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Research Article

What is the Best Imaging Modality for Glandular Lesions of the Neck

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Abstract

Objectives: To assess the reliability of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) and ultrasound (US) in evaluating thyroid and salivary glands lesions.

Background: The thyroid and salivary glands are regions of considerable anatomical and functional complexity with a challenging diagnosis. CT or MRI or US is performed for pretherapeutic assessment of their Lesions. All can supply the information needed by the clinician for adequate treatment planning.

Patients and Methods: 21 patients with thyroid lesions and 13 patients with salivary glands lesions were evaluated by CT and/or MRI and/or US according to the decision of the treating physician. The results of imaging were assessed based on the corresponding histopathological diagnosis to define the true benign, true malignant, false benign and false malignant results. Statistical analysis was done to calculate the sensitivity, specificity, accuracy, positive predictive value and negative predictive value of each technique.

Results: The study included 34 patients distributed among 2 anatomical lesions thyroid (21), salivary glands (13). The lesions included 18 malignant, 10 benign neoplastic and 6 inflammatory lesions. U.S was performed for all patients while C.T was performed for 27 patients while MRI was performed for 20 patients. US for thyroid revealed a sensitivity of 91.7%, a specificity of 77.8%, a diagnostic accuracy of 85.7%. CT for thyroid revealed a sensitivity of 70%, a specificity of 66.7%, a diagnostic accuracy of 68.8%. MRI for thyroid revealed a sensitivity of 75%, a specificity of 75% and a diagnostic accuracy of 75%. US for salivary glands revealed a sensitivity of 83.3%%, a specificity of 85.7%, a diagnostic accuracy of 84.6%. CT for salivary glands revealed a sensitivity of 80.9%, a specificity of 83.3%, a diagnostic accuracy of 81.7%. MRI for salivary glands revealed a sensitivity of 100%, a specificity of 75% and a diagnostic accuracy of 87.5%.

Conclusion: Ultrasound, computed tomography and magnetic resonance imaging, all are effective imaging modalities for evaluating a gland mass. Every anatomical region in the neck has its own criteria making it the target of a specific imaging modality. So ultrasound is the preferred imaging technique for thyroid and salivary glands followed by MRI then C.T.

Keywords: Computed Tomography; Magnetic Resonance Imaging; Ultrasonography; Thyroid; Salivary Glands; Sensitivity; Specificity; Accuracy

Introduction

The thyroid and salivary glands are regions of considerable anatomical and functional complexity, making the accurate diagnosis of their lesions a challenging task [1].

Modern imaging modalities visualize thyroid and salivary glands to an unprecedented level of detail. If carefully performed and interpreted, these techniques allow a comprehensive evaluation of the extent of their lesions [1]. Ultrasonography (US), Computed tomography (CT) or magnetic resonance imaging (MRI) is performed for pretherapeutic assessment of these Lesions. These techniques can supply the information needed by the clinician for adequate treatment planning [2].

Ultrasonography is a widely used technique for the evaluation of the thyroid gland and salivary glands, as it offers visualization of these structures with high spatial resolution, at a low cost and without using ionizing radiation. Ultrasonography in combination with fine needle aspiration cytology (FNAC) is the most accurate method for staging in most head and neck cancers [3].

The aim of this work is to assess the reliability of US, CT and MRI in evaluating thyroid and salivary glands lesions in terms of sensitivity, specificity and diagnostic accuracy with comparison between these imaging modalities.

Patients and Methods

The current study is an observational prospective case series study that was carried out on patients with thyroid and salivary gland lesions retrieved from the outpatient clinic of otorhinolaryngology department, Menoufia University hospital.

Patients selected for this study included those with acute or insidious onset of thyroid and salivary gland lesions. Patients with previous operation on the neck, previous radiotherapy to the neck or patients with congenital lesions were excluded from this study. Known hypersensitivity to contrast materials used with CT and MRI or History of cardiac pacemakers or any metallic implant contraindicated with MRI were exclusion criteria for our study.

All patients were assessed by full history taking: including age, sex, onset and course of swelling and symptoms of inflammation (fever-pain) or malignancy (loss of weight-anorexia). General examination was done including body built and vital signs. Neck examination was performed for each case for assessment of the site, size, consistency, surface, borders and mobility of any neck swelling with emphasis on thyroid and salivary gland swellings. Indirect laryngoscopy was performed for thyroid cases for assessment of vocal cord mobility.

Patients with thyroid and salivary gland lesions were evaluated by US, C.T or MRI according to the decision of the physician and the need for the imaging modality to reach a diagnosis.

Neck ultrasonography was performed with Gray-scale US coupled with color Doppler flow imaging was performed to all patients using a high frequency (7-15MHz) linear-array two dimensional transducers. Color and spectral Doppler analysis were performed to locate any abnormal vessels or vascularized tissue within the cysts. The morphological features including swelling location and its relation to the surrounding structures and wall thickness and echogenicity and vascularity of swelling were evaluated.

Computed Tomography with contrast was performed around matrix 512 x 512 pixels during bolus injection of intravenous contrast stressed on axial cuts. The whole neck will be scanned with 5 –mm cuts while the level of the larynx will be scanned with 1 mm to 3.00 mm cuts. Comments on CTs were documented with stress on the lesion site, size, shape, spread, relations and effects to surroundings and lymph nodes. The site of the lesion, the size of primary disease, the extent of involvement, enhancement pattern, calcification, necrosis, local extension and distant metastasis were reported.

Magnetic Resonance Imaging (MRI) with intravenous contrast (gadolinium) was performed using a 1.5T initially; coronal, sagittal and transverse planes localizer images were obtained. Subsequently T1W, T2W as well as postcontrast (after administration of 10 ml of IV Gadolinium) were obtained. Imaging parameters included a slice thickness of 3 or 4 mm with a 0- to 1-mm intersectional gap, a field of view of 20 x20 cm or less and acquisition matrix 256 X 256.

The definite diagnosis of each case of thyroid and salivary gland lesion was made based on the result of histopathological examination of tissue biopsy either Tru-cut biopsy or excisional biopsy.

Outcome assessment

These results of imaging studies US, CT, MRI were divided into malignant and benign lesions. The latter included benign tumors and inflammatory lesions.

Statistical analysis

The number of cases with true benign, true malignant, false benign and false malignant results for each imaging modality was used to calculate sensitivity, specificity, diagnostic accuracy, Precision (positive predictive value) and negative predictive value as follows:

- Sensitivity = True positive cases/(True positive cases + False negative cases).
- Specificity = True negative cases/(True negative cases + False positive cases).
- Diagnostic accuracy = (True positive cases + True negative cases)/(True positive + True negative + False positive + False negative).
- Precision (Positive predictive value) = True positive cases/(True positive cases + False positive cases).
- Negative predictive value = True negative cases/(True negative cases + False negative cases).
- The previous parameters were calculated for each imaging modality considering malignant cases as positive and benign cases as negative.

The results of CT and US for cases who were subjected to both modalities or the results of MRI and US were used to compare the two imaging modalities in diagnosing lesions of the thyroid and salivary gland lesions using Chi square test or Fischer exact test with p value < 0.05 considered significant and p value < 0.01 highly significant.

Results

The study included 34 patients distributed among 2 anatomical lesions thyroid (21), salivary glands (13). The lesions included 18 malignant, 10 benign neoplastic and 6 inflammatory lesions. U.S was performed for all patients while C.T was performed for 27 patients while MRI was performed for 20 patients (Table 1).

		Number of patients	percentage of patients	Total
Sex	Male	24	70.5%	34
	Female	10	29.5%	
Age	0-20	5	14.7%	34
	21-40	14	41.1%	
	41-60	9	26.6%	
	> 60	6	17.6%	
Anatomical Location	thyroid	21	61.8%	34
	Salivary glands	13	38.2%	
Final Diagnosis	Malignant Lesion	18	52.9%	34
	Benign Tumor	10	29.5%	
	Inflammatory	6	17.6%	

Table 1: Distribution of study patients according to sex, age, anatomical location of mass and final diagnosis.

US for thyroid revealed a sensitivity of 91.7%, a specificity of 77.8%, a diagnostic accuracy of 85.7%. CT for thyroid revealed a sensitivity of 70%, a specificity of 66.7%, a diagnostic accuracy of 68.8%, and MRI for thyroid revealed a sensitivity of 75%, a specificity of 75% and a diagnostic accuracy of 75% (Table 2), (Figure 1, 2).

sa		Histopathological Diagnosis			Sens	Spec	Acc	PPV	NPV
Malignant		Benign	Total						
CT	Malignant	7	2	9	70%	66.7%	68.8%	77.8%	57.1%
	Benign	3	4	7					
	Total	10	6	16					
MRI	Malignant	6	1	7	75%	75%	75%	85.7%	60%
	Benign	2	3	5					
	Total	8	4	12					
US	Malignant	11	2	13	91.7%	77.8%	85.7%	84.6%	87.5%
	Benign	1	7	8					
	Total	12	9	21					

Table 2: Evaluation of results of different imaging modalities for the thyroid based on histopathological diagnosis.

Sens: Sensitivity, Spec: Specificity, Acc: Accuracy, PPV: Positive Predictive Value, NPV: Negative Predictive Value.

Figure 1: Results of C.T and MRI and US for thyroid.

US for salivary glands revealed a sensitivity of 83.3%%, a specificity of 85.7%, a diagnostic accuracy of 84.6%. CT for salivary glands revealed a sensitivity of 80.9%, a specificity of 83.3%, a diagnostic accuracy of 81.7%, and MRI for salivary glands revealed a sensitivity of 100%, a specificity of 75% and a diagnostic accuracy of 87.5% (Table 3) (Figure 3, 4).

Comparing the overall results of CT and US for thyroid lesions as correct and incorrect diagnosis showed The Chi-square statistic is 3.2821. The P value is 0.070041. This result is significant at $p < 0.10$, and is not significant at $p < 0.05$. Comparing the overall results of MRI and US for thyroid lesions as correct and incorrect diagnosis showed The Chi-square statistic is 4.8. The P value is 0.02846. This result is significant at $p < 0.05$ (Table 4, 5).

Figure 2: A: A 24-year-old woman with metastatic papillary carcinoma including a Delphian nodal metastasis. Axial enhanced CT image shows a large mass in the right lobe of the thyroid (M). There are heterogeneously enhancing right level IV nodal masses (arrows) and an enlarged Delphian node (arrowhead). B: Ultrasound of a papillary carcinoma shows small hypoechoic solid nodule (N) with punctate calcification (arrows).

a Malignant		Histopathological Diagnosis			Sens	Spec	Acc	PPV	NPV
		Benign	Total						
CT	Malignant	4	1	5	80.9%	83.3%	81.7%	80%	83.3%
	Benign	1	5	6					
	Total	5	6	11					
MRI	Malignant	4	1	5	100%	75%	87.5%	80%	100%
	Benign	0	3	3					
	Total	4	4	8					
US	Malignant	5	1	6	83.3%	85.7%	84.6%	83.3%	85.7%
	Benign	1	6	7					
	Total	6	7	13					

Table 3: Evaluation of results of different imaging modalities for salivary glands based on histopathological diagnosis.

Sens: Sensitivity, Spec: Specificity, Acc: Accuracy, PPV: Positive Predictive Value, NPV: Negative Predictive Value.

Correct		US diagnosis		Total	Test of significance (Chi Square)	p value
		Incorrect				
CT diagnosis	Correct	11	0	11	3.2821	0.070041
	Incorrect	4	1	5		
Total		15	1	16		

Table 4: Comparison between the results of CT and US in patients with lesions of thyroid subjected to both modalities.

Correct		US diagnosis		Total	Test of significance (Chi Square)	p value
		Incorrect				
MRI diagnosis	Correct	8	0	11	4.8	0.02846
	Incorrect	4	0	10		
Total		12	0	12		

Table 5: Comparison between the results of MRI and US in patients with lesions of thyroid subjected to both modalities.

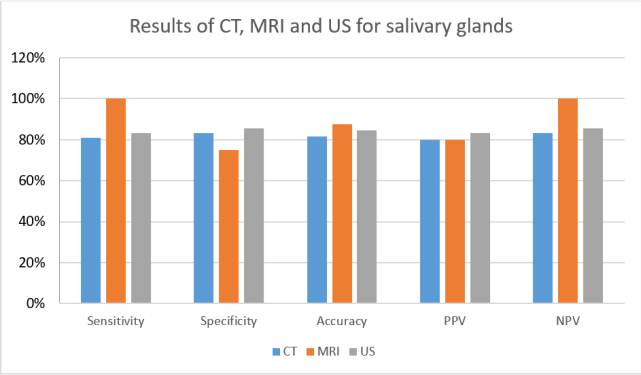

Figure 3: Results of C.T and MRI and US for salivary glands.

Comparing the overall results of CT and US for salivary gland lesions as correct and incorrect diagnosis showed The Chi-square statistic is 2.2. The P value is 0.138011. This result is not significant at $p < 0.05$. Comparing the overall results of MRI and US for thyroid lesions as correct and incorrect diagnosis showed The Chi-square statistic is 1.0667. The P value is 0.3017. This result is not significant at $p < 0.05$ (Table 6, 7).

Figure 4: 53-year-old woman with mucoepidermoid carcinoma A: ultrasound of right parotid shows blurred borders (white arrows), non-homogeneous structure, with multiple small calcifications (blue arrows). B: 61-year-old woman with an adenoid cystic carcinoma in the deep and superficial lobe of the right parotid gland. T1-weighted contrast medium enhanced fat suppressed image shows strong enhancement with hypointense areas in the centre and slightly irregular margins in the posterior part of the lesion (arrow).

Correct		US diagnosis		Total	Test of significance (Chi Square)	p value
		Incorrect				
CT diagnosis	Correct	9	0	9	2.2	0.138011
	Incorrect	2	0	2		
Total		11	0	11		

Table 6: Comparison between the results of CT and US in patients with lesions of salivary glands subjected to both modalities.

Correct		US diagnosis		Total	Test of significance (Chi Square)	p value
		Incorrect				
MRI diagnosis	Correct	7	0	7	1.0667	0.3017
	Incorrect	1	0	1		

Table 7: Comparison between the results of MRI and US in patients with lesions of salivary glands subjected to both modalities.

Discussion

Proper evaluation of thyroid or salivary gland lesion is essential for proper approach of management. Although histopathological diagnosis remains the only definitive tool to determine the nature of a lesion, imaging constitutes an important step of investigation. It helps us to have a respective idea about the expected pathology of the lesion and it provides us with its limits of extension and degree of involvement of adjacent structures. So imaging gives us the plan for the next invasive step to reach the pathological diagnosis and hence the treatment protocol.

The current study is a prospective case series study which tries to evaluate the validity of three common imaging modalities which are US, CT, MRI in thirty four patients suffering from thyroid and salivary gland lesions.

Our study has not involved ordering US, CT and MRI for every patient because this has not been applicable being depending on the decision of the treating physician. This decision can proceed from US to CT to MRI or choose CT or MRI from the start depending on the most convenient method that will help to establish the diagnosis needed to proceed to more invasive step for biopsy taking. Accordingly, U.S was performed for all patients while C.T was performed for 27 patients while MRI was performed for 20 patients.

Ultrasound is the most sensitive method for diagnosing intrathyroid lesions. It can depict 2-mm cystic lesions and 3-mm solid intrathyroid lesions. The challenge is differentiating a few malignant nodules from common benign nodules. Despite US's ability to clearly identify nodules, no single US criterion is reliable in differentiating benign ones from malignant thyroid nodules. Even so, many US features may aid in predicting the benign or malignant nature of a given nodule [4].

MRI and CT are not sensitive techniques for demonstrating intrathyroid lesions. However, CT is useful in evaluating lymphadenopathy, local tumor extension, and extension into the mediastinum or retrotracheal region. Therefore, US is used for primary detection of intrathyroid lesions, and CT or MRI is used for staging [5].

The specificity of MRI is not adequate to preclude further imaging or FNA. Once the diagnosis has been achieved by using alternative methods, MRI is particularly good for the detection of tumor extension into the surrounding tissues, particularly the trachea and esophagus.The differentiation of the various thyroid nodules localized to the thyroid gland can be difficult with MRI. A thyroid carcinoma in a multinodular goiter may be missed [6].

In the current study, ultrasound imaging of thyroid nodules showed a sensitivity of 91.7%, a specificity of 77.8% and a diagnostic accuracy of 85.7% for detection of malignant nodule. These results match the results of Kwak., *et al*. who studied 303 patients who had thyroid nodules and found that Sensitivity, specificity, accuracy of US were 96.4%, 74.5%, 92.7% respectively [7]. On the other hand, our results are different from the results of Stacul., *et al*. who evaluated 516 thyroid nodules in 420 patients (181 solitary thyroid nodules and 239 multiple nodules) with grey scale US and found that the sensitivity, specificity, overall accuracy values of grey-scale US were 46%, 73% and 67%, respectively [8]. Also, Lin., *et al*. evaluated 378 patients with palpable thyroid nodules with preoperative neck US. Comparing preoperative surveys with postoperative histopathology, the sensitivity, specificity, accuracy rate of US were 51.9%, 93.9% and 86.8%respectively [4]. This difference in the sensitivity of US between our study and these studies can be attributed to different sample sizes.

In the current study, CT imaging of thyroid nodules showed a sensitivity of 70%, a specificity of 66.7% and a diagnostic accuracy of 68.8% for detection of malignant nodule. Our measured sensitivity is much higher than that measured by Liu., *et al*. who investigated the diagnostic value of calcification detected by computed tomography (CT) for the differentiation of benign and malignant thyroid nodules. This is a retrospective study of 930 consecutive patients with pathologically proven thyroid nodules. Detection of calcification in diagnosing thyroid carcinoma had a sensitivity of 52.38% and specificity of 81.23% [5]. This difference can be attributed to the very large sample size in that study.

In the current study, MRI imaging of thyroid nodules showed a sensitivity, a specificity and a diagnostic accuracy of 75% for all three parameters. These results are lower than the results of Noda., *et al*. who studied 36 patients with solid thyroid nodules detected by thyroid sonography and underwent MRI. The T1 and T2 signal intensity ratio (SIR) of each thyroid nodule was calculated by measuring the mean signal intensity divided by that of paraspinal

muscle. Apparent diffusion coefficient (ADC) values of nodules were also computed. The SIRs and ADCs were then compared between benign nodules and papillary carcinomas. The sensitivity, specificity for the differentiation of papillary carcinomas were 86%, and 100%, respectively, on T2 SIR; 93% and 93% respectively, on ADC; and 93% and 93% respectively, on combined T2 SIR and ADC. So they stated that papillary thyroid carcinomas could be accurately differentiated from benign nodules on the basis of MRI T2 SIR or ADC values [6]. This difference can be attributed to different efficiency of radiologists performing and evaluating MRI results.

Tumor-like lesions of the salivary glands constitute 3% to 6% of all head-and-neck tumors. Most guidelines of ENT task forces recommend ultrasound as the initial imaging modality of choice for the assessment of palpable abnormalities of the salivary gland. US is able to demonstrate benign and malignant features of focal lesions and can be used to guide fine-needle aspiration biopsy or core biopsy to confirm their benign or malignant nature. Furthermore, US can be used to establish the need for imaging procedures (CT or MRI), particularly in those lesions showing malignant features on ultrasonography, or large masses whose extent is difficult to assess with US, particularly if located in the deep lobe [7-9]. Some studies found that MRI clearly outweighs CT in this regard. A study published by Konyuncu., *et al*. revealed that CT and MRI provide nearly the same information for presurgical planning and diagnosis [10].

In the current study, US imaging of salivary glands showed a sensitivity of 83.3%, a specificity of 85.7% and a diagnostic accuracy of 84.6% for detection of malignant lesions. However, CT imaging of salivary glands showed a sensitivity of 80.9%, a specificity 0f 83.3% and a diagnostic accuracy of 81.7% for detection of malignant lesions. On the other hand, MRI imaging of salivary glands showed a sensitivity of 100%, a specificity of 75% and a diagnostic accuracy of 87.5% for detection of malignant lesions.

The results of our study matches to a great extent the results of Rudack., *et al*. who evaluated 109 patients with a tumor-like lesion of the salivary glands underwent surgery. MRI and CT were arranged in 73 and in 40 patients respectively, whereas all 109 patients were prospectively diagnosed by US. The results of CT, MRI and US were compared with the histological outcome. In respect of the radiological assessment of the lesion (benign/malignant) and the correct diagnosis, CT, MRI and US were comparable in terms of sensitivity, specificity and accuracy. The sensitivity, specificity and diagnostic accuracy of US were 88%, 54% and 79% respectively. The sensitivity, specificity and diagnostic accuracy of CT were 91%, 57% and 85% respectively. The sensitivity, specificity and diagnostic accuracy of MRI were 98%, 52% and 84% [11].

Also, Liu., *et al*. conducted a Meta analysis to compare ultrasonography (US), computed tomography (CT), and magnetic resonance imaging (MRI) for clinical differential diagnosis in patients with salivary gland tumor (SGT). Nineteen articles were included. Pooled sensitivity for US, CT, and MRI was 62.9%, 83% and 80.7% respectively and pooled specificity for US, CT, and MRI was 92%, 85.1% and 88.6% respectively. So, they stated that CT was recommended, as it was an effective imaging tool for differential diagnosis in patients with primary SGT, and MRI was suggested for differential diagnosis between benign and malignant SGTs because of its highest sensitivity and specificity [12].

Conclusion

Ultrasound, computed tomography and magnetic resonance imaging, all are effective imaging modalities for evaluating a gland mass. Every anatomical region in the neck has its own criteria making it the target of specific imaging modality. So ultrasound is the preferred imaging technique for thyroid and saliverg glands followed by MRI then C.T.

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