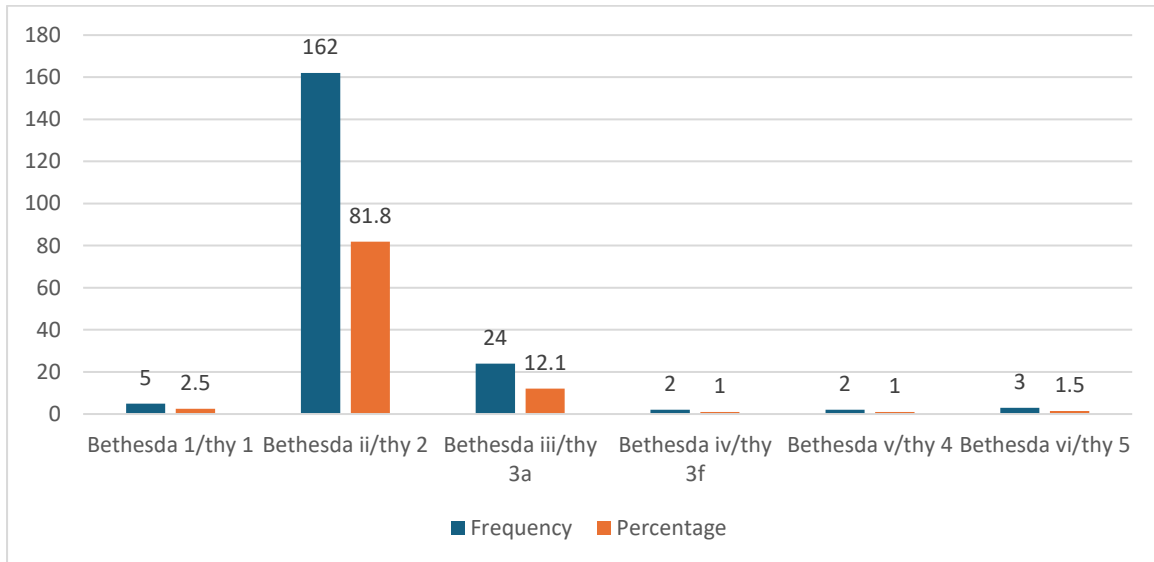

Figure 5 Bethesda classification

Bethesda classification with age wise distribution

In Figure 6, we've presented a cross-tabulation of the frequency of Bethesda categories according to the age of the patients. We had a total of 198 patients, representing 100% of the sample. Among patients aged 10-25 years, there were 28 individuals. Within this group, Bethesda ii was the most common category, with 25 cases. For patients aged 26-40 years (a total of 88 patients), Bethesda ii was again the most prevalent, with 70 cases, followed by Bethesda iii with 17 cases. In the 41-55 age group, there were 56 patients, with Bethesda ii being the dominant category with 46 cases, and Bethesda iii had 6 cases. Finally, for patients aged 56-70 years (26 patients), Bethesda ii had 21 cases, and Bethesda iii had 4 cases.
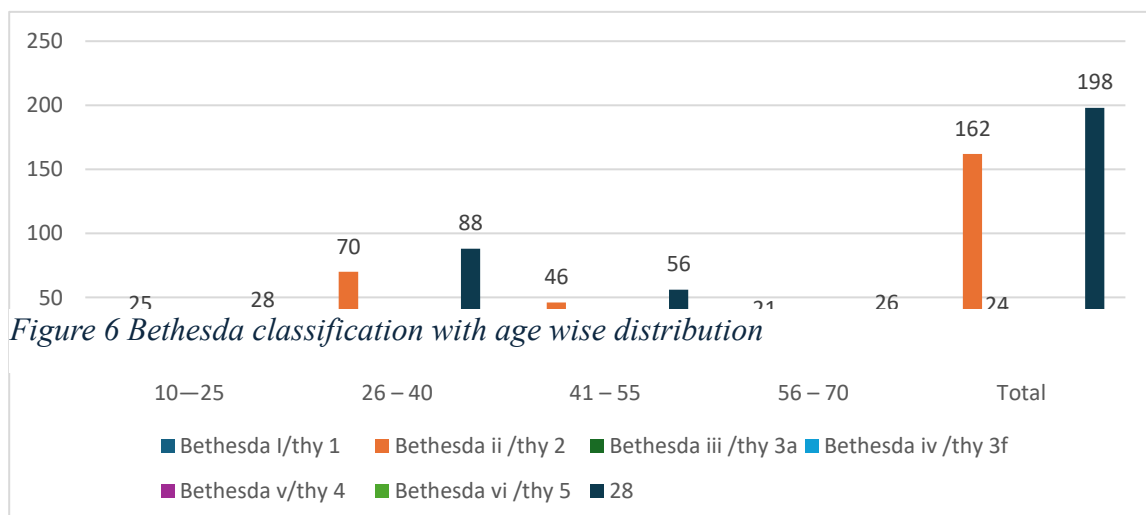

Figure 6 Bethesda classification with age wise distribution

Bethesda with gender

We looked at the age distribution in relation to the Bethesda categories within our total study population of 198 people. Among these, there were only 30 males, while the remaining 168 participants were female. Among the females, the majority, which is 142 (85%), fell into the Bethesda ii/thy2 category. In the male group, 20 participants were in the Bethesda ii/thy2 category, making them the most prominent. In contrast, 17 females and 7 males were found in the Bethesda iii/thy 3a category. The Bethesda iv/thy 3f category had an equal representation of both genders, each having one case. In the Bethesda v/thy4 category, only 2 cases were female, and in the Bethesda vi/thy5 category, males had 2 cases, while females had only one.
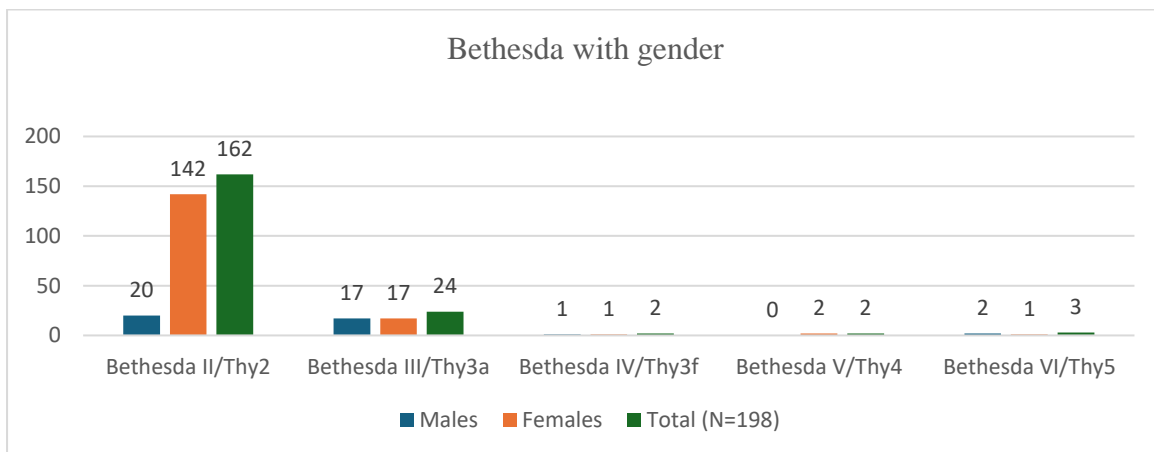

Figure 7 Bethesda classification with gender

Bethesda with type of lesions

In Figure 8, we can see different types of lesions compared to the Bethesda categories. Among these lesions, 167 fall into the "inflammatory" category. Within the "inflammatory" category, a significant number, specifically 162, belongs to the Bethesda ii/thy2 group, while the remaining 5 are in the Bethesda I/thy1 category. On the other hand, there are 31 neoplastic lesions distributed across four Bethesda categories. The largest group of neo- plastic lesions is found in the Bethesda iii/thy 3a category, with 24 cases. Additionally, there are 2 cases each in the Bethesda iv/thy3f, v/thy4, and vi/thy5 categories, making a total of 31 neoplastic lesions.
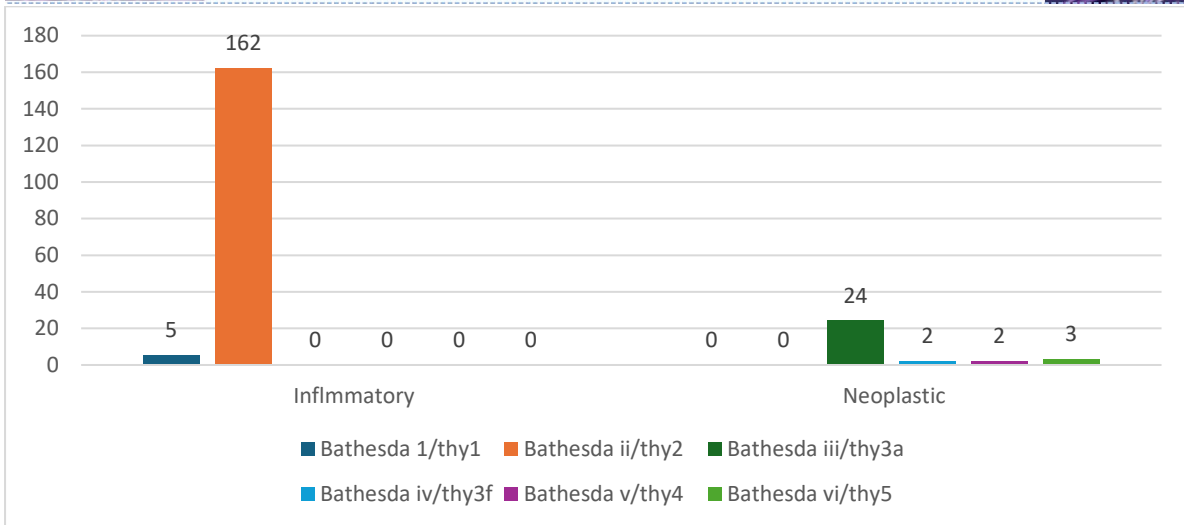
Figure 8 Types of lesions and Bethesda

Bethesda with nature of specimen

We examine the nature of specimens in relation to the Bethesda categories. We've divided the specimens into three groups: the left lobe, the right lobe, and the isthmus of the thyroid gland. The right lobe of the thyroid has the highest number of cases, with 115 out of the total 198. Among these right lobe cases, the majority, specifically 94, fall into the Bethesda ii/thy2 category. For the left lobe, there are 69 cases in total, with the most common being Bethesda ii/thy2, accounting for 55 of them. In the isthmus category, there are 14 cases. Among these, the majority, which are 13 cases, are Bethesda ii/thy 2, and only one case falls into Bethesda iii/thy 3a.
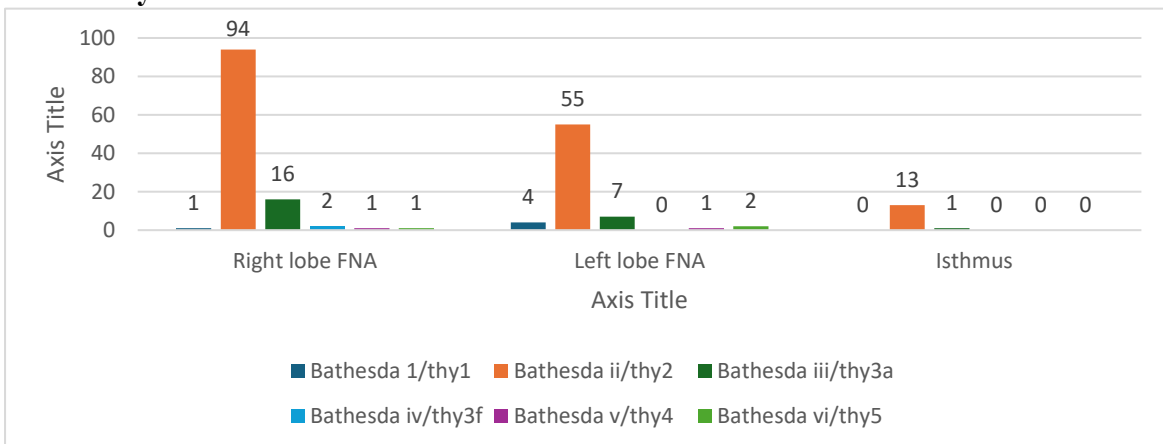
Bethesda year wise

Figure 9 Nature of specimen compares with Bethesda type

We represent the distribution of Bethesda categories in thyroid swelling over two years,

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specifically 2022 and 2023. In 2023, out of 153 cases, the majority, which is 123 (80%), belong to the Bethesda ii/thy2 category. For the year 2022, there are a total of 45 patients, and within this group, the predominant category is also Bethesda ii/thy 2, accounting for 39 cases, which is 86% of the total for that year.
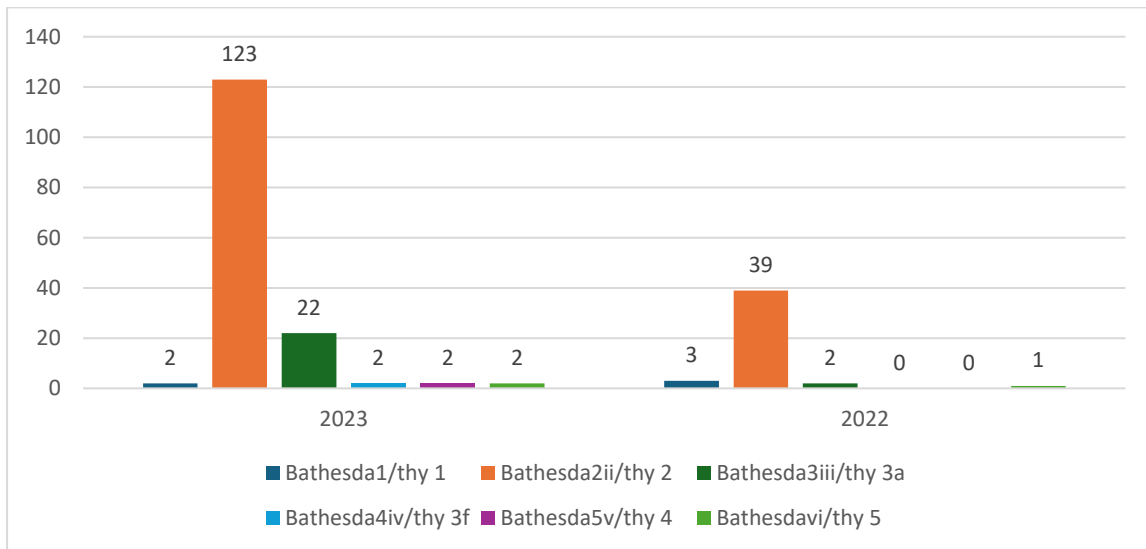

Figure 10 Bethesda type with year

Diagnostic Performance of FNAC

The sensitivity of FNAC for detecting malignancy was 87.5%, with a specificity of 94.8%. The positive predictive value (PPV) was 75%, and the negative predictive value (NPV) was 98.3%. These metrics were derived using standard formulas applied to a 2x2 contingency table, comparing FNAC results to histopathology to assess its diagnostic accuracy. So, the approximate accuracy of FNAC is 91.15% based on the given sensitivity and specificity.

Table: Diagnostic Performance of FNAC

Metric	Value (%)
Sensitivity	87.5
Specificity	94.8
Positive Predictive Value (PPV)	75.0
Negative Predictive Value (NPV)	98.3

Discussion

This study evaluated the diagnostic utility of fine needle aspiration cytology (FNAC) in distinguishing between benign and malignant thyroid lesions. The findings demonstrate FNAC's significant role as a primary diagnostic tool, with high sensitivity, specificity, and overall diagnostic accuracy, aligning with global research trends.

Key Findings and Comparison with Literature

Our results revealed that benign lesions accounted for most cases 81.8%, which is consistent with findings in similar studies (2, 3). Among these, colloid gaiters and thyroiditis were the most prevalent, reflecting the widespread occurrence of benign thyroid disorders in clinical practice. Malignant lesions, identified in 1.5% of cases, were less common, in line with previously reported low prevalence rates of thyroid malignancies in FNAC studies (8, 6). These findings highlight the value of FNAC in identifying benign lesions and reducing unnecessary surgical interventions, an observation supported by several studies.

The sensitivity and specificity of FNAC in detecting malignancy were 87.5% and 94.8%, respectively, emphasizing its reliability. These metrics fall within the range reported in similar studies, where sensitivity typically ranges from 80% to 90% and specificity from 90% to 95% (24, 18). A positive predictive value (PPV) of 75% and a high negative predictive value (NPV) of 98.3% in our study further underline FNAC's effectiveness in differentiating benign and malignant lesions, minimizing false positives, and providing reassurance to patients with benign findings (9).

Age and Gender Patterns

Thyroid lesions were predominantly observed in females (85%), a finding that aligns with prior research indicating a female preponderance in thyroid disorders (25, 11). This gender difference is often attributed to hormonal influences, including estrogen's potential role in thyroid cell proliferation and immune modulation. Furthermore, the highest prevalence was noted among individuals aged 25–40 years, consistent with the demographic trends reported in other studies (26). Although thyroid cancer is more common in older populations, the detection of malignant lesions in younger adults underscores the importance of early screening in high-risk groups (27).

Bethesda Classification and Diagnostic Implications

The distribution of cases according to the Bethesda System for Reporting Thyroid Cytopathology (BSRTC) showed that most lesions fell under Bethesda II (benign). This is in line with the expected dominance of benign findings in FNAC studies (28). Indeterminate categories, such as Bethesda III (Atypia of Undetermined Significance) and IV (Follicular Neoplasm/Suspicious for Follicular Neoplasm), comprised a smaller proportion of cases. These categories continue to pose diagnostic challenges due to their potential for malignancy, necessitating further evaluation through molecular testing or repeat FNAC (29).

The low frequency of Bethesda VI (malignant) cases highlights FNAC's capacity to effectively identify malignancies while avoiding overdiagnosis. However, it is essential to integrate FNAC findings with clinical and radiological data to enhance diagnostic accuracy. Studies have shown that combining FNAC with advanced imaging techniques or molecular diagnostics can improve outcomes, particularly in indeterminate cases (30).

Strengths and Limitations

The strengths of this study include its large sample size and the use of histopathology as the gold standard for evaluating FNAC accuracy. However, certain limitations must be acknowledged. The retrospective design may introduce selection bias, and the accuracy of FNAC is inherently dependent on the skill of the operator and the adequacy of the sample collected (13). Furthermore, while histopathology remains the definitive diagnostic method, occasional discrepancies between cytology and histopathology can occur, particularly in cases with insufficient or indeterminate samples.

Clinical Implications and Future Directions

The findings of this study reinforce FNAC as a highly effective and cost-efficient diagnostic tool for thyroid lesions. Its ability to differentiate benign from malignant lesions can guide clinicians in making timely and appropriate management decisions, reducing the need for unnecessary surgeries. Moving forward, integrating FNAC with molecular testing for genetic markers and advanced imaging modalities, such as elastography and PET-CT, may further enhance its diagnostic precision (31).

Future research should focus on prospective, multi-canter studies to validate the findings across diverse populations. Additionally, further investigation into the role of hormonal and

environmental factors in thyroid disease development could provide insights into targeted prevention strategies, particularly for high-risk groups, including women and younger adults.

Conclusion

In conclusion, FNAC remains an indispensable tool for diagnosing thyroid lesions, offering high sensitivity, specificity, and reliability. Its ability to distinguish between benign and malignant lesions ensures that patients receive timely and appropriate care, reducing unnecessary interventions. By addressing current limitations and leveraging advancements in molecular diagnostics, FNAC can continue to evolve as a cornerstone of thyroid disease management.

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