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Diagnostic Accuracy of Fine-Needle Aspiration Cytology of Thyroid Nodules and Seven Years of Experience

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ABSTRACT

Objective: Thyroid fine-needle aspiration cytology is a dependable, effective method of detecting thyroid nodules. This study aims to assess the diagnostic distribution of thyroid fine-needle aspiration cytology, compare it to postoperative histological tissue diagnoses, and explore its diagnostic compatibility with published data.

Materials and Methods: This single-center retrospective descriptive study included 172 cases diagnosed histopathologically out of the 1675 thyroid fine-needle aspiration cytology procedures performed in the Bolu Abant İzzet Baysal University Faculty of Medicine, Department of Medical Pathology, between 2014 and 2020. The study examined the correlation between cytological and histopathological diagnoses.

Results: Of the 172 cases, 132 were female (76.74%), and 40 were male (23.26%). The participants ranged in age from 14 to 79, with a mean age of 49.23±11.83. Fine-needle aspiration cytology results were compared to tissue diagnoses. The method's sensitivity was 61.29%, its specificity was 96.00%, its negative predictive value was 80.00%, its positive predictive value was 90.48%, and its diagnostic efficiency was 82.72%.

Conclusion: In our study, the sensitivity and specificity values of cytology were high. Fine-needle aspiration cytology had limited diagnostic contributions in diagnosing papillary microcarcinoma and follicular lesions. In addition to increasing cytopathology experience to improve diagnostic compliance, we believe evaluating patients with clinical and radiological findings will better benefit patient treatment.

Keywords: Thyroid nodule, fine-needle aspiration cytology, histopathology, sensitivity, specificity

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INTRODUCTION

Goiter is an enlargement of the thyroid tissue that can manifest as diffuse growth, a single nodule, or multiple nodules (1). Thyroid nodules are lesions that are sharply separated from the surrounding thyroid parenchyma; they are among the most commonly encountered diseases in Türkiye and the rest of the world (2–4). Thyroid nodules become more common with age and are more common in women than men (5, 6). Thyroid nodules are found in 4%–10% of adults and 0.2%–1.2% of children (3). Most of these nodules are benign, with a 7%–15% risk of malignancy (1–3). Papillary thyroid carcinoma (PTC) (80%–90%) is the most common malignant tumor, followed by follicular carcinoma (5%–10%) and medullary carcinoma (<5%) (7).

It is critical to distinguish between benign and malignant nodules to avoid unnecessary thyroidectomies (6). Ultrasonography is used to detect malignant thyroid nodules that have hypoechogenicity, microcalcification, irregular borders, local invasion, or lymphadenopathy (8). The thyroid fine-needle aspiration cytology (FNAC) diagnostic test is the gold standard first-line method in the preoperative diagnosis of thyroid nodules because it is simple, fast, and inexpensive (1, 2, 6). The primary goal of FNAC is to protect functional patients with inflammation who need clinical follow-up from surgical procedures, as well as to provide opportunities for surgical treatment of malignant nodules (1, 2, 9, 10).

Pathological evaluations are performed in accordance with the The Bethesda System for Reporting Thyroid Cytopathology, which was implemented in FNAC in 2009 and revised in 2017 (2, 11). This system provides clinically useful, concise, and clear results (11). The six-point evaluation system is used to assess nondiagnostic, benign, atypical/follicular lesions of unknown significance, follicular neoplasms/suspicion of follicular neoplasms, suspicion of malignancy, and malignant cytology (11, 12). The malignancy rates in these groups were reported to be 5%–10%, 0%–3%, 10%–30%, 25%–40%, 50%–75%, and 97%–99%, respectively (11).

FNAC's disadvantages include false-negative and -positive results and the inability to make a definitive differential diagnosis between follicular lesions (6, 13). Approximately 10%–30% of all cases are nondiagnostic (7). FNAC's success depends on skilled aspiration and cytological evaluation (1). It does not always provide accurate results due to insufficient sampling, a poor sampling technique, and the presence of follicular lesions (1).

This study aims to determine the diagnostic distribution of ultrasound-guided FNACs in thyroid tissue, assess the diagnostic adequacy of this procedure by correlating it with postoperative histopathological diagnoses, and discuss the predictive value of cytology in malignancies in light of current published studies.

MATERIALS and METHODS

This single-center, descriptive, and retrospective study included 176 cases with histopathological diagnoses among 1675 thyroid FNAC patients who visited the Bolu Abant İzzet Baysal University Faculty of Medicine, Department of Medical Pathology between 2014 and 2020. Cases with hemangioma (2 cases), arteriovenous malformation (1 case), and intrathyroidal thymic carcinoma (1 case) were excluded from the study because they were not primary thyroid lesions, and the study was conducted with 172 cases.

Clinical parameters, cytology, and surgical resection results for the cases came from archival records. The study included cases that underwent thyroid surgery following FNAC and were diagnosed with pathologies. Only one of the recurrent cytology samples with the same diagnosis was examined. The study excluded cases for which surgery was performed in an external center after FNAC and cases for which cytological examination was not performed despite having thyroidectomy material.

FNAC samples from thyroid nodules were sent to the pathology laboratory on eight slides, four of which were air-dried and four of which were alcohol-fixed. May Grünwald Giemsa (MGG) staining was used on the air-dried preparations, and alcohol-fixed preparations were stained with the Papanicolaou method and hematoxylin and eosin.

Cytopathological evaluations were made in six categories according to the Bethesda system (2). According to the Bethesda criteria in FNAC, it is considered sufficient to observe ten follicular epithelial cell groups consisting of at least six cells (2, 8). Colloidal nodules and lymphocytic thyroiditis were accepted as benign (8). According to Bethesda, the categories are: Category 1: Nondiagnostic cytology; Category 2: Benign cytology; Category 3: Atypia of undetermined significance or follicular lesion of undetermined significance (AUS/FLUS); Category 4: Follicular neoplasm/suspicious for a follicular neoplasm (FN/SFN); Category 5: Suspicious for malignancy, and Category 6: Malignant (2, 13).

Histopathological evaluations of the cases were performed following the World Health Organization's 2018 classification (2). Cytology results and histopathological results in cases operated after FNAC were compared, and the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of cytology results were calculated statistically. In benign cytology and pathology cases, true negative cases are presented (12).

According to the literature, Bethesda 5 and 6 are cytologically positive, while Bethesda 2 is cytologically negative (6, 13). False negatives were accepted as benign nodules with malignant histology, and false positives were accepted as malignant cytology with nonneoplastic or benign neoplasms (13). Cases with false-positive and false-negative results were re-evaluated.

Table 1. Bethesda diagnosis distributions of fine-needle aspiration cytologies

Bethesda	n	%
1 Nondiagnostic	8	4.65
2 Benign	60	34.88
3 AUS/FLUS	66	38.37
4 FN/SFN	17	9.88
5 Suspicious for malignancy	15	8.72
6 Malignant	6	3.49
Total	172	100.0

AUS: Atypia of undetermined significance; FLUS: Follicular lesion of undetermined significance; FN: Follicular neoplasm; SFN: Suspicious for a follicular neoplasm

Table 2. Histopathological diagnosis distributions of cases

Histopathological diagnosis	n	%
MNG	68	39.53
Papillary microcarcinoma	27	15.70
PTC	23	13.37
Thyroiditis	23	13.37
Follicular adenoma	18	10.47
Well-differentiated tumor with uncertain malignant potential	4	2.33
NIFTP	4	2.33
Follicular tumor with uncertain malignant potential	3	1.74
Minimally invasive follicular carcinoma	1	0.58
MTC	1	0.58
Total	172	100.0

MNG: Multinodular goiter; PTC: Papillary carcinoma; NIFTP: Non-invasive follicular thyroid neoplasm with papillary-like nuclear features; MTC: Medullary thyroid carcinoma

Ethics

The Bolu Abant İzzet Baysal University Ethics Committee for Clinical Research approved this study (2021/243-05.10.2021).

Statistical Analyses

The Anderson-Darling normality test was used to evaluate the data's distributional properties before statistical analysis. Descriptive statistics were obtained. Mean±standard deviation values were used to present the remaining variables. For the categorical variables, frequencies and percentages were obtained. Two-way cross tables were obtained for the bivariate analyses of the categorical variables. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of the FNAC procedures were calculated about the gold standard, histopathological diagnosis. Prevalence-adjusted bias-adjusted kappa (PABAK) calculated for agreement of Bethesda cytological diagnosis and biopsy diagnosis. The statistical analyses were conducted using the R statistical software (version 4.1.2) (14).

RESULTS

Among the 1,675 cases with thyroid FNAC between 2014 and 2020, 172 cases who underwent thyroid surgery were included in

Table 3. The distribution of the cytologic-histopathologic correlation of the nodules

Bethesda	MNG	Thyroiditis	FA	TUMP	NIFTP	PTC mi	PTC	FTC mi	MTC	Total
1	4	1	1	0	0	1	1	0	0	8
2	32	10	5	3	1	8	0	0	0	59
3	26	7	11	3	2	11	5	1	0	66
4	4	5	1	0	0	2	4	0	1	17
5	2	0	0	1	0	4	8	0	0	15
6	0	0	0	0	1	1	5	0	0	7
Total	68	23	18	7	4	27	23	1	1	172

MNG: Multinodular goiter; PTC: Papillary carcinoma; NIFTP: Non-invasive follicular thyroid neoplasm with papillary-like nuclear features; FA: Follicular adenoma; FC: Minimally invasive follicular carcinoma; TUMP: Tumors of uncertain malignant potential; NIFTP: Non-invasive follicular thyroid neoplasm with papillary-like nuclear features; PMC: Papillary microcarcinoma; PTC: Papillary thyroid carcinoma; FTCmi: Follicular carcinoma, minimally invasive; MTC: Medullary thyroid carcinoma

Table 4. Diagnostic value of fine-needle aspiration cytologies

	Biopsy diagnosis					
	Benign biopsy		Malignant biopsy		Total	
	n	%	n	%	n	%
Bethesda cytological diagnosis						
Benign cytology (Bethesda 2)	47	95.92	12	37.50	59	72.84
Malignant cytology (Bethesda 5–6)	2	4.08	20	62.50	22	27.16
Total	49	100.0	32	100.0	81	100.0

this study. Of these cases, 132/172 (76.74%) were women, and 40/172 (23.26%) were men. Their ages ranged from 14 to 79, with a mean age of 49.23±11.83 years. While 79/172 (45.93%) of the cytology procedures were carried out from the right lobe, 70/172 (40.70%) were carried out from the left lobe, 13/172 (7.56%) were carried out from the right and left lobes, and 10/172 (5.81%) were carried out from the isthmus. The diagnostic distributions per the Bethesda system were as follows: 8/172 (4.65%) nondiagnostic cases (Bethesda 1), 60/172 (34.88%) benign cases (Bethesda 2), 66/172 (38.37%) AUS/FLUS cases (Bethesda 3), 17/172 (9.88%) FN/SFN cases (Bethesda 4), 15/172 (8.72%) cases suspicious for malignancy (Bethesda 5), and 6/172 (3.49%) malignant cases (Bethesda 6) (Table 1).

Table 2 presents the tissue diagnosis results. The FNAC test results were compared to the tissue diagnoses (Table 3). Table 4 summarizes the bivariate cross classification of Bethesda cytological diagnosis and biopsy diagnosis. The PABAK statistics for agreement of Bethesda cytological diagnosis and biopsy diagnosis was 0.65 (SE: 0.11) while bias and prevalence were -0.12 and -0.33, respectively. In addition, while the sensitivity of the FNAC tests was 61.29%, their specificity was 96.00%, their NPV was 80.00%, their PPV was 90.48%, and their diagnostic accuracy (DA) was 82.72%.

There were 12/172 (6.97%) false-negative cases, 8 cases of papillary microcarcinoma (PMC) (Fig. 1), 3 cases of well-differentiated tumors with uncertain malignant potential (Fig. 2, 3), and 1 case of non-invasive follicular thyroid neoplasm with papillary-like nuclear features (NIFTP). Papillary microcarcinoma cases were detected to be incidental. Two false-positive cases (1.16%) were diagnosed as multinodular goiter (MNG) (Fig. 4, 5). On cytology, these cases were classified as Bethesda 5 (suspected malignancy). Among the Bethesda 6 cases, no benign cases were discovered.

There were 66 cases diagnosed as Bethesda 3 (AUS/FLUS) (38.37%). Considering the distribution of cases in the category of Bethesda 3, 26 cases were diagnosed with MNG, 7 cases were diagnosed with thyroiditis, 11 cases were diagnosed with follicular adenoma, 11 cases were diagnosed with PMC, 3 cases were diagnosed with tumors of uncertain malignant potential, 2 cases were diagnosed with NIFTP, 5 cases were diagnosed with PTC, and 1 case was diagnosed with minimally invasive follicular carcinoma. There were 17 cases in the category of Bethesda 4 (FN/SFN) (9.88%). Among these, there were 4 cases of MNG, 5 cases of thyroiditis, 1 case of follicular adenoma, 4 cases of PTC, 2 cases of PMC, and 1 case of medullary thyroid carcinoma (MTC).

MNG was the most common diagnosis in the biopsies, accounting for 39.53% of all diagnoses. The malignancy rates were 12.20% in cytology and 36.62% in histopathology. PTC was the most common type of malignant tumor (29%). The malignancy rates in the Bethesda 1, 2, 3, 4, 5, and 6 categories were 25.00%, 20.33%, 33.33%, 41.17%, 86.66%, and 100.00%, respectively.

DISCUSSION

The FNAC is the most useful diagnostic test for thyroid nodules (15). The systematic evaluation of thyroid FNACs using

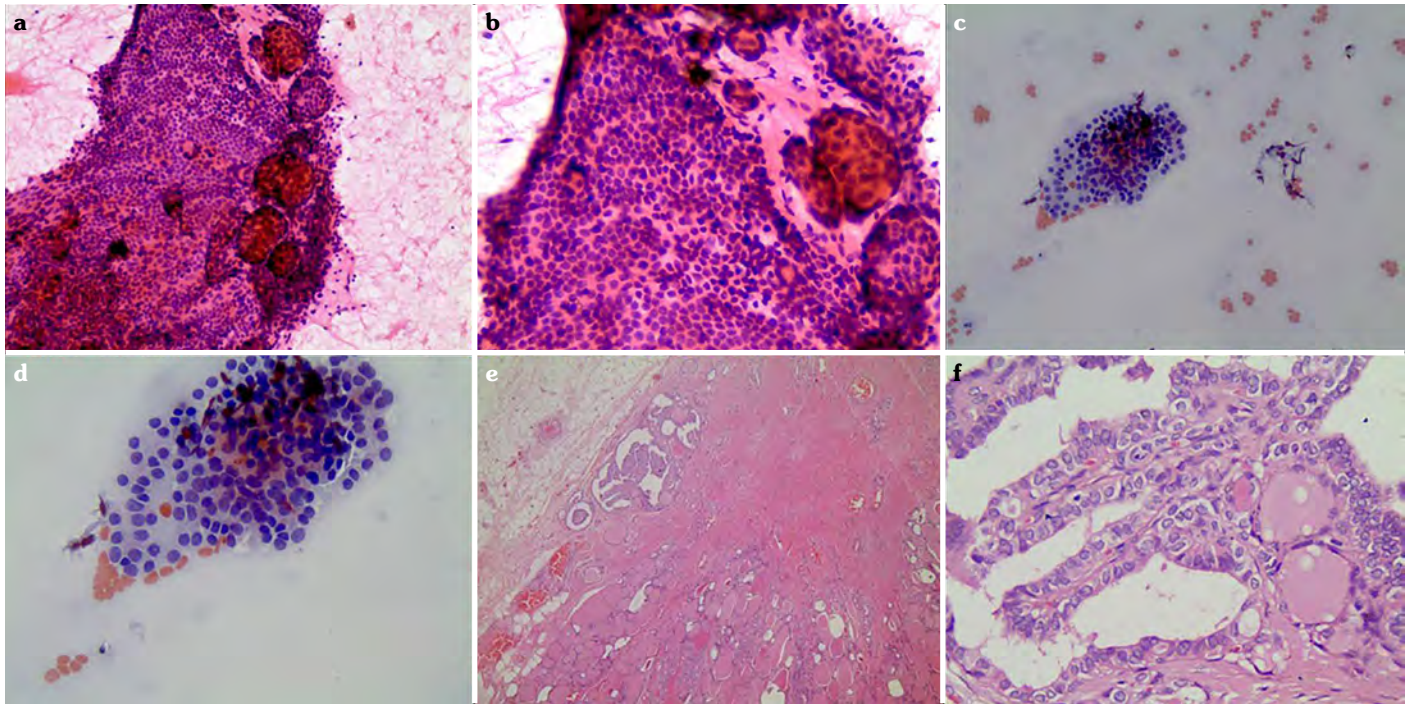

Figure 1. Papillary microcarcinoma. (a) Benign cytology with evenly stratified thyrocytes in FNAC, HEX200, (b) Thyrocytes and colloid without atypia, HEX400, (c) Thyrocytes forming macrofollicular structure, PAPX200, (d) Thyrocytes without significant atypia, PAPX400, (e) Incidental papillary microcarcinoma area in the periphery of the thyroid tissue, HEX40, (f) Tumor with papillary structure, HEX400

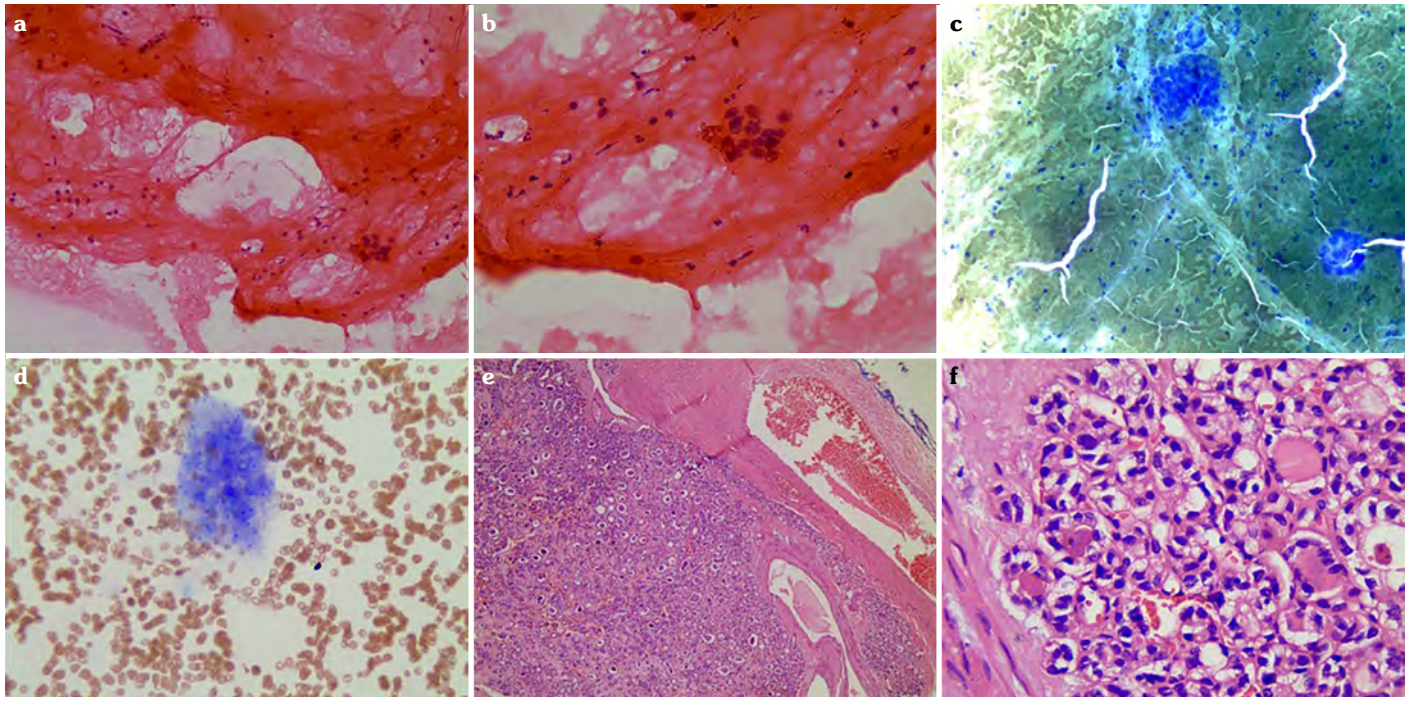

Figure 2. Well-differentiated follicular tumor with uncertain malignant potential. (a) Benign cytology sample originating from hypocellular cytology sample containing abundant colloid and few thyrocytes, HEX200, (b) Thyrocytes without atypia, HEX400, (c) Significant degenerated thyrocytes in the background with abundant colloid, MGGX200, (d) Thyrocyte group with prominent nucleoli, MGGX400, (e) Follicular tumor with suspected capsule invasion, HEX40, (f) Tumor forming follicle structures, HEX400

the Bethesda system improves the understanding of pathology reports and establishes a common language between clinicians and pathologists (12). FNAC has limitations in that it can be nondiagnostic and produce questionable results (3, 8). Furthermore, it is insufficient for differential diagnosis of benign/malignant follicular neoplasms in hypercellular goiter nodules (16).

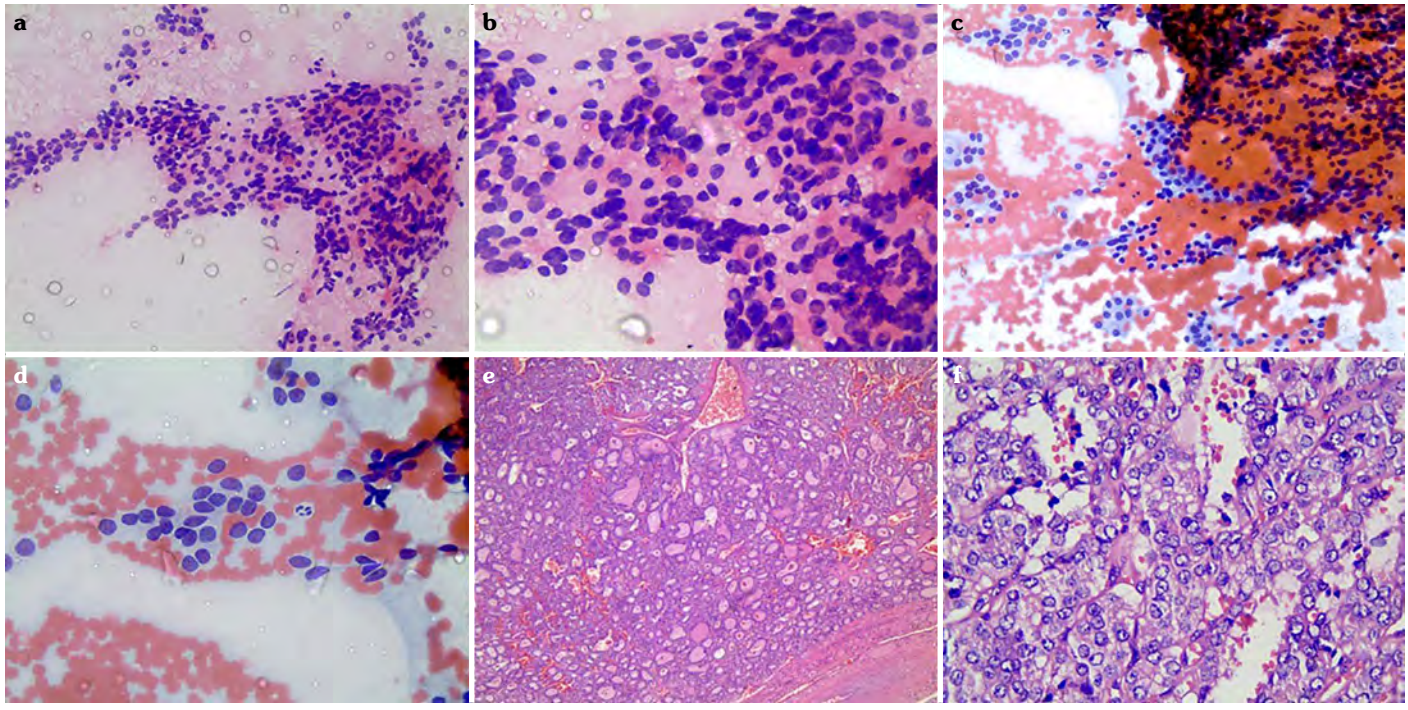

Figure 3. Well-differentiated tumor with uncertain malignant potential. (a) Highly cellular cytology, HEX200, (b) Nuclear overlapping, nuclear elongation, and nuclear contour disorder in thyrocytes, HEX400, (c) Colloid and crowded thyrocyte group, PAPx200, (d) Elongation and nuclear molding in thyrocytes, PAPX400, (e) Tumor, HEX40, (f) Tumor with suspected papillary carcinoma-like cytological features such as nuclear clarification, nuclear contour disorder, and overlapping, HEX400

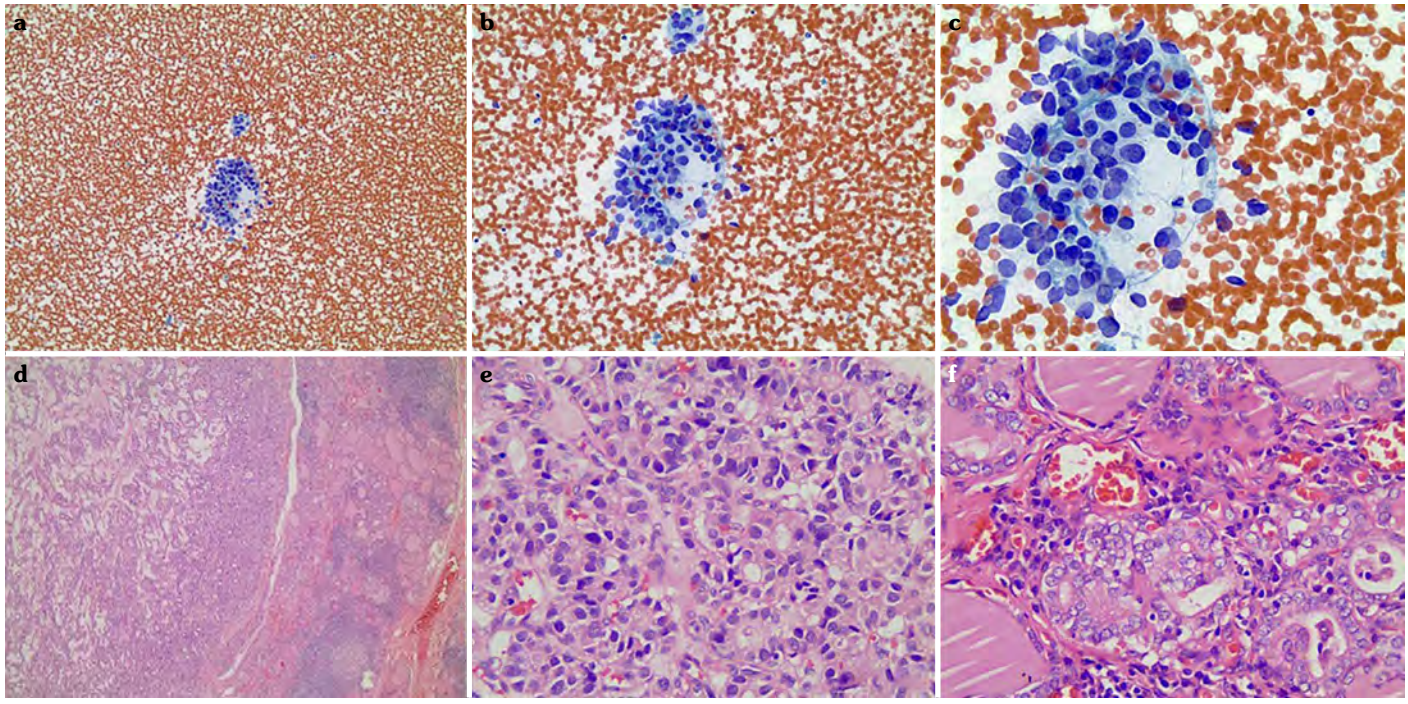

Figure 4. Multinodular goiter. (a) Colloid-poor cytology, PAPX100, (b) Thyrocyte group forming macro and microfollicular structures, PAPX200, (c) Nuclear crowding and elongation in thyrocytes, PAPX400, (d) Thyroid nodule and lymphocytic thyroiditis, HEX40, (e) Suspicious cellular features observed in cytology in some thyrocytes in the nodule, HEX400, (f) Nuclear crowding and clarification of thyrocytes between lymphocytes in the surrounding thyroid tissue, HEX400

In our study, most of the cases (76.74%) were women, which was consistent with the literature (3, 6, 17). The patients who underwent FNAC ranged in age from 14 to 79, with a mean age of 49.23. In the study by Imamoglu et al. (6), the mean age of the patients was 55, while the mean ages of patients were reported as 38.7 (3) by Gupta et al. (3) and 42 by Masereka et al. (17).

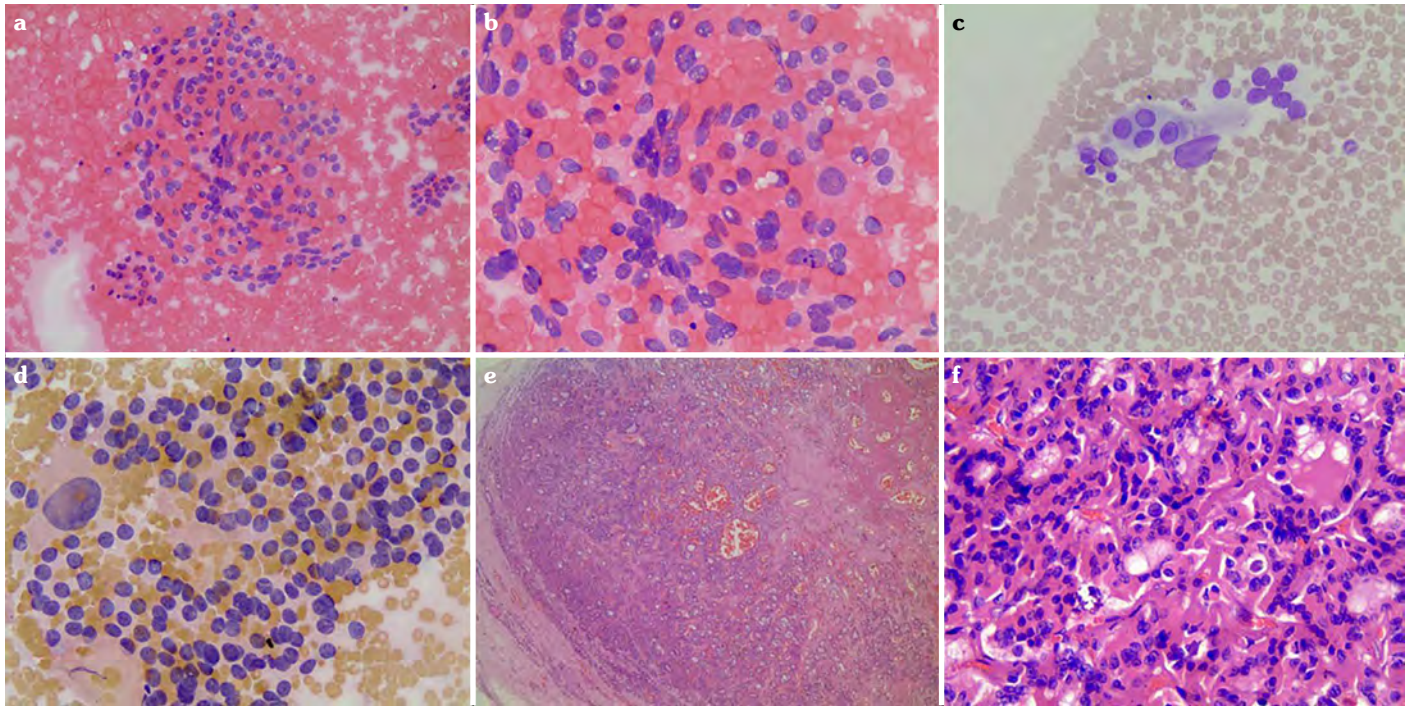

Figure 5. Multinodular goiter. (a) Cytology in cellular view, HEX200, (b) Swirl-like appearance in thyrocytes, nuclear overlapping, HEX400, (c) Markedly atypical thyrocyte, MGGX400, (d) Thyrocyte convergence and prominent nuclear deformities PAPX400 (e) Nodule containing capsule structure, HEX40, (f) Significant overlapping and presence of atypical cells in thyrocytes in the nodule, HEX400

In our study, the most common diagnosis in the biopsies was MNG, at a rate of 39.53%. The malignancy rate was 12.20% in cytology and 36.62% in histopathology. The most common malignant tumor was PTC (29%). The diagnostic distributions per the Bethesda system were as follows: 8 nondiagnostic cases (4.65%) (Bethesda 1), 60 benign cases (34.88%) (Bethesda 2), 66 AUS/FLUS cases (38.37%) (Bethesda 3), 17 FN/SFN cases (9.88%) (Bethesda 4), 15 cases suspicious for malignancy (8.72%) (Bethesda 5), and 6 malignant cases (3.49%) (Bethesda 6). Similar to our study, in the study by Bohacek et al. (18), the most common nodules were benign (280, 62.1%), and PTC was the most common malignancy in histological diagnoses. Wu et al. (15) found 112 malignant tumors in thyroidectomies in their study of 1,621 FNAC cases, and the most common type of malignancy was papillary carcinoma. Masereka et al. (17) also found PTC (84.6%) was the most common diagnosis. In the prospective study conducted by Gupta et al. (3) on 75 cases, the most common diagnosis was PTC (12 cases, 80%), similar to the result of our study.

In the study by Imamoglu et al. (6), of the 1,114 FNACs, 963 (86.5%) were benign, 79 (7.1%) were suspicious, 26 (2.3%) were malignant, and 46 (4.1%) were inadequate test material. Of the 52 malignant cases, 88.5% were diagnosed with PTC, 5.8% were diagnosed with follicular carcinoma, 3.8% were diagnosed with medullary carcinoma, and 1.9% was diagnosed with anaplastic carcinoma (6). Among 5,469 patients, Sangalli et al. (16) diagnosed 3361 (61.5%) as benign, 1105 (20.2%) as suspected of malignancy, 776 (14.2%) as malignant, and 227 (4.1%) as inadequate test material. In their study with 1,096 cases, Ugurluoglu et al. (4) diagnosed 12% of the cases as inadequate test material, 72% as benign, 3% as AUS/FLUS, 3% as FN/SFN, 4% as suspected malignancy, and 6% as malignant. The malignancy rates in the same cases were found to be 16%, 15%, 14%, 60%, 72%, and 97%, respectively (4), while PTC was reported at a rate of 94%, follicular carcinoma was at 5%, and medullary carcinoma was at 1% (4)

The sensitivity of thyroid FNAC varies between 57.8% and 98.1% in the literature, while its specificity varies in the range of 64.6%–98.8%, its NPV is in the range of 17.3%–100%, its PPV is in the range of 52.3%–99.3%, and its DA is in the range of 77.3%–98.4% (1, 4, 13, 18–21) (Table 5). Some authors have classified follicular lesions as malignant, while others have classified them as benign. Others have left these cases out of their calculations. As a result, the outcomes have varied in different studies (10, 20, 21). The sensitivity value in our study was 61.29%, the specificity value was 96.00%, NPV was 80.0%, PPV was 90.48%, and DA was 82.72%. Masereka et al. (17) discovered a lower specificity, similar to our study, of 61.5% and a sensitivity of 89.5%. The PPV and NPV in our study were found to be high.

According to the literature, some reasons for false-negative results are insufficient sampling, the cytopathologist's inexperience, and difficulties with the differential diagnosis of follicular lesions (6, 10). When the cytological samples of the cases with diagnostic mismatches were re-evaluated in our study, we found that MGG histochemical stains, which play an important role in diagnosis, were not suitable for evaluation. The number of false-negative cases in our study was 12 (6.97%), with 8 cases diagnosed as papillary PMC, 3 cases diagnosed as well-differentiated tumors with uncertain malignant potential, and 1 case diagnosed as NIFTP. Because 8 PMC cases in our study were found to be incidental, FNAC yielded negative cytological results because sampling was not performed from this focus. Because a PMC is only ≤1.0 cm in size, it can produce false-negative results (13).

Table 5. Literature data

Study	Year	Number of patients	Sensitivity	Specificity	Accuracy	NPV	PPV
Muratli et al. (5)	2014	126	87.1	64.6	77.3	79.5	76.1
Imamoglu (6)	2015	116	82.7	87.5	85.4	17.3	84.3
Yener et al. (2)	2019	34	81.81	86.20	85.0	92.59	69.23
Anand et al. (12)	2020	99	72.4	94.3	87.9	89.2	84
Zhu et al. (13)	2020	1122	98.1	81.5	97.5	61.1	99.3
Bohacek et al. (17)	2012	451	83.3	98.8		92.5	97.0
Gul et al. (8)	2009	249	89.1	98.7	96.3	96.3	96.1
Gupta et al. (3)	2010	75	80	86.6	84	86.6	80
Handa et al. (18)	2008	66	97	100	98.4	100	96
Erkinuresin et al. (1)	2020	149	57.8	88.1	82.5	90.2	52.3
Ugurluoglu et al. (4)	2015	1096	93	79	88	85	90
This study	2022	172	61.29	96.0	82.72	80.0	90.48

PPV: Positive predictive value; NPV: Negative predictive value

Cellularity was very low in three of the other false-negative cases. In these cases, no significant atypia was observed in the thyrocytes. As a result of sampling errors, these cases received false-negative diagnoses. On biopsy, only one patient was diagnosed with a well-differentiated tumor with uncertain malignant potential, and there were findings indicative of AUS, such as overlapping thyrocytes and nuclear contour disorder. Nevertheless, no cytological features necessitated a malignant diagnosis. The difference in evaluation among observers is thought to be the source of false negativity in this case. Wu et al. (15) discovered a 3% false-negative rate (11 cases) in their study, with 6 of them being diagnosed as incidental PMC. It was reported that these incidents were a result of sampling errors (15).

Our study had 2 (1.16%) false-positive cases, which were diagnosed as Bethesda 5 (suspected malignancy) in cytology and MNG in histopathology. Haberal et al. (10) discovered a false positivity rate of 15 (5.7%) in their cases, which were also hyperplastic nodules, as in ours. Overlapping cells may cause a false-positive diagnosis in hyperplastic nodules with increased cellularity (10). Errors can be caused by focal atypia in these nodules, groove structures, and overlapping (10, 13). The overlapping cytological features of a hyperplastic adenomatoid nodule, follicular adenoma, well-differentiated follicular carcinoma, and follicular variant papillary carcinoma are causes of limitations (10). Although cellularity was not very high in one of our false-positive cases, the thyrocytes had overlapping, nuclear clarification, and nuclear contour disorder. Furthermore, because follicular papillary carcinoma could not be ruled out due to the presence of microfollicular structures in the thyrocytes, it was classified as Bethesda 5. There was lymphocytic thyroiditis in the surgical material of this case, as well as suspicious cellular changes in the thyrocytes in these areas and in the thyrocytes within the nodule. In the other case, cellularity was extremely high, and Bethesda 5 was assigned due to the presence of cytological features indicative of papillary carcinoma and groove structures. When both cases were re-evaluated, it was considered that AUS/FLUS could be assigned instead of suspected malignancy. We believe that false positivity was due to the presence of suspicious cytological features in MNG and interobserver differences.

The AUS/FLUS category has different uses in different institutions, and it was reported that it should be 7% or lower (12). The AUS/FLUS category is a diverse group that includes structural abnormalities in follicular cells or nuclear atypia. Since these diagnoses are based on subjective criteria, the rate of diagnosis has been reported to vary between centers (5, 20). Muratli et al. (5) made this diagnosis at a rate of 12.1%. AUS/FLUS was diagnosed in 66 cases (38.37%) in our study, which was higher than those reported in the literature. We believe this was because the patients were cared for by pathologists with varying cytopathology experience levels, and treatment planning for these patients could not be accomplished through multidisciplinary meetings. Furthermore, it was reported that the FNAC technique, needle size, and slide fixation in the air or with alcohol may all contribute to AUS overdiagnosis (20). Because AUS/FLUS has a low malignancy risk, FNAC is performed again before excision, but surgery may be performed based on clinical and radiological findings (19). Some of our cases were referred to surgery not because of an AUS diagnosis, but for clinical complaints and cosmetic reasons.

Limitations

Although the number of cytological materials in our study was high, one of our limitations was the low number of cases with histopathological diagnoses.

CONCLUSION

For thyroid nodules, FNAC is a reliable minimally invasive method. The sensitivity and specificity of cytology were high in our study. Because FNAC has a limited diagnostic contribution in the diagnosis of PMC and follicular lesions, we believe that, in addition to gaining cytopathology experience, evaluating patients with clinical and radiological findings will be more beneficial for inpatient treatment.

Ethics Committee Approval: The Bolu Abant İzzet Baysal University Clinical Research Ethics Committee granted approval for this study (date: 05.10.2021, number: 2021/243).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – SED, NTK, HMA, SAK; Design – SED, HMA; Supervision – SED, HMA; Resource – SED; Materials – SED, NTK; Data Collection and/or Processing – SED, NTK; Analysis and/or Interpretation – SED, NTK, HMA, SAK; Literature Search – SED, NTK, HMA; Writing – SED, NTK, HMA, SAK; Critical Reviews – SED, NTK, HMA, SAK.

Conflict of Interest: The authors have no conflict of interest to declare.

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