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Original Article

Diagnostic Accuracy of Fine-Needle Aspiration Cytology in Thyroid Lesions: A Comparative Study with Histopathological Examination

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ABSTRACT:

Background: Fine-needle aspiration cytology (FNAC) is a rapid, minimally invasive, and cost-effective method for evaluating thyroid Lesions. However, its diagnostic performance varies depending on sampling technique, adequacy, and cytological interpretation. **Aim:** This study aimed to assess the diagnostic accuracy of FNAC compared with histopathological examination (HalPE). **Materials and Methods:** A retrospective cross-sectional study was conducted on patients who underwent thyroidectomy at the Department of General Surgery, Head and Neck Surgery, between June 2023 and October 2024. FNAC results were classified using the Bethesda system and compared with the final HPE. Diagnostic indices, including sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) were calculated using Jamovi. **Results:** Thirty-five patients were included (mean age 43.5 ± 13.6 years; 94% females), FNAC showed a sensitivity of 77.8%, specificity of 52.9%, accuracy of 65.7%, PPV of 63.6%, and NPV of 69.2% when compared with HPE. The majority of malignant lesions were papillary thyroid carcinoma. **Conclusion:** FNAC continues to be a valuable first-line diagnostic tool for thyroid nodules, demonstrating good sensitivity but moderate specificity. HPE remains crucial for a definitive diagnosis. Larger, multicenter studies are recommended to validate these findings and to enhance diagnostic reliability through better sampling and cytological expertise.

Keywords: Fine-needle aspiration cytology, thyroid nodules, histopathology, diagnostic accuracy, Bethesda system.

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INTRODUCTION:

Thyroid swellings are among the most common endocrine disorders worldwide, with the incidence of thyroid nodules ranging from 40 to 71% in the general population [1. 2]. Although most of the thyroid nodules are Benign subtypes, the risk of malignancy is approximately 0.45% to 13% with the papillary thyroid carcinoma (PTC) being the most prevalent histologic type. [3.5]. Accurate diagnosis is therefore essential to ensure the selection of appropriate management [5], which may include observation, local therapies, or surgical intervention, depending on the nature of the lesion [5.6]. Fine-needle aspiration cytology (FNAC) was first introduced by Leyden in 1883[7], and later, Martin and Ellis in 1930 reported its application in thyroid lesions for the first time [8]. FNA is currently recommended as the initial diagnostic tool for thyroid nodules due to its superior reliability, minimal invasiveness, and cost-effectiveness [7]. Despite its advantages, FNAC has several limitations. This can be attributed to differences in each step, from the obtainment of an adequate specimen, performing proper sampling, carrying out the aspiration, and eventually reaching an interpretation of the aspirate, to overlap cytological features between neoplastic and non-neoplastic lesions [7]. Additionally, differentiating between benign and malignant follicular neoplasms, as well as identifying papillary carcinoma in the presence of non-neoplastic conditions such as multinodular goiter, thyrotoxicosis, or cystic degeneration, remains particularly challenging [7]. Hence for the definitive diagnostic test is histopathological examination (HPE), which measures the sensitivity and specificity of FNAC[7].

Aim:

The present study aims to evaluate the diagnostic accuracy of FNAC by comparing its cytological classification with HPE findings among patients undergoing thyroidectomy.

MATERIAL AND METHOD:

Study Design and Setting:

The data were obtained from the registered archives of the Histopathology Diagnostic Center. All available records relevant to the study period were reviewed systematically, and the required information was extracted in accordance with institutional protocols and ethical guidelines. This retrospective cross-sectional study was conducted among patients undergoing thyroidectomy. The study period is between June 2023 and October 2024. FNAs of thyroid swellings were Collected And performed in the outpatient department (OPD) under aseptic conditions using standard technique, and the prepared smears were submitted to the pathology department for cytological interpretation. Following surgery, thyroidectomy specimens were preserved in 10% neutral buffered formalin and processed for histopathological examination in the same department. All cytological and histopathological slides were reviewed by experienced pathologists.

FNAC Classification was in accordance with the Bethesda system for reporting thyroid cytopathology, including six diagnostic categories (DCs) [9]:

- DC I: Non-diagnostic or unsatisfactory
- DC II: Benign
- DC III: Atypia of undetermined significance or follicular lesion of undetermined significance
- DC IV: Suspicious for follicular neoplasm or follicular neoplasm
- DC V: Suspicious for malignancy
- DC VI: Malignant

Results of FNAC and HPE for corresponding areas were compared (non-neoplastic, benign, or malignant) to obtain the measures of accuracy in FNAC diagnosis.

Inclusion and Exclusion Criteria:

Inclusion criteria:

- The study included adult patients (≥18 years) presenting with thyroid swellings who underwent both FNAC and thyroidectomy, had complete clinical and radiological records.

Exclusion criteria:

- Patients younger than 18 years.
- Patients unfit for or who refused surgery.
- Patients who underwent FNAC but did not proceed to thyroidectomy (no histopathological confirmation available).
- Patients with incomplete clinical, cytological, or histopathological data.
- Recurrent thyroid cases or those who had previous thyroid surgery.

- Ethical approval

"The research protocol was reviewed and approved by the Research Ethical Committee of Sirte University (Approval No: 4 s.u.2025)."

- Statistical Analysis:

Data were analyzed using Jamovi 2.3 Statistics software. Descriptive statistics were generated, and diagnostic performance measures were calculated, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), overall accuracy, prevalence of malignancy, post-

test disease probability, post-test health probability, and positive and negative likelihood ratios (LR+ and LR−).

RESULT:

A total of thirty-five patients were included in this study. The mean age was 43.5 (±13.6) with a range of 16-74 years. The majority were female (n = 33; 94%), while males comprised only two cases (5.7%). The distribution of FNAC results according to the Bethesda system was as follows: 2 cases (5.7%) were non-diagnostic or unsatisfactory (DC I), 11 (31%) were benign (DC II), 2 (5.7%) showed atypia of undetermined significance (DC III), 14 (40%) were suspicious for follicular neoplasm (DC IV), 5 (14%) were suspicious for malignancy (DC V), and 1 (2.9%) was malignant (DC VI).

The definitive diagnosis presented by HPE revealed that 13 cases (37%) were non-neoplastic, most commonly nodular thyroid hyperplasia. Among neoplastic lesions, 4 cases (11%) were benign—primarily follicular adenomas—and 18 cases (52%) were malignant, with papillary thyroid carcinoma (PTC) being the predominant subtype. More details about the pathological characteristics are shown in Table 1.

Table 1. Pathological characteristics of the cases (n=35):

Variable	Value
Age, mean (SD)	43.5 (±13.6)
Gender, n (%)	
Female	33 (94%)
Male	2 (5.7%)
Presenting lesion, n (%)	
bilateral thyroid nodules	1 (2.9%)
diffuse neck swelling	5 (14%)
left thyroid cyst	1 (2.9%)
left thyroid nodule	10 (29%)
right thyroid cyst	3 (8.6%)
right thyroid nodule	15 (43.6%)
FNAC (Bethesda System), n (%)	
I	2 (5.7%)
II	11 (31%)
III	2 (5.7%)
IV	14 (40%)
V	5 (14%)
VI	1 (2.9%)
HPE, n (%)	
Anaplastic thyroid carcinoma	1 (2.9%)
Follicular Adenoma	2 (5.7%)
Hashimoto's thyroiditis	3 (8.6%)
Hürthle Cell Adenoma	1 (2.9%)
Multinodular goiter with oncotic nodules	1 (2.9%)
Nodular Thyroid Hyperplasia	9 (26%)
Oncocytic thyroid carcinoma	1 (2.9%)
Papillary Thyroid Carcinoma, Classic subtype	10 (29%)
Papillary Thyroid Carcinoma, Follicular Variant	3 (8.6%)
Papillary thyroid microcarcinoma	3 (8.6%)
Right thyroid Follicular Adenoma	1 (2.9%)

Non-neoplastic	13 (37%)
Benign	4 (11%)
Malignant	
PTC	16 (46%)
ATC	1 (2.9%)
FTC	1 (2.9%)

ATP: Anaplastic thyroid carcinoma, PTC: Papillary Thyroid Carcinoma, FTC: Follicular Thyroid Carcinoma,

To determine the diagnostic performance of FNAC, cases classified as category DC III or higher on the Bethesda system were considered cytology positive, while categories below DC III were considered cytology negative. Histopathological examination (HPE) confirmed that 14 of the 22 cytology-positive cases were truly malignant, whereas 8 were false-positive. Among the 13 cytology-negative cases, 9 were confirmed as benign, and 4 were false-negative. Based on these findings, FNAC demonstrated a sensitivity of 77.8%, specificity of 52.9%, and an overall accuracy of 65.7%. The positive predictive value (PPV) and negative predictive value (NPV) were 63.6% and 69.2%, respectively. The gold positive value of HPE corresponds to a prevalence of (51.4%), he positive likelihood ratio (LR+) was 1.65, and the negative likelihood ratio (LR−) was 0.42, indicating that FNAC moderately reduced but did not exclude the likelihood of malignancy Table 2.

Table 2. Values of diagnostic tests of FNAC with HPE reference :

Diagnostic test	Percentage (%)
Sensitivity	77.8 %
Specificity	52.9 %
Accuracy	65.7 %
Positive Predictive Value	63.6 %
Negative Predictive Value	69.2 %
Prevalence	51.4 %
Post-test Disease Probability	63.6 %
Post-test Health Probability	69.2 %
Positive Likelihood Ratio	1.65
Negative Likelihood Ratio	0.420

DISCUSSION:

Thyroid swellings can present with a wide range of clinical manifestations, although most cases remain asymptomatic [5.10]. The most common presentation is a neck lump, which may or may not cause cosmetic deformity, yet develops compressive symptoms affecting the mediastinum or great vessels, which warrant more urgent evaluation [10]. To manage this, providing a suitable treatment surgery is not necessarily the option for all cases due to the undeniable perioperative risks [11]. FNAC is widely recognized as the first-line diagnostic tool for evaluating thyroid swellings due to its simplicity, safety, and cost-effectiveness. In addition to its

diagnostic role, FNAC can provide temporary therapeutic relief by aspirating cystic or compressive lesions, thereby reducing local pressure symptoms. Once obtained, the aspirated material is examined by a cytopathologist, who interprets the cellular features alongside the patient's clinical history, physical findings, and thyroid function profile. However, since cytological assessment relies on small tissue samples and may show overlapping features between benign and malignant lesions, its findings are considered provisional. Therefore, confirmation through HPE of surgically excised specimens remains essential, as HPE provides the definitive diagnosis and serves as the gold standard against which FNAC results are compared and evaluated [6]. In the present study, most patients were in their third or fourth decade of life, consistent with previous literature [13.14]. Females almost resembled the whole population as thyroid nodules are more common in females, with a female-to-male ratio ranging from 7:1 to 10:1[13]. The sensitivity of FNAC in this study, 77.8%, correlates well with findings from the broader literature, which reports values ranging widely between 57.8% and 98.1% [11.15]. Specifically, some research, such as that by Jamaiyar et al., places the typical sensitivity range between 74% and 92%, a range that includes our current finding [11.15]. However, the specificity observed (52.9%) was lower than expected, as previous studies reported specificity values between 64.6% and 100% [11.15]. The reduced specificity in our results may be attributed to sampling errors of a small sample, sampling technique, size of the nodules, interpretive overlap between benign and malignant follicular lesions, or cystic degeneration, which complicates cytological interpretation [16]. Among the 4 false negative cases, 3 of them had a solitary right lobe nodule, and 1 had a right lobe cyst, which could have caused difficulty that might have required multiple aspurations from different parts of the lesion[16]. Such technical limitations of the FNAC process contribute to modest accuracy (65.7%), PPV (63.6%), and NPV (69.2%) compared with the higher ranges reported in the literature [15.17].

This study adopted a standardized approach while using HPE as a reference, fortifying the validity of diagnostic tests of FNAC. The application of the Bethesda System for Reporting Thyroid Cytopathology ensured standardized categorization, improving reproducibility and comparability with other studies. However, the study's small sample size (n=35) from a single center, with a retrospective design, limits the generalizability of the results. Additionally, thyroid function profiles were not included, which could have provided further insight into the underlying pathology.

Regarding public health implications, these findings can assist policymakers in improving thyroid cancer diagnostic pathways. Enhancing FNAC services, upgrading cytopathology training, and establishing standardized sampling protocols could improve early detection and reduce unnecessary surgeries, especially in resource-limited settings. Future research should include larger, multicenter prospective studies to enhance statistical power and explore factors influencing FNAC accuracy. Emerging techniques such as immunohistochemistry, molecular biomarkers, and mass spectrometry may complement FNAC to improve diagnostic precision, particularly in indeterminate or follicular-patterned lesions[18].

CONCLUSION:

FNAC has demonstrated adequate diagnostic accuracy in distinguishing between benign and malignant thyroid lesions, exhibiting good sensitivity but only moderate specificity. The presence of false-negative and false-positive cases highlights the necessity for meticulous sampling, proper cytological techniques, and expert interpretation. While FNAC remains an essential initial diagnostic tool, HPE is still regarded as the gold standard for confirming thyroid pathology. Future research involving larger, multicenter cohorts, along with the integration of molecular and immunocytochemical techniques, may further enhance the diagnostic accuracy of FNAC in thyroid diseases.

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Conflict of Interest

The authors declare no conflicts of interest.

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