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ROLE OF FINE NEEDLE ASPIRATION CYTOLOGY IN THE DIAGNOSIS OF THYROID DISEASE AT BOLAN MEDICAL COMPLEX HOSPITAL, QUETTA.

Original Research

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ABSTRACT

Background: Thyroid nodules are increasingly encountered in clinical practice, with a substantial proportion requiring diagnostic evaluation to exclude malignancy. Fine-needle aspiration cytology (FNAC) is widely utilized due to its minimally invasive nature, cost-effectiveness, and high diagnostic yield. Early and accurate differentiation between benign and malignant thyroid lesions is essential for appropriate surgical planning and to prevent overtreatment. This study investigates the diagnostic performance of FNAC in assessing thyroid nodules, using histopathology as the reference standard.

Objective: To evaluate the diagnostic accuracy of fine-needle aspiration cytology (FNAC) in differentiating benign and malignant thyroid nodules.

Methods: This cross-sectional study was conducted in the ENT Department of Bolan Medical Complex Hospital, Quetta, over six months, from November 2023 to May 2024. A total of 229 patients aged 18 to 75 years with clinically or radiologically suspected thyroid nodules underwent ultrasound-guided FNAC. The cytological findings were compared with postoperative histopathological outcomes. Inclusion criteria encompassed patients with suspected malignant thyroid nodules. Exclusion criteria included prior thyroid surgery, current treatment for thyroid malignancy, and non-consent. Data analysis was performed using IBM SPSS version 25.0. Diagnostic metrics including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated.

Results: Among 229 patients, 202 (88.21%) were female and 121 (52.84%) were between 18–45 years. FNAC results revealed 89 true positives, 10 false positives, 119 true negatives, and 11 false negatives. FNAC demonstrated a sensitivity of 89.0%, specificity of 92.25%, PPV of 89.90%, NPV of 91.54%, and an overall diagnostic accuracy of 90.83%.

Conclusion: FNAC showed high diagnostic accuracy in distinguishing malignant from benign thyroid nodules, supporting its routine use in preoperative evaluation to guide surgical decision-making and improve patient outcomes.

Keywords: Accuracy, Cytology, Diagnosis, Fine-Needle Aspiration, Histopathology, Thyroid Neoplasms, Thyroid Nodule.

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INTRODUCTION

Thyroid nodules represent a significant clinical concern due to their high prevalence and potential association with malignancy. Defined by the American Thyroid Association (ATA) as discrete lesions within the thyroid gland that are radiologically distinguishable from the surrounding parenchyma, these nodules are commonly detected in the general population, particularly with the use of high-resolution imaging modalities such as ultrasonography (1). The incidence of thyroid nodules varies widely depending on the method of detection, with ultrasound-based studies reporting a prevalence ranging from 20% to 76% among adults (2). Gender differences are particularly striking, with women exhibiting a fourfold higher incidence than men, a disparity that is believed to be influenced by hormonal changes, especially during pregnancy, when nodules may increase in both size and number (3). Although most nodules are benign, their frequent occurrence necessitates careful evaluation to exclude malignancy, especially when nodules become symptomatic or are identified incidentally during imaging for unrelated conditions. The challenge in clinical management lies in differentiating benign from malignant nodules efficiently and non-invasively. While thyroid nodules can occasionally lead to compressive symptoms or hormonal dysfunction, the primary clinical concern remains the identification of malignant potential (4). Fine-needle aspiration cytology (FNAC) has emerged as a cornerstone in the diagnostic evaluation of thyroid nodules, offering a reliable, minimally invasive, and cost-effective alternative to surgical biopsy.

FNAC is considered the gold standard preoperative diagnostic tool, with the ability to accurately classify approximately 60% of nodules as benign, thereby preventing unnecessary surgeries and reducing patient morbidity (5). The widespread use of FNAC has been bolstered by its high sensitivity and specificity, which range from 65% to 98% and 72% to 100%, respectively, in diagnosing malignant thyroid nodules (6). Furthermore, the increased utilization of advanced imaging techniques has led to a surge in the incidental discovery of thyroid nodules, further amplifying the clinical value of FNAC in triaging these findings (7). Despite its utility, FNAC is not without limitations. In some cases, indeterminate cytological findings or sampling errors can complicate clinical decision-making, necessitating further diagnostic intervention (8). Nonetheless, its role in distinguishing benign from malignant lesions is irreplaceable, particularly in settings where surgical intervention carries additional risks or cosmetic concerns (9). Almost any thyroid pathology can present as a nodule, and distinguishing between reactive, benign, or malignant lesions remains a diagnostic challenge. However, by minimizing surgical exploration and facilitating early intervention when malignancy is suspected, FNAC serves as a crucial tool in modern thyroidology (10). Given the growing prevalence of thyroid nodules and the increasing reliance on non-invasive diagnostic strategies, this study aims to critically evaluate the diagnostic accuracy and clinical utility of fine-needle aspiration cytology in the assessment of thyroid nodules. The objective is to explore FNAC's role in optimizing patient management, minimizing unnecessary surgical procedures, and ensuring timely detection of malignancy.

METHODS

This cross-sectional study was conducted in the Department of Ear, Nose, and Throat (ENT) at Bolan Medical Complex Hospital, Quetta, over a six-month period from November 20, 2023, to May 19, 2024. A total of 229 patients aged 18 to 75 years, of either gender, presenting with clinically or radiologically suspected thyroid nodules were enrolled. Ethical approval for the study was granted by the Institutional Review Board of Bolan Medical College and Hospital, and written informed consent was obtained from all participants after a thorough explanation of the study's purpose, procedures, and possible benefits or risks. At presentation, baseline demographic and clinical information was recorded for each patient. All patients underwent ultrasound evaluation to confirm the presence and characteristics of thyroid nodules. Although ultrasound was not analyzed through a structured classification system such as the Thyroid Imaging Reporting and Data System (TI-RADS), findings were documented descriptively and used to guide FNAC. Ultrasound-guided fine-needle aspiration cytology was performed on each patient under aseptic conditions, ensuring accurate targeting of nodular lesions. The aspirated material was sent for cytopathological analysis to determine benign or malignant features (11).

Patients who were indicated for surgical intervention subsequently underwent thyroidectomy, and the excised specimens were submitted to the histopathology department for definitive diagnosis. Histopathological findings were used as the reference standard and were compared with preoperative FNAC and ultrasound results to assess diagnostic concordance. The study thus evaluated the diagnostic accuracy of FNAC in identifying thyroid malignancy and its agreement with postoperative histopathology. The inclusion criteria

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comprised adult patients (aged 18–75 years) of both sexes with thyroid nodules clinically or radiologically suspected to be malignant. Patients with a known history of thyroid surgery, those already on treatment for thyroid cancer, and those who refused consent were excluded. Importantly, individuals with multinodular goiter were included if a dominant or suspicious nodule was present and met the criteria for FNAC. Statistical analysis was performed using IBM SPSS Statistics version 25.0. Frequencies and percentages were calculated for categorical variables, while diagnostic indices including sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of FNAC were determined based on its correlation with histopathological outcomes.

RESULTS

A total of 229 patients were included in the study, with ages ranging from 18 to 75 years. The majority of participants (n = 121, 52.84%) were in the 18–45-year age group, while 108 patients (47.16%) were aged 46–75 years. Females comprised a significant proportion of the study population, accounting for 88.21% (n = 202), whereas males represented 11.79% (n = 27), with a male-to-female ratio of 1:7.5. Most of the patients (n = 142, 62.01%) were from urban areas, while 87 patients (37.99%) belonged to rural localities. Regarding family history, a majority of the patients (n = 190, 82.97%) reported no known family history of thyroid malignancy, whereas 39 patients (17.03%) had a positive family history. The mean duration of symptoms was 4.26 ± 1.45 weeks. Among the participants, 123 patients (53.71%) presented with symptoms lasting longer than four weeks, while 106 patients (46.29%) had symptom duration of four weeks or less. In terms of diagnostic performance, 89 cases were reported as malignant on both FNAC and final histopathology (true positives), while 10 cases were found to be false positives—malignant on FNAC but benign on histopathology. Similarly, 119 cases were true negatives and 11 cases were false negatives. Based on these findings, FNAC demonstrated a sensitivity of 89.0%, specificity of 92.25%, positive predictive value (PPV) of 89.90%, negative predictive value (NPV) of 91.54%, and an overall diagnostic accuracy of 90.83% in differentiating benign from malignant thyroid nodules.

Further stratification by age revealed that diagnostic accuracy was 46.7% in patients aged 18–45 years and 44.10% in the 46–75-year group, with a statistically significant association (p = 0.03). Gender-based stratification also showed a significant relationship with diagnostic accuracy, where 185 out of 202 females had accurate FNAC results compared to 23 out of 27 males, yielding a p-value of 0.01. Subgroup analysis between ultrasound findings and histopathology outcomes revealed a strong correlation between sonographic suspicion level and final histopathological diagnosis. Among patients classified as “High Suspicion” on ultrasound—typically characterized by hypoechogenicity, irregular margins, and microcalcifications—75 were confirmed as malignant on histopathology, whereas only 5 turned out to be benign. In the “Intermediate Suspicion” category, 10 nodules were histologically malignant, while 8 were benign. Patients with “Low Suspicion” ultrasound features had 5 malignant and 20 benign nodules, whereas the “Benign” category (suggestive of purely cystic or smooth, isoechoic nodules) demonstrated the highest concordance with benign histology, with 96 confirmed as non-malignant and no cases of malignancy identified. These findings support the clinical relevance of ultrasound-based stratification in preoperative risk assessment and its role in guiding the use of FNAC for thyroid nodules.

Table 1: Demographics characteristics

Description	Frequency	Percentage
Age groups		
18-45 years	121	52.84
46-75 years	108	47.16
Gender		
Female	202	88.20
Male	27	11.79
Locality		
Urban	142	62.01
Rural	87	37.99

Table 2: Distribution of Patients by Family History of Thyroid Malignancy

Family history of thyroid malignancy	No. of Patients	Percentage
Yes	39	17.03
No	190	82.97

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Table 3: Duration of Symptoms Before FNAC Evaluation

Duration (weeks)	No. of Patients	Percentage
≤4	106	46.29
>4	123	53.71

Table 4: Correlation Between FNAC and Histopathology Findings in Thyroid Nodule Diagnosis

Result Positive on FNAC and Histopathology		Result Negative on FNAC and Histopathology	
True Positive (malignant)	False Positive	True Negative (Benign)	False Negative
89	10	119	11

Table 5: Stratified Analysis of FNAC Diagnostic Accuracy by Age and Gender

Variable	Accuracy Yes	Accuracy No	p-value
Age 18–45	107	14	0.03
Age 46–75	101	07	
Male	23	04	0.01
Female	185	17	

Table 6: Ultrasound Findings vs Histopathology Outcomes

Ultrasound Category	Malignant on Histopathology (n)	Benign on Histopathology (n)
High Suspicion	75	5
Intermediate Suspicion	10	8
Low Suspicion	5	20
Benign	0	96

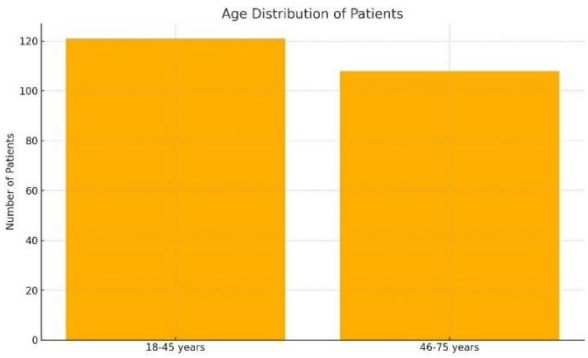

Figure 1 Age Distribution of Patients

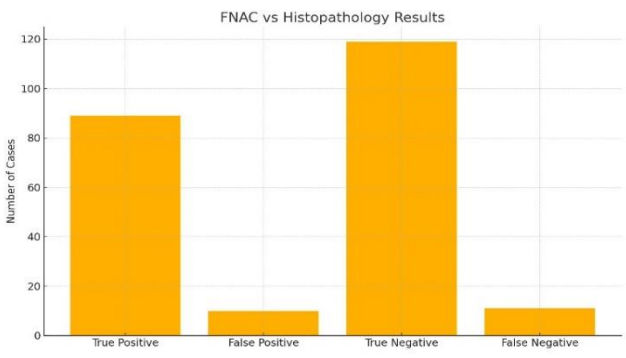

Figure 1 FNAC vs Histopathology Results

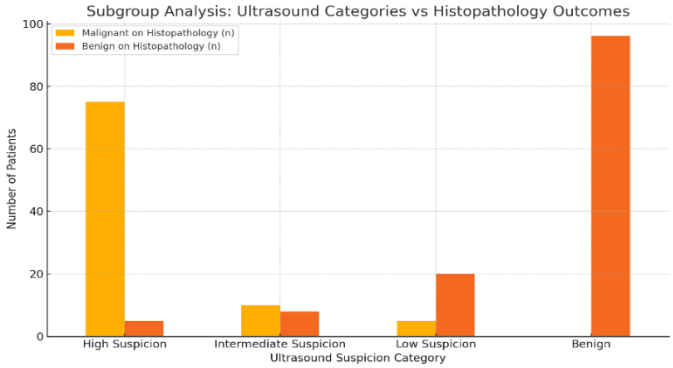

Figure 3 Subgroup Analysis: Ultrasound Categories vs Histopathology Outcomes

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DISCUSSION

The findings of this study demonstrated a notably high diagnostic performance of fine-needle aspiration cytology (FNAC) in evaluating thyroid nodules, with an overall accuracy of 90.83%, sensitivity of 89.0%, and specificity of 92.25%. These metrics highlight FNAC as a reliable and minimally invasive diagnostic tool for distinguishing between benign and malignant thyroid lesions prior to surgical intervention. The results were in alignment with several national and international studies, supporting the consistency and reproducibility of FNAC's diagnostic strength across diverse populations and healthcare settings (12,13). A dominant female representation in the study cohort reinforced the well-documented gender disparity in thyroid disorders. The gender distribution, with females constituting 88.21% of the study population, closely mirrored findings from previous regional and international research where female predominance ranged between 85% and 91%. This pattern is attributed to hormonal influences, particularly estrogen, which modulates thyroid cellular activity and may contribute to the increased incidence of nodular thyroid disease in females (14). Age distribution revealed that over half of the patients were between 18 and 45 years, with a mean age of 44.78 ± 11.47 years, which is consistent with existing literature from the region, although some prior studies have reported slightly younger average ages.

Comparison of FNAC results with histopathological outcomes revealed a malignancy rate of 38.86% and a benign lesion rate of 51.96% on FNAC. These proportions were found to be in close agreement with prior studies, which reported benign cytological findings in approximately 52–69% of cases (15). Notably, the false positive rate in this study was 4.36% and the false negative rate was 4.80%, both within acceptable ranges documented in global literature. These findings are important because they underline the high predictive reliability of FNAC while acknowledging the inevitable limitations of sampling and cytological interpretation, particularly in nodules with overlapping features (16). Diagnostic accuracy remained robust when stratified by age and gender, with statistically significant associations noted for both variables. However, these observations differed from some studies where age was not found to significantly influence FNAC accuracy, suggesting that demographic variables may have context-dependent effects, potentially influenced by disease burden, nodule characteristics, or operator proficiency (17). This study also compared local findings with national data, revealing comparable or slightly improved diagnostic performance. In contrast, one international study reported notably lower specificity (<50%), which may reflect differences in sampling techniques, cytological expertise, or study populations (18).

Ultrasound findings, though not formally stratified using TI-RADS, were descriptively evaluated and compared with histopathological diagnoses (19). The correlation between high-suspicion ultrasound features and malignant histopathological outcomes emphasized the relevance of ultrasonography as a complementary tool in pre-FNAC evaluation. While formal TI-RADS classification would have strengthened the imaging analysis, the descriptive correlation still provided valuable insight into the combined utility of imaging and cytology in diagnostic planning (20). A key strength of this study was its well-defined patient selection criteria and the use of histopathology as the reference standard, which reinforced the reliability of reported diagnostic metrics. The relatively large sample size and the inclusion of both demographic and clinical stratification added depth to the analysis. Furthermore, the study adhered to standardized FNAC protocols and ensured histological confirmation in all cases, reducing the likelihood of misclassification bias.

Despite its strengths, the study had some limitations. It did not employ a standardized ultrasound risk stratification system, such as TI-RADS, which could have enhanced the imaging-to-pathology correlation. Additionally, while the study was conducted in a tertiary care center, the findings may not be fully generalizable to rural or primary healthcare settings where diagnostic infrastructure and expertise might differ. Sampling error and interobserver variability in cytological interpretation remain inherent limitations of FNAC, although minimized through trained personnel and consistent protocols. Future research should focus on the integration of standardized imaging classifications and the use of molecular markers in cytology to improve diagnostic precision, particularly in indeterminate cases. Multicenter trials with broader geographic representation would also help validate these findings and facilitate the development of region-specific diagnostic algorithms for thyroid nodules. In conclusion, this study reaffirmed the high diagnostic utility of FNAC in evaluating thyroid nodules and emphasized its role as a first-line tool in the preoperative assessment of thyroid malignancy. Combined with imaging findings, FNAC continues to offer a dependable, low-risk method for guiding clinical decision-making and optimizing surgical planning.

Comparison of Diagnostic Performance of FNAC in Thyroid Nodule Evaluation Across Different Studies in Pakistan

Study	Place and time	Accuracy	Specificity	Sensitivity	Positive predictive value (ppv)	Negative predictive value (npv)
(Kumar, Aqil et al. 2008)	Karachi 2008	97.7%	100%	77.0%	-	-
(Bukhari, Niazi et al. 2008)	Lahore 2008`	87.0%	87.5%	90.0%	93.0%	79.5%
(Wahid, Khan et al. 2011)	Peshawar 2011	82.92%	77.50%	88.09%	80.43%	86.11%
Current study	Quetta 2024	90.83%	92.25%	89.0%	89.90%	91.54%

Comparison of FNAC Diagnostic Performance in Thyroid Nodule Evaluation Across International Studies

Study	Place and time	Accuracy	Specificity	Sensitivity	Positive predictive value (ppv)	Negative predictive value (npv)
(Osseis, Jammal et al. 2023)	Lebanon 2023	-	48.45%	89.30%	78%	69%
(Attia, Kotb et al. 2019)	Egypt 2019	80.0%	87.5%	80.0%	-	-
(Korah and El-Habashi 2005)	Egypt 2005	98.0%	100%	88.0%	100%	98%
(Kessler, Gavriel et al. 2005)	Israel 2005	87.0%	98.5%	79.0%	98.75%	76.6%
Current Study	Quetta 2024	90.83%	92.25%	89.0%	89.90%	91.54%

CONCLUSION

This study concludes that fine-needle aspiration cytology (FNAC) is a highly effective and reliable diagnostic tool for distinguishing between benign and malignant thyroid nodules. Its integration into routine clinical practice significantly enhances preoperative decision-making, allowing for precise surgical planning and improved patient care. By providing accurate cytological assessment, FNAC reduces unnecessary surgeries and supports timely intervention in malignant cases. The findings strongly support the widespread adoption of FNAC as a standard component in the diagnostic workup of thyroid lesions to ensure better outcomes and more efficient management of thyroid disorders.

Author Contribution

Author	Contribution
Adnan Yousaf*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Abdul Lateef Kakar	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Faiza Fayyaz	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Sarah Nathaniel	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Saeed Khan	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Aria Masoom	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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