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Original article

The Role of CT and MRI in Diagnosis and Characterization of causes of Dysphonia Compared to indirect Laryngoscope

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Abstract

Background: Hoarse voice is often used interchangeably with dysphonia; however, the former is a symptom while the latter is a clinical diagnosis. Dysphonia is a broad term for impaired vocal production, including altered quality, pitch, loudness, or effort. **This study aimed to** compare the diagnostic efficacy of imaging techniques including the computed tomography (CT) and magnetic resonance imaging (MRI) studies in comparison to the indirect laryngoscope in detection and tissue characterization of etiological pathologies of dysphonia. **Methods:** This retrospective diagnostic accuracy study included 100 patients complaining of dysphonia referred from the speech and language clinic of the ENT department to the radiology departments in Benha University Hospital and Kobri El-Kobba Military Medical Complex. All studied cases were subjected to indirect laryngoscopy, CT and MR studies. **Results**: There was a good agreement between CT and MRI assessments in VCP detection (kappa =0.85). Comparative study between CT and MRI assessments revealed; significant increase in accuracy (30% add value), in MRI modality in detecting Nodule lesions ($p < 0.01$) while non-significant difference accuracy in detecting all the remaining lesions ($p > 0.05$).**Conclusion:** Both CT and MRI are valuable imaging modalities in the diagnosis of the etiology of dysphonia, with mild, statistically insignificant, superior diagnostic accuracy of MRI over CT.

Keywords: Imaging, Diagnosis, Lesional Characterization, Dysphonia, indirect Laryngoscope.

Introduction

Hoarse voice is often used interchangeably with dysphonia; however, the former is a symptom while the latter is a clinical diagnosis (1).Dysphonia is a broad term for impaired vocal production, including altered quality, pitch, loudness, or effort. Causes for dysphonia can be divided into organic and functional etiologies. Organic dysphonia is due to a physiologic change in vocal production, and is further divided into structural and neurogenic dysphonia. Structural etiologies impact a physical change upon the mechanism of vocal production, while neurogenic etiologies effect via the nervous system. Functional dysphonia is due to vocal overuse or abuse and can have overlap with organic dysphonia improve diagnostic yield while minimizing complications (2).

The differential diagnosis for hoarseness is extensive and includes a multitude of etiologies that span a large geographic area from the brainstem to the mediastinum. Therefore, localizing a causative lesion can be extremely difficult for clinicians and radiologists alike. Radiologists can impact patient care by suggesting the appropriate imaging test and tailoring their search patterns to detect the subtle findings of laryngeal dysfunction (1).

The first line of investigation is laryngoscopy; however, diagnostic imaging comes into play if a cause is not identified or if further evaluation is warranted (1).The biomechanics of phonation is a complex process which can be altered by a wide range of local and systemic processes, many which are not readily apparent on laryngoscopy (1).

The purpose of this study was to compare the diagnostic efficacy of imaging techniques including the CT and MRI studies in comparison to the indirect laryngoscope in detection and tissue characterization of etiological pathologies of dysphonia.

Patients and methods

This retrospective diagnostic accuracy study included 100 patients complaining of dysphonia referred from the speech and language clinic of the ENT department to the radiology departments in Benha University Hospital and Kobri El-Kobba Military Medical Complex, during the period from March 2022 to March 2023

An informed written consent was obtained from the patients. Every patient received an explanation of the purpose of the study and had a secret code number. The study was done after being approved by the Research Ethics Committee, Faculty of Medicine, Benha University.

All studied cases were subjected to the following: Brief clinical history taking, indirect laryngoscopy and CT and MR studies.

Indirect laryngoscopy:

Laryngeal mirror, size 4 or 5 (or dental mirror) was used. The patient was asked to relax and to stick out his or her tongue. The tongue was covered in gauze and was pulled with the thumb and middle finger of the non dominant hand. The index finger was free to lift up the upper lip, if necessary, with the patient breathing in and out, the mirror was directed into the mouth and toward the back of the throat, making sure the glass side was downward. When at the back of the throat, the mirror was pressed upward, against the uvula and soft palate. The gag reflex was avoided by not touching the posterior pharyngeal wall or tongue base. The mirror was slightly altered, and various angles were tried to visualize the desired structures. The patient's head, chin, and body were ensured being in the correct position, and the patient is breathing in and out. We took note of the vocal cords while they were at rest. Then the patient was asked to make a loud sound and watch the vocal cord activity. If the mirror began to fog up, it was reheated and we repeated from step 1.

CT study:

It was done using GE evolution evo 128 slice & Toshiba activion 16 CT scanners: The study ranged from the skull base to the left lung hilum. Spiral imaging using 1mm slice thickness (both soft tissue and bone windows), followed by 2D reformatting and 3D reconstruction.

MR study:

It was performed using Siemens MAGNETOM AERA 1.5 T (48 channels) scanner. Axial T1WIs and axial, sagittal and coronal heavily T2WIs sequences of the neck (range from the skull base to the arch of aorta). Axial FLAIR for the posterior fossa of the brain. The imaging studies were then sent to the PACS and reviewed by two radiologists in a blind manner. In case of conflict in their opinion, third opinion was acquired. The radiological data were then compared to the laryngoscopic findings for calculation of accuracy and description of any added value.

Approval Code: MD 25-4-2022

Statistical analysis:

Data entry, processing and statistical analysis was carried out using MedCalc ver. 20 (MedCalc, Ostend, Belgium). Tests of significance (McNemar's, Kappa statistics, and ROC Curve analysis) were used. Data were presented and suitable analysis was done according to the type of data (parametric and non-parametric) obtained for each variable. P-values less than 0.05 (5%) was considered to be statistically significant. Descriptive statistics: Mean, Standard deviation (± SD) and range for parametric numerical data, while Median and Inter-quartile range (IQR) for non-parametric numerical data. Freque ncy and percentage of non-numerical data. Analytical statistics: McNemar's test was used to examine the relationship between two (paired) qualitative variables. The ROC Curve (receiver operating characteristic) provides a useful way to evaluate the Sensitivity and specificity for quantitative Diagnostic measures that categorize cases into one of two groups. Kappa statistics to compute the measure of agreement between two investigational methods Kappas over 0.75 is excellent, 0.40 to 0.75 is fair to good, and below 0.40 is poor.

Results

The mean age of all patients was (54.8 ± 10.5) years. Regarding gender of the patients, the majority (70%) of patients were males, while (30%) were females. **Figure 3**

Regarding Indirect laryngoscopy (gold standard modality) data; (30%) of patients had VCP, (5%) had Nodules, (25%) had Polyps, with (5%) Hemorrhagic Polyps, (10%) had Iatrogenic / post-thyroidectomy lesions, (5%) had Reinke's oedema, (5%) had Leukoplakia patches, (9%) had Vocal cord thickening, (20%) had Laryngeal mass, with (15%) had Laryngeal carcinoma at Indirect laryngoscopy assessment. **Table 1**

Regarding CT data, (15%) of patients had VCP, (1%) had Nodules, (2%) had Polyps, (5%) had Mediastinal mass, (5%) had Iatrogenic / post-thyroidectomy lesions, (2%) had Reinke's oedema, (1%) had Leukoplakia patches, (10%) had Vocal cord thickening, (29%) had Laryngeal mass, with (24%) had Laryngeal carcinoma, and (5%) had Metastatic disease (extra laryngeal spread), at CT assessment. **Table 1**

Regarding MRI data, (19%) of patients had VCP, (4%) had Nodules, (5%) had Polyps, (6%) had Iatrogenic / post-thyroidectomy lesions, (1%) had Reinke's oedema, (2%) had Leukoplakia patches, (9%) had Vocal cord thickening, (30%) had Laryngeal mass, with (23%) had Laryngeal carcinoma, and (5%) had Metastatic disease (extra laryngeal spread), at MRI assessment. **Table 1**

CT modality usage detected patients with VCP, with fair (75%) accuracy ($p <0.01$). CT modality usage detected patients with post-thyroidectomy lesions, with fair (75%) accuracy ($p < 0.01$). CT modality usage detected patients with Vocal cord thickening, with fair (75%) accuracy ($p < 0.01$). CT modality usage detected patients with Laryngeal mass, with fair (78%) accuracy ($p < 0.01$). CT modality usage detected patients with Laryngeal carcinoma, with excellent (94%) accuracy ($p < 0.01$). CT modality usage showed non-significant detective values regarding Nodule, Polyp, Reinke's oedema, and Leukoplakia patches detection ($p > 0.05$). **Table 2**

MRI modality usage detected patients with VCP, with good (81%) accuracy ($p < 0.01$). MRI modality usage detected patients with Nodules, with excellent (90%) accuracy ($p < 0.01$). MRI modality usage detected patients with Polyps, with poor (60%) accuracy ($p < 0.05$). MRI modality usage detected patients with post-thyroidectomy lesions, with good (80%) accuracy ($p < 0.01$). MRI modality usage detected patients with Vocal cord thickening, with fair (75%) accuracy ($p < 0.01$). MRI modality usage detected patients with Laryngeal mass, with good (81%) accuracy ($p < 0.01$). MRI modality usage detected patients with Laryngeal carcinoma, with excellent (95%) accuracy ($p < 0.01$). MRI modality usage showed non-significant detective values regarding Reinke's oedema and Leukoplakia patches detection ($p > 0.05$).**Table 2**

Comparative study between CT and MRI assessments revealed; non-significant difference Accuracy in detecting VCP ($p >0.05$).

Table 3 shows a good agreement between CT and MRI assessments in VCP detection (kappa =0.85). Comparative study between CT and MRI assessments revealed; significant increase in accuracy (30% add value), in MRI modality in detecting Nodule lesions (p <0.01) while non-significant difference accuracy in detecting all the remaining lesions (p >0.05). **Table 4**

Table 1: Indirect laryngoscopy, CT and MRI data of the dysphonia patients

Variables			**Frequency(%)**
Indirect laryngoscopy	**VCP (laryngoscopy)**	+ve	30 (30%)
	Nodule (laryngoscopy)	+ve	5 (5%)
	Hemorrhagic Nodule (laryngoscopy)	+ve	0 (0%)
	Polyp (laryngoscopy)	+ve	25 (25%)
	Hemorrhagic Polyp (laryngoscopy)	+ve	5 (5%)
	Mediastinal mass (laryngoscopy)	+ve	0 (0%)
	Cranial nerve neuropathy (laryngoscopy)	+ve	0 (0%)
	Iatrogenic / post-laryngeal cancer TTT (laryngoscopy)	+ve	0 (0%)
	Iatrogenic / post-thyroidectomy (laryngoscopy)	+ve	10 (10%)
	Reinke's oedema (laryngoscopy)	+ve	5 (5%)
	Leukoplakia patches (laryngoscopy)	+ve	5 (5%)
	Vocal cord thickening (laryngoscopy)	+ve	9 (9%)
	Laryngeal mass (laryngoscopy)	+ve	20 (20%)
	Laryngeal carcinoma (laryngoscopy)	+ve	15 (15%)
	Metastatic disease (extra laryngeal spread) (laryngoscopy)	+ve	0 (0%)
CT	**VCP (CT)**	+ve	15 (15%)
	Nodule (CT)	+ve	1 (1%)
	Hemorrhagic Nodule (CT)	+ve	0 (0%)
	Polyp (CT)	+ve	2 (2%)
	Hemorrhagic Polyp (CT)	+ve	0 (0%)
	Mediastinal mass (CT)	+ve	5 (5%)
	Cranial nerve neuropathy (CT)	+ve	0 (0%)
	Iatrogenic / post-laryngeal cancer TTT (CT)	+ve	0 (0%)
	Iatrogenic / post-thyroidectomy (CT)	+ve	5 (5%)
	Reinke's oedema (CT)	+ve	2 (2%)
	Leukoplakia patches (CT)	+ve	1 (1%)
	Vocal cord thickening (CT)	+ve	10 (10%)
	Laryngeal mass (CT)	+ve	29 (29%)
	Laryngeal carcinoma (CT)	+ve	24 (24%)
	Metastatic disease (extra laryngeal spread) (CT)	+ve	5 (5%)
MRI	**VCP (MRI)**	+ve	19 (19%)
	Nodule (MRI)	+ve	4 (4%)
	Hemorrhagic Nodule (MRI)	+ve	0 (0%)
	Polyp (MRI)	+ve	5 (5%)
	Hemorrhagic Polyp (MRI)	+ve	0 (0%)
	Mediastinal mass (MRI)	+ve	0 (0%)
	Cranial nerve neuropathy (MRI)	+ve	0 (0%)
	Iatrogenic / post-laryngeal cancer TTT (MRI)	+ve	0 (0%)
	Iatrogenic / post-thyroidectomy (MRI)	+ve	6 (6%)
	Reinke's oedema (MRI)	+ve	1 (1%)
	Leukoplakia patches (MRI)	+ve	2 (2%)
	Vocal cord thickening (MRI)	+ve	9 (9%)
	Laryngeal mass (MRI)	+ve	30 (30%)
	Laryngeal carcinoma (MRI)	+ve	23 (23%)
	Metastatic disease (extra laryngeal spread) (MRI)	+ve	5 (5%)

Table 2: Roc-curve of CT modality to detect overall diagnostic accuracy (VCP) and to to detect patients with different dysphonia lesions

Variable	AUC (%)	Sensitivity (%)	Specificity (%)	PPV(%)	NPV(%)	P value
VCP (CT)	0.750	50	100	100	50	<0.0001**
Nodule (CT)	0.600	20	100	100	80	0.3173
Polyp (CT)	0.540	8	100	100	92	0.1486
Post-thyroidectomy (CT)	0.750	50	100	100	50	0.0027**
Reinke's oedema (CT)	0.595	20	98.95	100	81	0.3441
Leukoplakia patches (CT)	0.505	100	1	100	0	0.3173
Vocal cord thickening (CT)	0.750	55.5	94.5	100	47.5	0.0048**
Laryngeal mass (CT)	0.788	75	82.5	100	30	<0.0001**
Laryngeal carcinoma (CT)	0.947	100	89.4	100	0	<0.0001**
VCP(MRI)	0.817	63.33	100	100	37	<0.0001**
Nodule (MRI)	0.900	80	100	100	20	0.0001**
Polyp (MRI)	0.600	20	100	100	80	0.014*
Post-thyroidectomy(MRI)	0.800	60	100	100	40	0.0002**
Reinke's oedema (MRI)	0.600	20	100	100	80	0.3173
Leukoplakia patches (MRI)	0.595	20	98.95	100	81	0.3441
Vocal cord thickening (MRI)	0.756	55.56	95.60	12.6	46	0.0038**
Laryngeal mass (MRI)	0.812	80	82.5	100	24	<0.0001**
Laryngeal carcinoma (MRI)	0.953	100	90.5	100	0	<0.0001**

ROC (Receiver operating characteristic), AUC= Area under curve. Positive detective value (PPV). Negative detective value (NPV).

Table 3: An agreement between CT and MRI in VCP detection

		CT		Total	Agreement
		-ve	**+ve**		Kappa
MRI	**Negative**	81	0	81 (81%)	0.858
	Positive	4	15	19 (19%)	
	Total	85 (85%)	15 (15%)	100 (1000%)	

Table 4: Comparison between CT and MRI as regards diagnostic accuracy assessments (add value)

Variables	CTassessment	MRIassessment	McNemar's test
	Accuracy (%)	**Accuracy (%)**	**P value**
Nodule	60 %	90 %	< 0.0001**
Polyp	54 %	60 %	= 0.3926
Post-thyroidectomy	75 %	80 %	= 0.3984
Reinke's oedema	59 %	60 %	= 0.8857
Leukoplakia patches	50 %	59 %	= 0.2024
Vocal cord thickening	75 %	75 %	= 1.000
Laryngeal mass	78 %	81 %	= 0.6002
Laryngeal carcinoma	94 %	95 %	= 0.7570

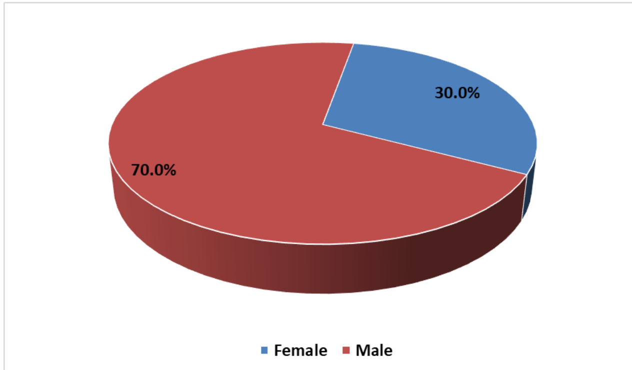


Figure1: Gender among100 dysphonia patients

Case presentations

Case l. A case of 54 year old male presented to the language speech unit with dyphonia underwent indirect laryngoscope revealing right mass immobility**.**

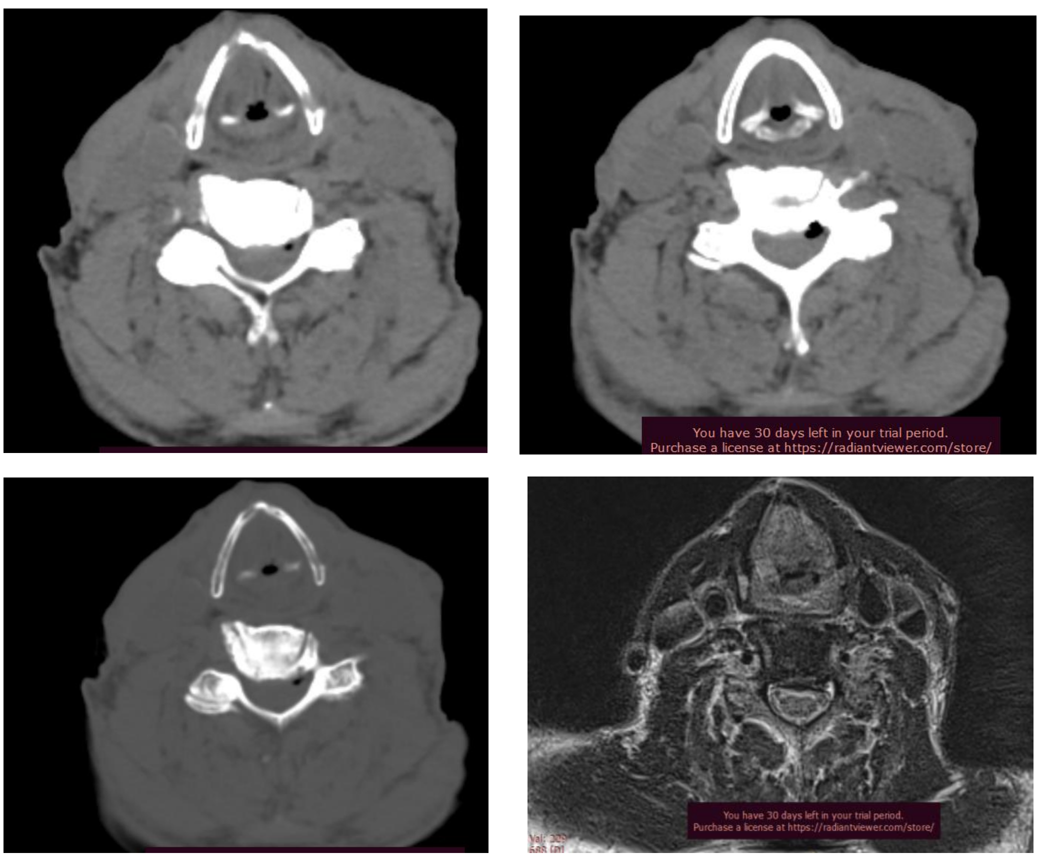


Fig.2 A, B,C and D : axial non contrast CT scan of the neck soft tissue and bone windows images at the level of the true vocal cords (A,B and C) are showing a well defined soft tissue mass lesion seen centered over the right vocal cord extending to the anterior commissure and subglottic region without cartilage invasion **D:** Axial BLADE T2WIs MR Image of the same patient at the corresponding level to the CT images revealing a hyperintense signal mass with anterior fissural extension. No extra laryngeal spread.

Case 2.A know case of pathologically proven laryngeal squamous cell carcinoma underwent surgery and radiotherapy

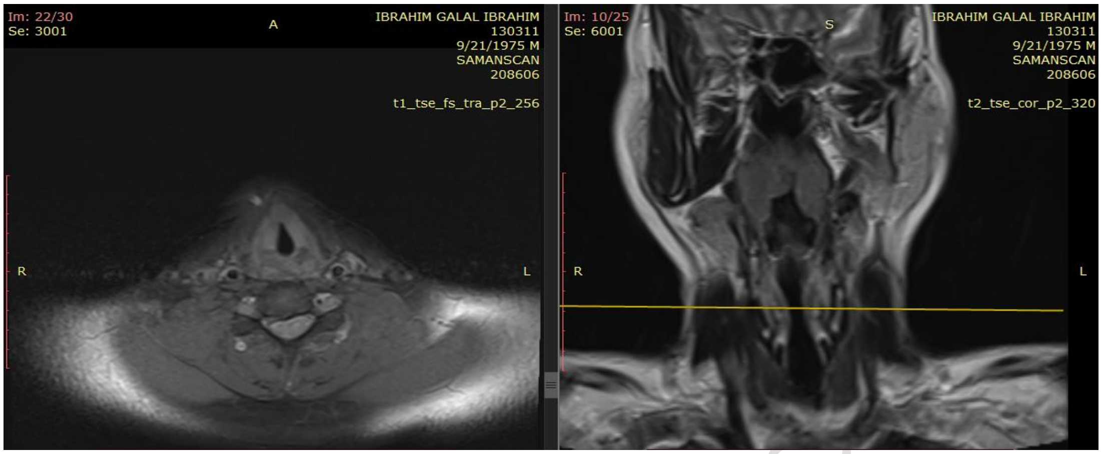


Fig.2: axial T2WIa fat sat and coronal T2WIs MR Images at the level of the vocal cords reveal no residual or recurrent masses

Case 3. : a case with post thyroidectomy right vocal cord paralysis

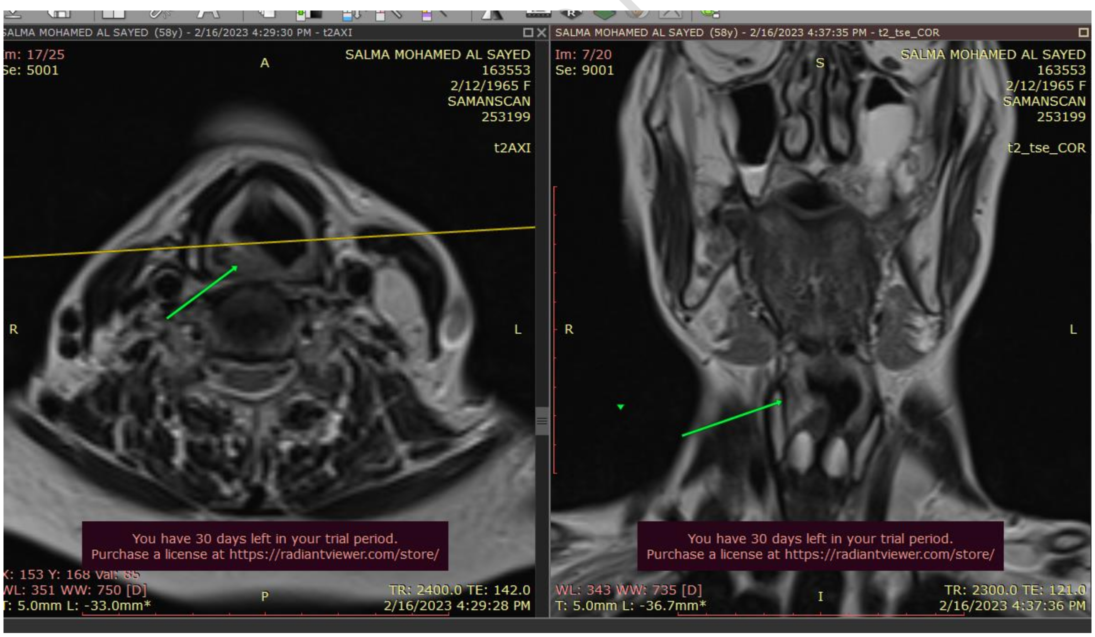


Fig.3: Axial T2WIs and coronal T2WIs MR images : Enlargement of the right piriform sinus , mild antero-medial deviation of the arytenoid cartilage(green arrow tagged structure) , relative widening of the right laryngeal ventricle and mild thickening and adduction of the right aryepiglottic fold are seen

Case 4.: a case of laryngeal mass

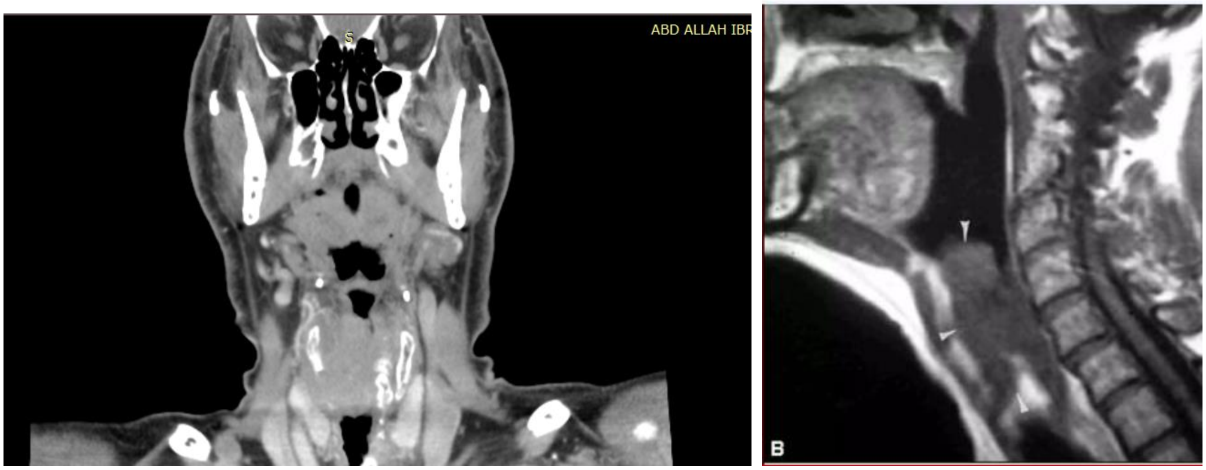


Fig..4: Non contrast Coronal CT of the neck reveals a large trans-glottic laryngeal mass lesion infiltrating the para laryngeal soft tissue at the right side, grossly attenuating the thyroid, cricoid and arytenoid cartilage at the right side and implicating the anterior commissure. The sagittal T1WIs image reveals the full extent of the tumor.

Case 5: A case of MAPLs (minimally associated pathological lesions) with bilateral vocal cords polypoid degeneration.

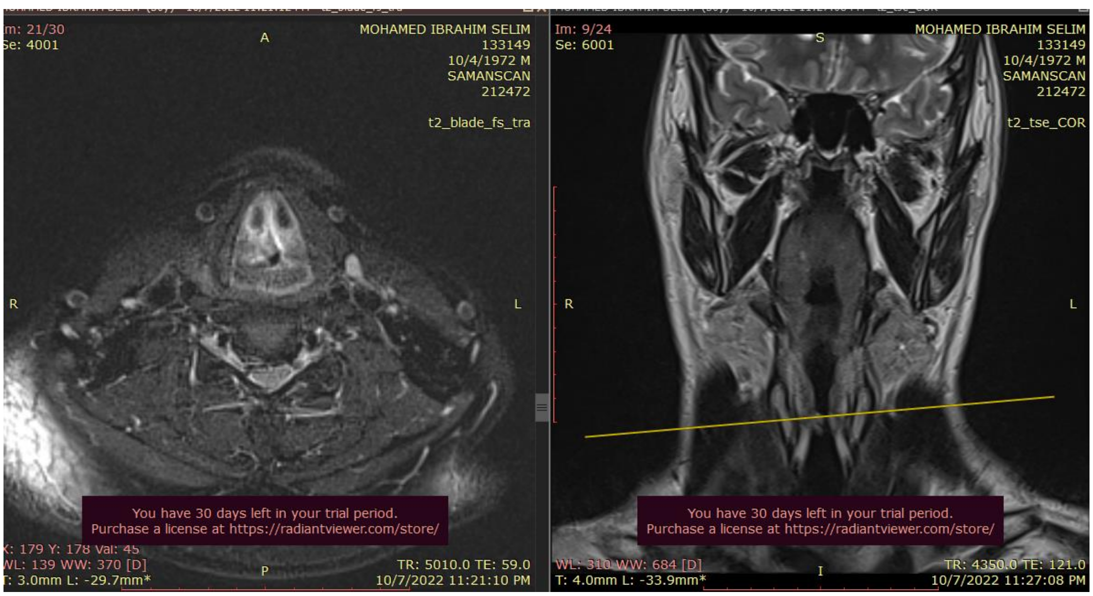
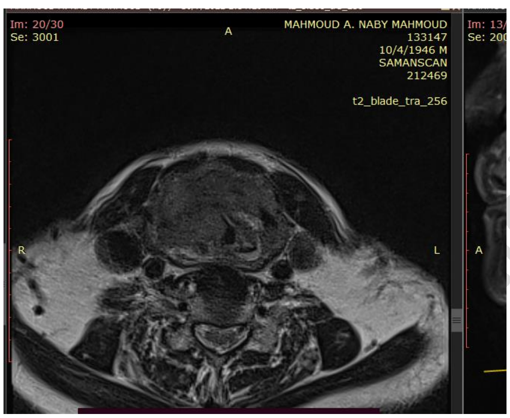


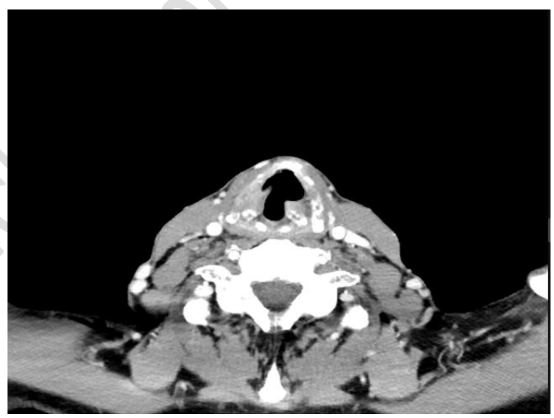
Fig.5: MRI axial T2WIs fat sat and coronal T2WIs images shows bilateral true vocal cord thickening with a small polypoid lesion arising from the right vocal cord.

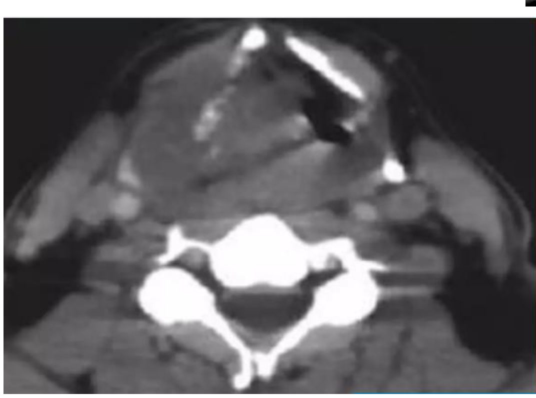
Case 6.: A case of left mediastinal mass with left vocal cord palsy.

Fig.6: an Axial contrast enhanced CT image on the right shows thickening of the left aryepiglottic fold with cord asymmetry. A contrast enhanced axial CT image on the left shows left superior mediastinal soft tissue mass.

Case 7 . A patient with supra glottic mass showing extension to the right vocal cord







Case 8 . Left VCP

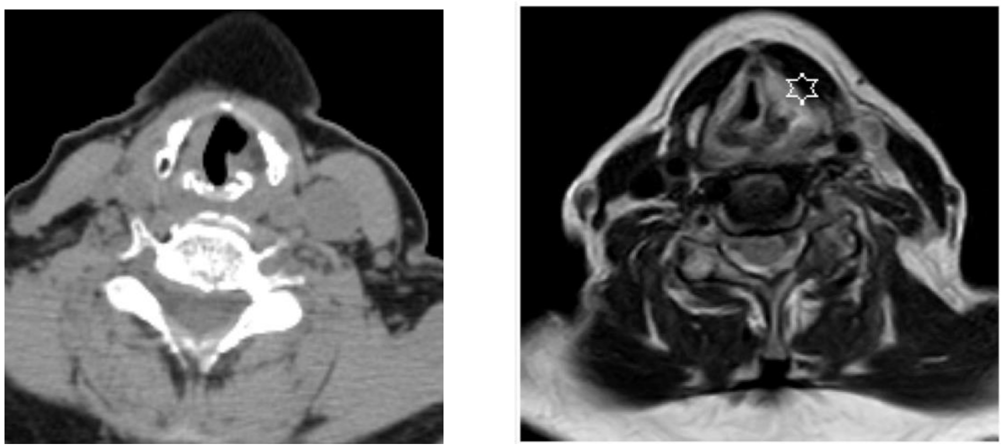


Fig.8: non contrast axial CT and axial M T2WIs images show mild antero-medial deviation of the left arytenoid cartilage

Case 9 . A case of reinke edema with polypoid degeneration.

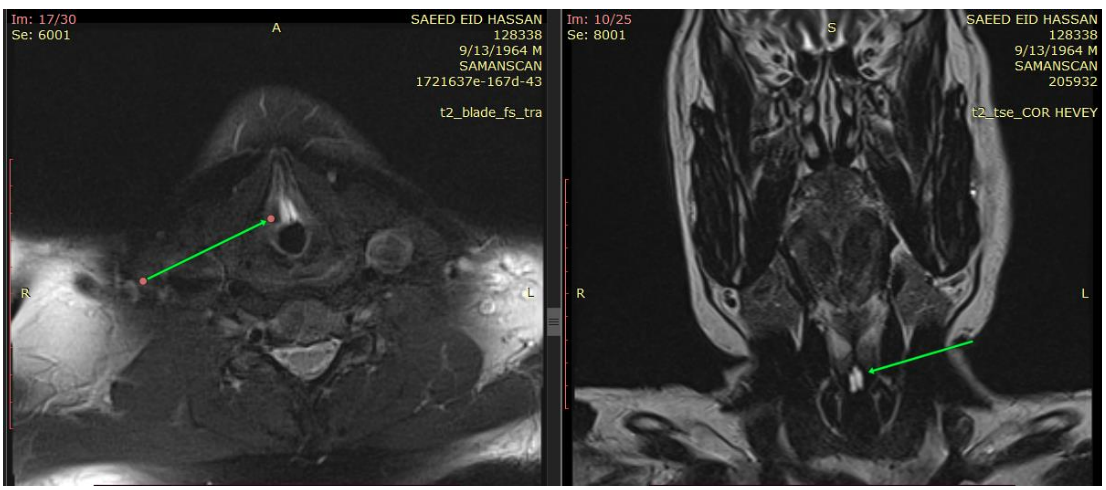


Fig.9: Axial BLADE T2WIs and coronal T2WIs images reveal bilateral small hyperintense signal polypoidal lesions arising from vocal cords at the vicinity of the anterior commissure.

Case 10. A case of vocal cord polyp

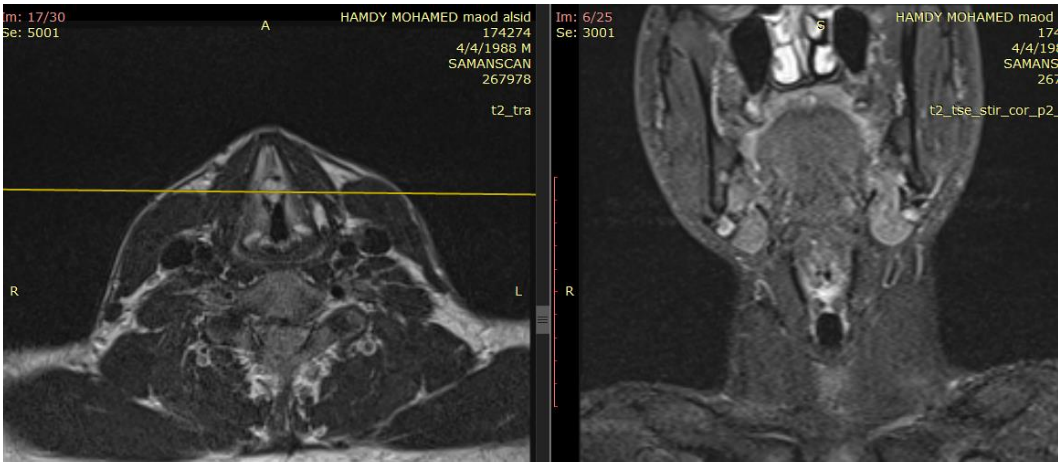


Fig.10: MR axial T2WIs and coronal T2WIs fat sat image demonstrate a small anterior midline hyperintense signal polypoidal lesion arising close to the anterior commissure

Discussion

This study was to compare the diagnostic efficacy of CT and MR studies in comparison to indirect laryngoscope in detection, and characterization of the etiology of dysphonia.

Regarding indirect laryngoscopy (gold standard modality) data; (30%) of patients had VCP, (5%) had Nodules, (25%) had Polyps, with (5%) Hemorrhagic Polyps, (10%) had Iatrogenic / post-thyroidectomy lesions, (5%) had Reinke's oedema, (5%) had Leukoplakia patches, (9%) had Vocal cord thickening, (20%) had Laryngeal mass, with (15%) had Laryngeal carcinoma, at Indirect laryngoscopy assessment.

Nasr et al.,(3) reported that, the indirect laryngoscopic examination of the patients included in this study revealed laryngeal masses (whether benign or malignant) in 14 patients of 54 total, vocal cord nodules in 11 (unilateral in three/3 and bilateral in eight/8 patients), vocal cord polyps in 14 (sessile in five and pedunculated in nine patients), vocal cord cyst in six, Reinke's oedema in five and chronic laryngitis in the form of vocal cord thickening and interarytenoid oedema in four.

In contrast to the current study results, Beser et al., (4)reported that, the main pathology of the patients was found to be laryngeal masses (23/38; 60% of patients, single in each patient) that were found to be polyps (n = 8), papilloma (n = 4) and carcinoma (n = 11) according to histopathological evaluation.

By using ROC-curve analysis, CT modality usage detected patients with VCP, with fair (75%) accuracy, (50%) sensitivity and (100%) specificity ($p < 0.01$). Also, CT modality showed fair (78%) accuracy, (75%) sensitivity and (82%) specificity ($p < 0.01$), in the detection of the patients with laryngeal masses. The ROC-curve analysis for MRI detection of VCP showed good (81%) accuracy, (63%) sensitivity and (100%) specificity ($p < 0.01$). MRI also detected patients with Laryngeal mass, with good (81%) accuracy, (80%) sensitivity and (82%) specificity ($p < 0.01$).

Brouwer et al., (5)reported that, using a random effects model, the pooled estimates (95%CI) for sensitivity and specificity for the other 7 studies were 89% (80%–94%) and74% (64%–83%), respectively. Sensitivity ranged from 80% to 100% (Q test for heterogeneity p >.73) and specificity from 63% to 100% (Q test for heterogeneity p 5.05).

The current study results came in line with Cho et al., (6)who reported that, CT and MRI showed pooled sensitivities of 66% and 90%, respectively, and pooled specificities of 88% and 81%. Also, Desouky et al. (7) concluded that, ADC MRI effectively differentiated benign and malignant lesions with 100% sensitivity, 74.2% specificity and 84% accuracy. Mean WR MRI in benign or inflammatory lesions was significantly lower than in malignant tumors with sensitivity of 96.6%, specificity of 81.2% and overall accuracy of 88.9%**.**

Basha et al., (8)reported that, MRI shows greater accuracy than CT. Laryngeal carcinomas with AVC involvement may be better assessed for thyroid cartilage involvement and T stage if CT and MRI are used together. Cristalli et al., (9)found that, The AUC was 0.96 (95% CI: 0.91–1.00) or highly accurate according to the Swets classification. The resulting sensitivity, specificity, PPV, and NPV were 92%, (81%–98%),93% (76%–99%), 96% (86%–99%), and 87% (70%–98%). There were two false positive (FP) and four false negative (FN).

The current results were against Jain (10)who reported that CT with contrast is the imaging of choice to evaluate the laryngeal tumors and find the etiology of VCP. Song et al., (11)concluded that, CT is helpful for the early detection of primary malignancy or progression of malignancy between follow-ups. Moreover, it can reveal various non-malignant causes of VCP.

Regarding diagnostic accuracy of CT modality vs MRI modality (add value); comparative study between CT and MRI assessments revealed; non-significant difference Accuracy in detecting VCP ($p > 0.05$) and in detecting all lesions ($p > 0.05$).

Basha et al., (8)concluded that, when it comes to assessing tumor infiltration and spread in the local area, both imaging methods have their benefits and drawbacks. If used together, CT and MRI have the potential to eliminate limitations and increase accuracy, especially in the areas of thyroid cartilage evaluation and T staging of laryngeal carcinomas, Due to its great sensitivity and enhanced degree of diagnostic accuracy, MRI is increasingly being seen as the investigation of choice in the clinical evaluation of laryngeal tumors, especially early glottic lesions, for the planning of therapeutic measures.

Our results came in disagreement with Cho et al., (6)who conducted a study aiming to compare the diagnostic performance of contrast-enhanced CT with that of MRI in the detection of cartilage invasion in patients with laryngo-hypopharyngeal cancer, and reported that, MRI showed significantly higher sensitivity than CT ($p = 0.02$). The specificities showed no statistically significant difference between CT and MRI ($p = 0.39$).

Conclusion

The current study has proven that, Both CT and MRI are valuable imaging modalities in the diagnosis of the etiology of dysphonia, with mild, statistically insignificant, superior diagnostic accuracy of MRI over CT.

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