



Evaluation of ultrasound and fine-needle aspiration in the assessment of head and neck lesions

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Abstract

Purpose Neck masses of uncertain character need further investigation through imaging and tissue sampling. This is the most extensive study in the literature of clinician-operated ultrasound and fine-needle aspiration (US + FNA) of the head and neck with histological verification, itemized into organ system. The purpose of the present study was to comprehensively evaluate the combination of US + FNA in the assessment of various kinds of head and neck lesions in the hand of the clinician in one single study.

Methods A total of 408 histologically verified head and neck lesions in 376 consecutive patients undergoing all three diagnostic steps (US, FNA, US + FNA) were included. Excisional biopsy or core-needle biopsy served as a gold standard. US and FNA were evaluated alone and in combination to distinguish between malignant and benign lesions as well as to establish an approximate and specific diagnosis. Each calculation was itemized by organ system.

Results In detecting malignancy, US + FNA showed a significantly higher accuracy (97% vs 86% and 92%) than US and FNA alone. An approximate diagnosis was established in 93%, and a specific diagnosis in 88%, which was significantly better than that of US and FNA alone.

Conclusion US + FNA is suited for an efficient evaluation of head and neck masses. This combined method should be the first line of investigation in such lesions before any other imaging and/or sampling methods. While discrepancies in diagnostic findings potentially occur, the key is the interpretation of the package (US and cytologic findings, clinical information) made in one consultation by one clinician to proceed in proper decision making regarding an adequate treatment plan. Consequently US + FNA belong to the standard armamentarium of the otolaryngologist.

Keywords Diagnostic imaging · Tissue sampling · Lymph nodes · Soft tissue · Thyroid · Salivary gland

Introduction

Otolaryngologists are often confronted with lesions in the head and neck. These lesions can originate from different organ systems such as lymph nodes, salivary glands, soft tissue and thyroid gland. Depending on the affected structure, several differential diagnoses come into consideration.

The clinician primarily gathers information from medical history and physical examination. To further assess neck masses of uncertain character, different imaging modalities such as computed tomography (CT), positron emission

tomography (PET), magnetic resonance imaging (MRI) and ultrasound (US) are used [1]. These normally belong to the armamentarium of the radiologist, whereas financial aspects and availability factor into the decision of approach. However, none of the above-mentioned imaging modalities are able to clearly distinguish between malignant and benign nor accurately predict the specific diagnosis of a lesion [2]. Therefore, neck masses of uncertain character need further investigation through specimen collection, which generally includes fine-needle aspiration (FNA), core-needle biopsy or excisional biopsy.

On the one hand, US is a cost-efficient, broadly available, simple and non-invasive method for the initial evaluation of a head and neck lesion. On the other hand, FNA has emerged as a simple, accurate, fast and economical diagnostic tool. Thus, a combination of ultrasound and

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fine-needle aspiration (US + FNA) seems to be suited for an efficient evaluation of suspicious lesions in this region.

The purpose of this study was to comprehensively evaluate the combination of US + FNA in the assessment of various kinds of head and neck lesions in the hand of the clinician in one single study.

Materials and methods

A retrospective case series including a total of 408 histologically verified head and neck lesions in 376 consecutive patients was performed. The diagnostic investigation consisted of obtaining a medical history (including information about bleeding tendency, intake of platelet-inhibiting medications and/or anticoagulants), physical examination, laboratory tests (if considered necessary), cervical US and subsequent FNA. Then, histological verification by excisional biopsy or core-needle biopsy was carried out, which served as the gold standard for establishing a specific diagnosis. Only patients undergoing all three diagnostic steps were included in the present study, disregarding age and sex. In this respect, informed consent was obtained from the patient or their guardian to perform US, FNA and biopsy. All methods were performed in accordance with the relevant guidelines and regulations. The study protocol met the ethical standards of the Declaration of Helsinki in its current version.

An Acuson X700 (Siemens Healthcare, Zurich, Switzerland) ultrasonograph with a 12-MHz VF12-4 linear transducer was used for the investigation of the neck. Each patient received ultrasound-guided FNA by an experienced clinician. Cytological and histological specimens were evaluated by the local pathologist in a semi-blinded manner. FNA was carried out with a 24-gauge needle after a modified technique as described elsewhere [3]. The cytopathologist was present during the FNA procedure and fixed the smears himself immediately before taking the samples to the department of pathology for staining, microscopic examination and diagnosis. This results in a semi-blinded study.

US and FNA were evaluated alone and in combination to distinguish between malignant and benign lesions as well as to establish an approximate and specific diagnosis. Sensitivity, specificity, accuracy, and positive and negative predictive value in detecting malignancy were calculated for each method. Furthermore, each calculation was also itemized by organ system such as lymph nodes, salivary glands, soft tissue and thyroid gland. Fisher's exact test was used for statistical analysis. A *p* value of <.05 was considered statistically significant, whereas *p* values of <.01 were defined as highly significant.

Results

Clinical data and histopathology

There were 234 male (62%) and 142 female patients (38%). The mean age at diagnosis was 54 years (range 1–94 years). In accordance with the World Health Organization (WHO) classification [4], a total of 408 head and neck lesions in 376 consecutive patients were observed. On the one hand, 269 (66%) were neoplastic lesions and 139 (34%) non-neoplastic. On the other hand, 187 (46%) were malignant lesions and 221 (54%) benign (Tables 1, 2). The neck masses consisted of a wide range of different pathologies found in the head and neck. They were itemized into 4 different organ systems and consisted of 189 (46%) lymph node, 103 (25%) salivary gland, 72 (18%) soft tissue and 44 (11%) thyroid gland pathologies. The malignant tumors consisted of 120 (30%) lymph node, 29 (7%) salivary gland, 21 (5%) soft tissue and 17 (4%) thyroid gland neoplasms. The benign tumors included 61 (15%) salivary gland, 14 (3%) soft tissue and 7 (2%) thyroid gland lesions. The specific diagnoses of all head and neck lesions are listed in Table 3. The combination of US + FNA showed the highest rate of correctly established approximate and specific diagnosis compared to the two investigation methods alone (Tables 9, 10). In total, there were 33 (8%) non-diagnostic samples, of which 24 (6%) occurred in the thyroid gland. There were no complications such as bleeding, infection, nerve injury or tumor cell seeding in our series.

All head and neck lesions

In detecting malignancy, US + FNA showed a significantly higher accuracy (97% vs 86% and 92%) than US and FNA alone (Table 4). Only four false-positive and eight false-negative results were found in US + FNA. FNA alone also achieved a higher accuracy than US alone in all head and neck lesions (92% vs 86%). With the help of US + FNA, an approximate diagnosis was established in 93%, and a specific diagnosis in 88% (Tables 9, 10). These results were significantly better than those of US and FNA alone.

Lesions itemized by organ system

As shown in Tables 4, 5, 6, 7 and 8, US + FNA showed significantly better results regarding accuracy in detecting malignancy compared to US and FNA alone. Furthermore, with the help of US + FNA, the rate of an approximate

Table 1 Approximate diagnosis of head and neck lesions as a function of organ system ($n = 408$)

WHO classification	Lymph nodes	Salivary glands	Soft tissue	Thyroid gland	All lesions
Malignant tumors	120 (30%)	29 (7%)	21 (5%)	17 (4%)	187 (46%)
Metastasis	95	5	14	0	114
Carcinoma	0	21	6	17	44
Lymphoma	25	3	0	0	28
Sarcoma	0	0	1	0	1
Benign tumors	0 (0%)	61 (15%)	14 (3%)	7 (2%)	82 (20%)
Adenoma	0	38	0	7	45
Warthin tumor	0	20	0	0	20
Epidermoid cyst	0	0	5	0	5
Lipoma	0	2	2	0	4
Schwannoma	0	0	3	0	3
Other	0	1	4	0	5
Non-neoplastic lesions	69 (17%)	13 (3%)	37 (9%)	20 (5%)	139 (34%)
Lymphadenopathy	38	1	0	0	39
Cyst/fistula	0	4	25	3	32
Lymphadenitis	31	0	0	0	31
Nodular goiter	0	0	0	16	16
Abscess	0	2	8	0	10
Sialadenitis	0	6	0	0	6
Other	0	0	4	1	5
Total lesions	189 (46%)	103 (25%)	72 (18%)	44 (11%)	408 (100%)

WHO World Health Organization

Percentage of total lesions in parenthesis

diagnosis and specific diagnosis was significantly higher than by US alone (Tables 9, 10).

Discussion

To our knowledge, this is the most extensive study in the literature of clinician-operated US + FNA of the head and neck. All samples were histologically verified and itemized into the different organ systems. US + FNA was performed by only a few investigators using always the same technique. Patient care, interpretation of the diagnostic steps and counseling of the patient were made by the same clinician. So far, only a few research groups described the diagnostic accuracy of US + FNA in head and neck lesions [5, 6]. However, the majority of their results were not histologically verified, and their case series were considerably lower than ours. Likewise, other publications often included only a single organ system in the head and neck such as lymph nodes, salivary glands or thyroid gland [7, 8].

Nevertheless, the present study has a few potential limitations. First, it shows a retrospective design. In addition, many benign lesions on initial US examination or consecutive FNA were excluded from the study, and only suspicious or bothersome lesions were operated and thus histologically verified. In such a manner, a certain selection

bias is possible. This is especially true in the thyroid gland explaining the relatively low number and less convincing results in our series. However, many lesions would not have been detected without previous US examination and subsequently not cytologically assessed by FNA. With the help of US, accurate visualization also allowed for sampling of non-palpable lesions, which is especially important in tumor follow-up.

In the assessment of head and neck lesions, otolaryngologists primarily gather clinical information through medical history and physical examination to narrow the differential diagnosis. During the further procedure, imaging and tissue sampling are frequently required, but availability and finances often determine the course of approach.

US is a favorable mode of imaging in terms of availability and cost efficiency in comparison to CT and MRI. Furthermore, it is a dynamic real-time examination method allowing for sonopalpation and performing FNA in one step [9]. US alone has high sensitivity but low specificity, especially in determining if a lesion is benign or malignant. Recently, US elastography has been described as a possible technique to identify malignant cervical lesions [10]. However, none of the imaging modalities are able to clearly distinguish between malignant and benign. Therefore, neck masses of uncertain character need further investigation through tissue sampling.

Table 2 Approximate diagnosis of head and neck lesions as a function of investigation method ($n=408$)

WHO classification	US alone	FNA alone	US + FNA	All lesions
Malignant tumors	138 (74%)	161 (86%)	173 (93%)	187 (100%)
Metastasis	91	101	108	114
Carcinoma	25	35	37	44
Lymphoma	22	24	27	28
Sarcoma	0	1	1	1
Benign tumors	59 (72%)	68 (83%)	69 (84%)	82 (100%)
Adenoma	33	36	37	45
Warthin tumor	20	21	21	20
Epidermoid cyst	2	5	5	5
Lipoma	3	4	4	4
Schwannoma	1	2	2	3
Other	0	0	0	5
Non-neoplastic lesions	109 (78%)	125 (90%)	130 (94%)	139 (100%)
Lymphadenopathy	32	39	39	39
Cyst/fistula	28	29	31	32
Lymphadenitis	24	29	31	31
Nodular goiter	14	14	14	16
Abscess	5	7	8	10
Sialadenitis	4	4	4	6
Other	2	3	3	5
Total lesions	306 (75%)	354 (87%)	372 (91%)	408 (100%)

Percentage of total lesions in parenthesis

WHO World Health Organization, US ultrasound, FNA fine-needle aspiration, US + FNA combination of US and FNA

The favorable mode of specimen collection is FNA in terms of cost and time efficiency, which can be realized by a clinician on an outpatient basis [11]. US-guided FNA has replaced palpation-guided FNA due to a clear visualization of neck masses before becoming clinically apparent [12]. Avoiding necrotic and cystic parts of tumors or nodules allows for targeted aspiration of representative samples under US guidance providing better accuracy. So far, clinical examination, imaging and sampling have been in the hand of potentially three different professionals such as otolaryngologists, radiologists and pathologists. However, to provide the finest patient care and counseling, it would be an advantage to put these three modalities in the hand of the same clinician.

FNA is known to have high specificity and moderate sensitivity in detecting malignancy [13]. However, the latter supplies non-diagnostic material in 10–15% of cases, and even more if performed palpation guided. Furthermore, it is to be considered that another factor contributing to diagnostic accuracy of FNA is the experience of the cytopathologist [14]. In the literature, non-diagnostic samples are usually

reported as false-negative results. They can occur when taking samples of unfavorable sites of a lesion such as necrotic, cystic or vascularized areas. The majority of non-diagnostic samples in our series occurred in the thyroid gland. To date, studies assessing the role of FNA in the head and neck mostly evaluated thyroid nodules or salivary glands [15–18]. The thyroid gland is a well blood-perfused organ and thus bears a higher probability for non-diagnostic samples due to excessive blood aspiration. Blood perfusion is even more elevated in inflammatory or neoplastic lesions. However, even with a moderate non-diagnostic rate, the clinician can take the pretest probability of clinical information, course of disease and cervical US of their patients into account when interpreting FNA results.

The Bethesda system is a standardized, category-based reporting system for thyroid cytology dividing results into six categories [19]. Inadequate samples are reported as non-diagnostic and fall into category I. In that case, FNA should be repeated. Non-diagnostic samples include specimens with obscuring blood, poor cell preservation or an insufficient sample of follicular cells. For a satisfactory and benign specimen, at least six groups of benign follicular cells are required, each group being composed of at least ten cells. Excessive suction during FNA draws too much obscuring blood into the sample. In contrast, too little suction results in a minimal cell count. In such a manner, the use of a thin needle during aspiration, visualization of the needle within the lesion by US and moderate suction are crucial for adequate sampling, especially in the thyroid gland. However, even with the best technique, there will always remain a certain rate of unsatisfactory specimens in FNA.

Clinical information including US and FNA findings are key to establish the further process in decision making, especially in cases where there is a discrepancy between the diagnostic findings [5]. The combination of US + FNA with consideration of all clinical information established an approximate diagnosis rate of 93%. Although the specific diagnosis is lower, the approximate diagnosis is usually sufficient to determine an adequate treatment plan. In such a manner, the clinician is able to proceed in proper decision making. Only in multimorbid or non-operable patients, a specific diagnosis might be more suitable for further procedure. In summary, other more expensive imaging methods such as MRI, CT or PET-CT are often not initially necessary. In cases where malignancy is suspected or a lesion cannot be demarcated by US, well-directed imaging is appropriate.

FNA is frequently unable to differentiate between different subtypes of head and neck tumors and to clearly diagnose cystic metastasis. However, clues in cytology can lead the otolaryngologist to the correct decision, especially with consideration of the clinical information and US findings. In rare cases, FNA causes complications such as bleeding, infection, nerve injury or tumor cell seeding [20]. In our

Table 3 Specific diagnosis of head and neck lesions as a function of organ system ($n = 408$)

WHO classification	Lymph nodes	Salivary glands	Soft tissue	Thyroid gland
Malignant tumors (187)				
Metastasis (114)	Squamous cell ca (55) Adeno ca (14) Papillary ca (8) Mucoepidermoid ca (4) Poorly diff ca (3) Lymphoepithelial ca (2) Superf spreading me (2) Nodular me (1) Follicular ca (1) Acinic cell ca (1) Salivary duct ca (1) Urothelial ca (1) Terato ca (1) Leiomyo sa (1)	Squamous cell ca (3) Glioblastoma (1) Nodular me (1)	Squamous cell ca (7) Adeno ca (2) Superf spreading me (2) Spitzoid me (1) Sebaceous gland ca (1) Transitional cell ca (1)	
Carcinoma (44)		Mucoepidermoid ca (4) Adenoid cystic ca (3) Acinic cell ca (3) Adeno ca (3) Basal cell adeno ca (2) Hurthle cell ca (2) Basal cell ca (1) Salivary duct ca (1) Myoepithelial ca (1) Ca ex pleomorphic ad (1)	Squamous cell ca (5) Spitzoid me (1)	Papillary ca (12) Follicular ca (3) Poorly diff ca (2)
Lymphoma (28)	Diffuse large cell ly (8) Follicular B-cell ly (4) Nodular sclerosing hl (4) Mixed-cellularity hl (3) Mantle cell ly (3) Marginal zone ly (2) Burkitt B-cell ly (1)	Diffuse large cell ly (2) Follicular B-cell ly (1)		
Sarcoma (1)			Lipo sa (1)	
Benign tumors (82)				
Adenoma (45)		Pleomorphic ad (35) Basal cell ad (2) Monomorphic ad (1) Warthin tumor (20)		Follicular ad (6) Hurthle cell ad (1)
Warthin tumor (20)				
Epidermoid cyst (5)			Epidermoid cyst (5)	
Lipoma (4)		Lipoma (2)	Lipoma (2)	
Schwannoma (3)			Schwannoma (3)	
Other (5)		Lymphoepithelial cyst (1)	Hemangioma (2) Pilomatrixoma (1) Squamous metaplasia (1)	
Non-neoplastic lesions (139)				
Lymphadenopathy (39)	Reactive node (38)	Reactive node (1)		
Cyst/fistula (32)		Salivary gland cyst (4)	Thyroglossal cyst (15) Branchial cyst (9) Thyroglossal fistula (1)	Thyroid cyst (3)
Lymphadenitis (31)	Unspecific (19)			

Table 3 (continued)

WHO classification	Lymph nodes	Salivary glands	Soft tissue	Thyroid gland
	Toxoplasmosis (4)			
	Tuberculosis (3)			
	Cat scratch (2)			
	Sarcoidosis (2)			
	Cytomegaly (1)			
Nodular goiter (16)				Nodular goiter (16)
Abscess (10)		Abscess (2)	Abscess (8)	
Sialadenitis (6)		Acute sialadenitis (2)		
		Chronic sialadenitis (4)		
Other (5)			Seroma (2)	Thyroiditis (1)
			Fibrosis (1)	
			Unspecific (1)	

Absolute number of lesions in parenthesis

WHO World Health Organization, *ad* adenoma, *ca* carcinoma, *diff* differentiated, *hl* Hodgkin's lymphoma, *ly* non-Hodgkin's lymphoma, *me* melanoma, *sa* sarcoma, *superf* superficial

Table 4 Detection of malignancy in all head and neck lesions ($n=408$)

Method	Sensitivity	Specificity	Accuracy	Pos. pred. value	Neg. pred. value
Comparison of US + FNA and US alone					
US + FNA	96% [†] ($p=.001$)	98% [†] ($p=.001$)	97% [†] ($p=.001$)	98% [†] ($p=.001$)	96% [†] ($p=.001$)
US alone	80%	90%	86%	88%	84%
Comparison of US + FNA and FNA alone					
US + FNA	96% [†] ($p=.001$)	98% ($p=.492$)	97% [†] ($p=.001$)	98% ($p=.447$)	96% [†] ($p=.001$)
FNA alone	86%	98%	92%	97%	89%
Comparison of FNA alone and US alone					
FNA alone	86% ($p=.076$)	98% [†] ($p=.001$)	92% [†] ($p=.002$)	97% [†] ($p=.001$)	89% ($p=.085$)
US alone	80%	90%	86%	88%	84%

Malignant tumors are classified as positive, benign lesions as negative for the calculation of sensitivity, specificity, accuracy, and positive and negative predictive values

US ultrasound, FNA fine-needle aspiration, US + FNA combination of US and FNA

[†]high statistical significance ($p < .01$)

Table 5 Detection of malignancy in lymph node lesions ($n=189$)

Method	Sensitivity	Specificity	Accuracy	Pos. pred. value	Neg. pred. value
Comparison of US + FNA and US alone					
US + FNA	96%* ($p=.017$)	100% [†] ($p=.001$)	97% [†] ($p=.001$)	100% [†] ($p=.001$)	93%* ($p=.013$)
US alone	87%	84%	86%	90%	80%
Comparison of US + FNA and FNA alone					
US + FNA	96%* ($p=.017$)	100% ($p=.496$)	97%* ($p=.011$)	100% ($p=.482$)	93%* ($p=.026$)
FNA alone	88%	99%	92%	99%	82%
Comparison of FNA alone and US alone					
FNA alone	88% ($p=.568$)	99% [†] ($p=.002$)	92% ($p=.070$)	99% [†] ($p=.004$)	82% ($p=.441$)
US alone	87%	84%	86%	90%	80%

Malignant tumors are classified as positive, benign lesions as negative for the calculation of sensitivity, specificity, accuracy, and positive and negative predictive values

US ultrasound, FNA fine-needle aspiration, US + FNA combination of US and FNA

*Statistical significance ($p < .05$); [†]high statistical significance ($p < .01$)

Table 6 Detection of malignancy in salivary gland lesions ($n=103$)

Method	Sensitivity	Specificity	Accuracy	Pos. pred. value	Neg. pred. value
Comparison of US + FNA and US alone					
US + FNA	100% [†] ($p=.002$)	99% ($p=.104$)	99% [†] ($p=.001$)	97% ($p=.070$)	100% [†] ($p=.004$)
US alone	74%	93%	87%	82%	89%
Comparison of US + FNA and FNA alone					
US + FNA	100%* ($p=.013$)	99% ($p=.748$)	99%* ($p=.033$)	97% ($p=.710$)	100%* ($p=.017$)
FNA alone	81%	99%	93%	96%	92%
Comparison of FNA alone and US alone					
FNA alone	81% ($p=.356$)	99% ($p=.108$)	93% ($p=.119$)	96% ($p=.105$)	92% ($p=.380$)
US alone	74%	93%	87%	82%	89%

Malignant tumors are classified as positive, benign lesions as negative for the calculation of sensitivity, specificity, accuracy, and positive and negative predictive values

US ultrasound, FNA fine-needle aspiration, US + FNA combination of US and FNA

*Statistical significance ($p < .05$); [†]high statistical significance ($p < .01$)

Table 7 Detection of malignancy in soft tissue lesions ($n=72$)

Method	Sensitivity	Specificity	Accuracy	Pos. pred. value	Neg. pred. value
Comparison of US + FNA and US alone					
US + FNA	95%* ($p=.047$)	98% ($p=.181$)	97%* ($p=.015$)	95% ($p=.141$)	98% ($p=.062$)
US alone	71%	92%	86%	79%	89%
Comparison of US + FNA and FNA alone					
US + FNA	95% ($p=.187$)	98% ($p=.748$)	97% ($p=.221$)	95% ($p=.731$)	98% ($p=.194$)
FNA alone	82%	98%	93%	95%	92%
Comparison of FNA alone and US alone					
FNA alone	82% ($p=.328$)	98% ($p=.187$)	93% ($p=.137$)	95% ($p=.170$)	92% ($p=.371$)
US alone	71%	92%	86%	79%	89%

Malignant tumors are classified as positive, benign lesions as negative for the calculation of sensitivity, specificity, accuracy, and positive and negative predictive values

US ultrasound, FNA fine-needle aspiration, US + FNA combination of US and FNA

*Statistical significance ($p < .05$); [†]high statistical significance ($p < .01$)

Table 8 Detection of malignancy in thyroid gland lesions ($n=44$)

Method	Sensitivity	Specificity	Accuracy	Pos. pred. value	Neg. pred. value
Comparison of US + FNA and US alone					
US + FNA	82%* ($p=.035$)	96% ($p=.755$)	91% ($p=.072$)	93% ($p=.620$)	90% ($p=.105$)
US alone	47%	96%	77%	89%	74%
Comparison of US + FNA and FNA alone					
US + FNA	82% ($p=.672$)	96% ($p=.755$)	91% ($p=.643$)	93% ($p=.759$)	90% ($p=.665$)
FNA alone	82%	96%	91%	93%	90%
Comparison of FNA alone and US alone					
FNA alone	82%* ($p=.035$)	96% ($p=.755$)	91% ($p=.072$)	93% ($p=.620$)	90% ($p=.105$)
US alone	47%	96%	77%	89%	74%

Malignant tumors are classified as positive, benign lesions as negative for the calculation of sensitivity, specificity, accuracy, and positive and negative predictive values

US ultrasound, FNA fine-needle aspiration, US + FNA combination of US and FNA

*Statistical significance ($p < .05$); [†]high statistical significance ($p < .01$)

Table 9 Correctly estimated approximate diagnosis of head and neck lesions ($n=408$)

Method	Lymph nodes	Salivary glands	Soft tissue	Thyroid gland	All lesions
Comparison of US + FNA and US alone					
US + FNA	95% [†] ($p=.001$)	98% [†] ($p=.001$)	96% [†] ($p=.001$)	80%* ($p=.019$)	93% [†] ($p=.001$)
US alone	81%	79%	69%	57%	75%
Comparison of US + FNA and FNA alone					
US + FNA	95% ($p=.077$)	98% [†] ($p=.001$)	96% ($p=.247$)	80% ($p=.500$)	93% [†] ($p=.003$)
FNA alone	91%	85%	92%	82%	87%
Comparison of FNA alone and US alone					
FNA alone	91% [†] ($p=.005$)	85% ($p=.138$)	92% [†] ($p=.001$)	82%* ($p=.010$)	87% [†] ($p=.001$)
US alone	81%	79%	69%	57%	75%

Correctly estimated approximate diagnoses are classified as positive, falsely as negative for the calculation of accuracy

US ultrasound, FNA fine-needle aspiration, US + FNA combination of US and FNA

*Statistical significance ($p < .05$); [†]high statistical significance ($p < .01$)

Table 10 Correctly estimated specific diagnosis of head and neck lesions ($n=408$)

Method	Lymph nodes	Salivary glands	Soft tissue	Thyroid gland	All lesions
Comparison of US + FNA and US alone					
US + FNA	84% [†] ($p=.001$)	98% [†] ($p=.001$)	93% [†] ($p=.001$)	73% [†] ($p=.001$)	88% [†] ($p=.001$)
US alone	58%	60%	67%	36%	58%
Comparison of US + FNA and FNA alone					
US + FNA	84% ($p=.252$)	98% [†] ($p=.001$)	93% ($p=.281$)	73% ($p=.500$)	88% [†] ($p=.003$)
FNA alone	80%	79%	89%	70%	80%
Comparison of FNA alone and US alone					
FNA alone	80% [†] ($p=.001$)	79% [†] ($p=.003$)	89% [†] ($p=.001$)	70% [†] ($p=.001$)	80% [†] ($p=.001$)
US alone	58%	60%	67%	36%	58%

Correctly estimated specific diagnoses are classified as positive, falsely as negative for the calculation of accuracy

US ultrasound, FNA fine-needle aspiration, US + FNA combination of US and FNA

[†]high statistical significance ($p < .01$)

series of 408 head and neck lesions, there were no complications. However, US + FNA is highly experience dependent. Understanding anatomy and disease process, application of a proper technique and recognition of pitfalls make US + FNA a successful tool for the otolaryngologist. Given the importance of clinical information gathered by the clinician, the high sensitivity of US and high specificity of FNA, imaging and specimen collection should become established as an integral part of our specialist education.

In conclusion, US + FNA is suited for an efficient evaluation of head and neck masses, explicitly for accurate visualization of non-palpable or clinically inapparent lesions as well as targeted sampling in large masses. This combined method should be the first line of investigation in such lesions before any other imaging and/or sampling methods and should be analyzed together with the patient's medical history and physical examination. While discrepancies in diagnostic findings potentially occur, the key is the interpretation of the package (US and cytologic

findings, clinical information) made in one consultation by one clinician, leading to an approximate diagnosis, which is typically sufficient to proceed in proper decision making regarding an adequate treatment plan. Consequently, US + FNA belong to the standard armamentarium of the otolaryngologist.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All methods were performed in accordance with the relevant guidelines and regulations. The study protocol met the ethical standards of the Declaration of Helsinki in its current version.

Informed consent Informed consent to perform US, FNA and biopsy was obtained from all individual participants or their guardians.

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