A Novel Laryngeal Palpatory Scale (LPS) in Patients with Muscle Tension Dysphonia

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Abstract: Objectives. Laryngeal palpation is a routine clinical method for evaluation of patients with muscle tension dysphonia (MTD). The aim of this study was to develop a new comprehensive valid and reliable "laryngeal palpatory scale" (LPS), based on psychometric criteria.

Methods. The scale items were selected based on an in-depth analysis of the literature and an expert focus group. Scale item generation and item reduction were followed by a psychometric assessment. Qualitative and quantitative content validity (the content validity ratio (CVR), content validity index (CVI)), the qualitative face validity, and the inter-rater reliability were determined. For this purpose, 531 patients were assessed and finally 55 patients with primary MTD (26 women, mean age: 40.8 years, SD: 12.5; 29 male, mean age: 41.6 years, SD: 11.8) participated in the study. A weighted kappa (k*) statistic was used to examine the inter-rater reliability for each single item.

Results. Based on the CVR, three items were omitted because they had a score of less than 0.62. The CVI for all remaining items was greater than 0.79 and the scale CVI was equal to 0.96. The final 45 items were a result of the study. The inter-rater reliability for each single item ranged from 0.41 to 1, indicating moderate to almost perfect agreement.

Conclusions. The LPS is a reliable and valid instrument for assessing patients with MTD. However, future studies are needed to provide adequate data on sensitivity, specificity, concurrent validity, and cutoff scores.

Key Words: Muscle tension dysphonia−Laryngeal palpatory scale−Validity−Reliability−Assessment−Larynx.

INTRODUCTION

Muscle tension dysphonia (MTD) is one of the most widespread diagnoses in subjects frequenting voice clinics.[1] MTD is often characterized by an altered position of the larynx in the neck due to an imbalanced tension of the extrinsic laryngeal musculature. This condition may in turn influence the intrinsic laryngeal musculature,[1−3] possibly contributing to causing an altered vocal fold tension and disturbed vocal quality.[4] However, these assumptions are not established wisdom in the literature and it is unclear whether the muscle tension phenomena are a cause or a result of the voice disorder. Presumably, multiple factors are involved in the process of increased (para)laryngeal muscle tension, such as vocal misuse and abuse, personality factors, excessive stretch, or underlying organic pathologies.[4] These factors can lead to compensatory or overload strategies that disturb the laryngeal and cervical function and cause tight muscles, pain, and poor posture.[4]

Despite the unknown cause−effect relationship between extrinsic muscle tension and voice disorders, the assessment of laryngeal muscular tension is considered by some to be a prerequisite in diagnosing voice disorders, especially in MTD.[5] Palpation can be considered a meaningful outcome measure to document changes in muscle tension.[6,7] Laryngeal palpation is rarely reported or measured and definitely not clearly validated or tested for reliability. It is generally based on subjective measures assessing physiologic core traits such as elevated laryngeal position and increased extrinsic laryngeal muscle activation in patients with MTD.[8,9] Palpation can provide useful information about the degree of laryngeal muscle tension, pain, nodularity, discomfort, resistance, focal tenderness, tightness, laryngeal height, size of laryngeal spaces, and abnormal displacement of cartilages.[6,8,10−12] Laryngeal palpation can be considered a safe approach with no special side effects. Notably, it does not need any equipment and largely relies upon the skill and experience of the examiner.[12]

Aronson pioneered the first palpation method for clinical assessment of voice disorders.[13,14] Laryngeal palpation approaches have been subsequently utilized in research and clinic surveys to assess patients with MTD.[12] Practically, these are mostly qualitative methods, which only focus on the presence or absence of tension in the larynx or neck.[12] There are only a few systems rating the grade of muscle tension.[12] Angsuwarangsee and Morrison[8] developed a four-point grading system based on the work of Lieberman[7] to document muscle tension severity. The suprahyoid, the cricothyroid, the thyrohyoid, and the pharyngolaryngeal

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muscles are assessed based on a particular guideline text. In another study, Mathieson et al[9] introduced a palpatory rating system to document the resistance of the supralaryngeal muscle area, thyroid cartilage, and sternocleidomastoid muscles using a five-point grading scale. The laryngeal position in the vocal tract is also assessed on a four-point nominal scale by Mathieson et al.[9]

Most palpation methods assess only a few anatomical structures in the larynx or neck with absence of bilateral (two-sided "left versus right") differentiation, but with extensive distinctions among structures. In general, the hyoid bone,[3,6,9,10,13–19] the suprahyoid muscles,[6,8,9,11,14,15,19–21] the thyrohyoid muscles,[8,10,11,17,18,21] the thyrohyoid space,[6,13,14–16,19,22,23] the cricothyroid muscles,[3,8,10,11,17,18,21] and the cricothyroid space[3,11,17–19] are the common target laryngeal structures assessed in most palpation methods.[12] Other anatomical structures considered in some palpation methods[12] include inferior constrictor,[11] lateral laryngeal gutters,[11] sternocleidomastoid (SCM),[9,10,14,15,17–19] pharyngolaryngeal muscles,[8] infrahyoid muscles,[22] and some internal laryngeal structures such as posterior cricoarytenoid muscles and interarytenoid muscles.[7]

Systems that quantitatively rate the grade of muscle tension show limitations.[8,9] They mostly lack item categorization, information on posture as an influencing factor, a suitable instructive text, and, most importantly, evidence on psychometric properties for validity and reliability.[12] These limitations explain the absence of formal documentation of muscle tension using these methods.[24]

In general, there is a need for a quickly administered and easily rated laryngeal palpatory scale (LPS) to determine the severity of tension in vulnerable anatomical structures and the treatment efficacy in patients with MTD. It is particularly important for evaluating treatment outcomes as slight changes must be identified. Furthermore, it should be practical and easily implementable in clinical practice, enabling more standardized and well-informed patient care and follow-up.

Given the limitations of existing laryngeal palpation methods, the aim of this study was to develop and validate a new comprehensive laryngeal palpatory scale. The authors suggest that this scale is suitable for assessing anatomical structures influenced in MTD using quantitative measurement.

MATERIAL AND METHODS

We report the development of our new laryngeal palpatory scale in two stages: item generation and psychometric evaluation.

Scale development

Item generation

Items were selected from two sources: a literature review and opinions of an expert panel.

Computerized and manual searches were performed from 1980 to 2016, using a variety of databases: ScienceDirect, MEDLINE (PubMed), Scopus, ISI, Cochrane Library, and Web of Knowledge. Search terms were "palpation," "evaluat*," "diagnos*," "posture," "neck and laryngeal anatomical structures," "larynx," "muscles," "assess*," "scale," "psychometric," "validity," "reliability," "muscle tension dysphonia," "functional dysphonia," "functional voice disorder," "vocal hyperfunction," "influencing factors in the development of MTD," and "criteria to assess muscle tension."

Experts comprised seven certified speech–language pathologists (SLPs), three otolaryngologists, and five physical therapists experienced in the assessment and treatment of voice disorders. All were academically active in the field (authors of several published articles and history of teaching). The data were collected through face-to-face interviewing and e-mail. The face-to-face (one-to-one) interviewing time with experts was about 120 minutes. During the interview, notes were taken by the interviewer and the discussion was also recorded. If needed, more than one meeting was organized. Some of the issues discussed at this stage were as follows: influencing factors in the development of MTD, neck and laryngeal anatomical structures, item categorization, appropriate title, evaluation methods, appropriate factors that can be used as criteria to assess muscle tension, and appropriate grading system.

Second, items were refined, organized, and classified into an appropriate style in order to collect the pre-final items in a practical format.

Psychometric evaluation

In the next step, content validity and face validity of the pre-final LPS were assessed.[25]

Content validity

Content validity of the instrument was determined through the experts' viewpoints.[26–28] A panel of experts with more than 4 years of experience in the assessment and treatment of patients with voice disorders was selected as content experts to assess the LPS content validity. In the present study, qualitative and quantitative content validity were determined by taking viewpoints of five SLPs, three otolaryngologists, and two physical therapists.

Qualitative content validity. For a qualitative assessment of content validity, a review of the instrument components as well as the experts' suggestions on the appropriateness and accuracy of the items is needed.[29] The 10 experts (as described above) were asked to express their attitude toward the items. They were asked to respond to the following questions (Figure 1) using yes/no answers or present their suggestions in a qualitative way.

Quantitative content validity. To evaluate the quantitative-based content validity, the content validity ratio (CVR), item-content validity index (I-CVI), and scale-content validity index (S-CVI) were calculated. The most crucial and correct content in an instrument is the quantification by CVR. To examine CVR, each item was

Questions
A) Is the title of the scale appropriate?;
B) Are the directions appropriate for the scale?;
C) Is the content area covered?;
D) Are the considered factors appropriate to assess muscle tension?;
E) Are the evaluation methods appropriate?;
F) Is it needed to revise any items?;
G) Is it needed to eliminate any items?;
H) Is it needed to add any items?;
I) Is the scoring process appropriate?;
J) Do you have any additional comments?

FIGURE 1. Questions used to determine qualitative content validity.

scored for importance by the 10 experts using a three-point Likert scale ("essential," "useful but not essential," "not necessary"). The scale's CVR was then calculated according to the following formula[29]:

$$\mathrm{CVR} = \frac{N_e \text{ (the number of experts indicating essential)} - \frac{N \text{ (the total number of experts)}}{2}}{\frac{N \text{ (the total number of experts)}}{2}}$$

Extra agreement of the experts on the necessity of each item leads to a higher score. According to the number of experts in our study as well as the Lawshe method[30] (widely used method to quantify content validity in diverse fields),[31] an item score over 0.62 was considered appropriate and necessary.[30] Items with lower scores were excluded.

The CVI is widely reported[32] and can be computed for each item on a scale (referred to as I-CVI) as well as for the overall scale (S-CVI). To calculate I-CVI, experts rated the relevance of each item on a four-point scale: (1) not relevant; (2) needs some revision; (3) relevant but needs minor revision; and (4) very relevant.[32] For each item, the I-CVI is computed as the number of experts giving a rating of either 3 or 4, divided by the number of experts. Items with I-CVI > 0.79 were retained.[32]

Furthermore, the experts answered these two questions: (1) what other changes should be applied to the scale? (2) What other items should be added to the scale?

The S-CVI was determined as the average value of the I-CVIs (sum of the I-CVIs divided by the number of items).[33]

Face validity

Face validity is relevant to instrument apparent attractiveness and appearance, which potentially has impact on the instrument acceptability by responders.[34] The 10 mentioned experts, as well as 8 different certified and graduated SLPs with about 1 year of experience in the field, participated in the present study to determine face validity of the LPS on a qualitative basis. The data were collected through face-to-face interviewing, as well as e-mail. Clarity of wording, intelligibility of the items, the layout and style of the scale, and ambiguity, misinterpretations, and/or incomprehensibility of the meaning of words or sentences in the guideline text are the issues discussed in the interviews.[35]

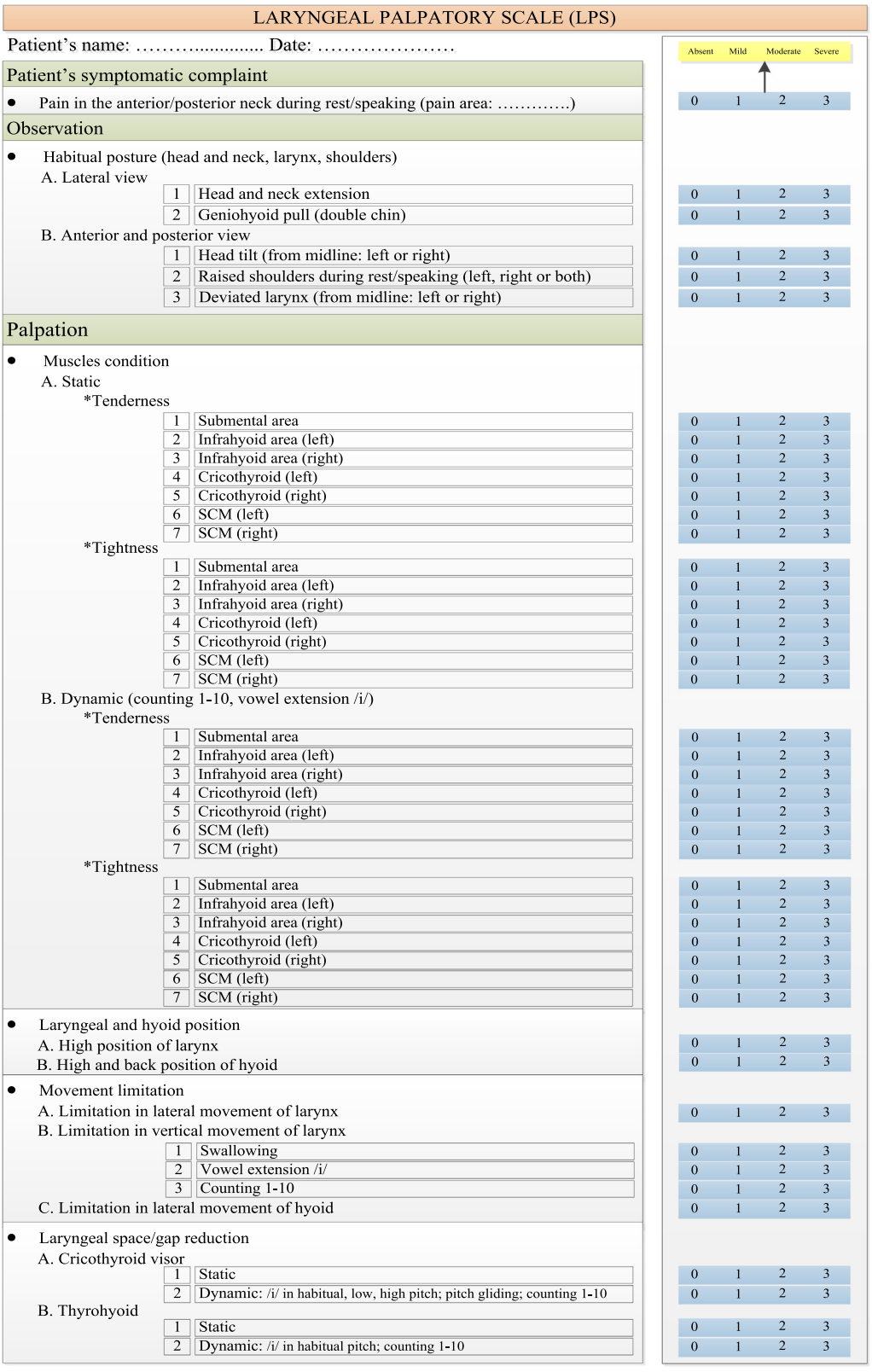
Reliability

Subjects

Three otolaryngologists and one SLP with more than 7 years of exposure in the evaluation and treatment of voice disorders identified MTD patients within the Ear, Nose, and Throat (ENT) Department of the Tehran University Hospital, as well as the ENT Department of the Iran University Hospital in Tehran, Iran. Five hundred thirty-one patients were assessed and finally 55 patients with MTD and without evidence of laryngeal lesions or laryngeal neuropathology (26 women, mean age: 40.8 years, SD: 12.5, age range: 24−70 years; 29 male, mean age: 41.6 years, SD: 11.8, age range: 25−65 years) participated in the study. The MTD patients were diagnosed based on case history, rigid videolaryngostroboscopy, and auditory−perceptual voice evaluation. Inclusion criteria were (1) aged 18 years or older, (2) not received voice therapy services, (3) without history of laryngeal surgery, and (4) without current or prior swallowing problems. Furthermore, participants were excluded if they had acute or chronic upper respiratory infection at the time of testing and a history of cardiac, pulmonary, or neurological problems. The local Institutional Review Board of the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran, approved the study and all enrolled patients signed an approved consent form.

Rater training

To determine inter-rater reliability, two experienced and blinded SLPs assessed the same individuals with MTD using the current version of the LPS rating system (Figure 2). Both raters had experience with laryngeal palpation and manipulation as a part of clinical practice before the initiation of this study. At first, they were asked to read the LPS guideline text (Appendix A) and they were trained in the correct use of the criteria defined in the instruction text. The rating procedure for each rater lasted approximately 15 minutes, with around 30 minutes gap between two evaluations.



LARYNGEAL PALPATORY SCALE (LPS)

Patient's name: ……..... Date: ……

		Absent	Mild	Moderate	Severe
Patient's symptomatic complaint					
• Pain in the anterior/posterior neck during rest/speaking (pain area: ……)		0	1	2	3
Observation					
• Habitual posture (head and neck, larynx, shoulders)					
A. Lateral view					
1	Head and neck extension	0	1	2	3
2	Geniohyoid pull (double chin)	0	1	2	3
B. Anterior and posterior view					
1	Head tilt (from midline: left or right)	0	1	2	3
2	Raised shoulders during rest/speaking (left, right or both)	0	1	2	3
3	Deviated larynx (from midline: left or right)	0	1	2	3
Palpation					
• Muscles condition					
A. Static					
*Tenderness					
1	Submental area	0	1	2	3
2	Infrahyoid area (left)	0	1	2	3
3	Infrahyoid area (right)	0	1	2	3
4	Cricothyroid (left)	0	1	2	3
5	Cricothyroid (right)	0	1	2	3
6	SCM (left)	0	1	2	3
7	SCM (right)	0	1	2	3
*Tightness					
1	Submental area	0	1	2	3
2	Infrahyoid area (left)	0	1	2	3
3	Infrahyoid area (right)	0	1	2	3
4	Cricothyroid (left)	0	1	2	3
5	Cricothyroid (right)	0	1	2	3
6	SCM (left)	0	1	2	3
7	SCM (right)	0	1	2	3
B. Dynamic (counting 1-10, vowel extension /i/)					
*Tenderness					
1	Submental area	0	1	2	3
2	Infrahyoid area (left)	0	1	2	3
3	Infrahyoid area (right)	0	1	2	3
4	Cricothyroid (left)	0	1	2	3
5	Cricothyroid (right)	0	1	2	3
6	SCM (left)	0	1	2	3
7	SCM (right)	0	1	2	3
*Tightness					
1	Submental area	0	1	2	3
2	Infrahyoid area (left)	0	1	2	3
3	Infrahyoid area (right)	0	1	2	3
4	Cricothyroid (left)	0	1	2	3
5	Cricothyroid (right)	0	1	2	3
6	SCM (left)	0	1	2	3
7	SCM (right)	0	1	2	3
• Laryngeal and hyoid position					
A. High position of larynx		0	1	2	3
B. High and back position of hyoid		0	1	2	3
• Movement limitation					
A. Limitation in lateral movement of larynx		0	1	2	3
B. Limitation in vertical movement of larynx					
1	Swallowing	0	1	2	3
2	Vowel extension /i/	0	1	2	3
3	Counting 1-10	0	1	2	3
C. Limitation in lateral movement of hyoid		0	1	2	3
• Laryngeal space/gap reduction					
A. Cricothyroid visor					
1	Static	0	1	2	3
2	Dynamic: /i/ in habitual, low, high pitch; pitch gliding; counting 1-10	0	1	2	3
B. Thyrohyoid					
1	Static	0	1	2	3
2	Dynamic: /i/ in habitual pitch; counting 1-10	0	1	2	3

FIGURE 2. Laryngeal palpatory scale (LPS).

Statistical analysis

Reliability – consistency with repeated application of the same test on the same subject – helps to give confidence in the value of the instrument. A weighted kappa (k^*) statistic (which is possible when categorical items are ordered) was utilized to test inter-rater agreement for each single item. Weighted kappa was estimated using the MedCalc software, version 15.0 (MedCalc Software, Ostend, Belgium).

TABLE 1.
Selected Items of 'Observation' Subscale Based on Literature Review and Panel of Experts in the Pre-Final Version of the Laryngeal Palpatory Scale (LPS)

First Subscale	Parts		Items
Observation	**Habitual posture (head and neck, larynx, shoulders)**	Lateral view	Head and neck extension
			Geniohyoid pull (double chin)
		Anterior/posterior view	Raised shoulders during rest/ speaking (left, right, or both)
			Deviated larynx (from midline: left or right)
			Obvious activity in the anterior neck (omohyoid, SCM) (during counting)
	Obvious activity in the anterior neck (omohyoid, SCM) (during counting)		
	Limitation in vertical movement of larynx		(1) During deep breathing
			(2) During swallowing
			(3) During vowel extension /i/

As a guide, we followed the benchmarks suggested by Landis and Koch[36] for agreement: <0.00 = poor, 0.00 −0.20 = slight, 0.21−0.40 = fair, 0.41−0.60 = moderate, 0.61−0.80 = substantial, and 0.81−1.0 = almost perfect. As a result, $k^* > 0.41$ was our baseline.

RESULTS

Item generation

The initial pool of 36 items was classified into two distinct subscales: "observation" included 9 items (Table 1) and "palpation" comprised 27 items (Table 2).

The pre-final scoring procedure consisted of a three-point Likert-type scale, which paved the way to rate each mentioned item as follows: 0 = "absent"; 1 = "mild"; 2 = "severe," with the higher score indicating the severity of the problem.

Psychometric evaluation

Validity

Qualitative and quantitative content validity. In the second step, the panel members were requested to judge on qualitative content validity. According to the expert panel views, the section "limitation in vertical movement of larynx" was transferred from *observation* to the *palpation* subscale (Table 3).

Table 3 gives CVR for the LPS items. Three items with CVR < 0.62 were eliminated: "obvious activity in the anterior neck (omohyoid, SCM) (during counting)," "limitation in vertical movement of larynx (during deep breathing)," and "limitation in anterioposterior movement of hyoid".

The remaining 33 items were modified according to the recommendations of the panel members in the first round of judgment and the I-CVI and S-CVI were calculated. The I-CVI of all items was greater than 0.79 and the S-CVI was equal to 0.97 (Table 4). No items needed to be eliminated or revised because they all had I-CVI and S-CVI values above 0.79. Furthermore, the experts suggested adding 12 items to the scale, which have been listed in Table 5.

A separate CVI was calculated for each new proposed item. The proportion of agreement among panel members was calculated on the relevance of the 12 suggested items. (The expert number was 7 in this step.) The I-CVI of all items was greater than 0.79 and the S-CVI was equal to 0.96 (Table 5). In addition, all members agreed to set scoring based on a severity scale of 0 to 3 (0 = "absent"; 1 = "mild"; 2 = "moderate"; 3 = "severe").

Face validity

At this stage, the qualitative opinions of experts were included in the scale. According to their opinions, and to make items more understandable, the scale's background color was revised to increase the contrast property of the items. Moreover, related items were categorized in an appropriate format; eg, "high position of larynx" and "high and back position of hyoid" were classified as "laryngeal and hyoid position."

Finally, the LPS contains 45 items, categorized into three distinct subscales named "patient's symptomatic complaint," "observation," and "palpation" (Figure 2). The items evaluate symptomatic pain, posture, muscle condition (tenderness and tightness), laryngeal and hyoid position, movement limitation, and laryngeal space/gap reduction. In general, LPS is a clinician-based four-point Likert-type scale. However, only patients can provide a rating for the items "pain in the anterior/posterior neck" and "tenderness" of muscles (pain or discomfort that occurs when an area is touched by clinician during examination). To increase feasibility and objectivity, we introduced a scoring technique for these items as well as the others (summarized in Appendix A).

TABLE 2.
Selected Items of 'Palpation' Based on Literature Review and Panel of Experts in the Pre-Final Version of the Laryngeal Palpatory Scale (LPS)

Second Subscale	Parts			Items	
Palpation	**Muscles condition**	(A) Static	Tenderness	Submental area	
				Infrahyoid area (left)	
				Infrahyoid area (right)	
				SCM (left)	
				SCM (right)	
			Tightness	Submental area	
				Infrahyoid area (left)	
				Infrahyoid area (right)	
				SCM (left)	
				SCM (right)	
		(B) Dynamic (counting 1–10, vowel extension /i/)	Tenderness	Submental area	
				Infrahyoid area (left)	
				Infrahyoid area (right)	
				SCM (left)	
				SCM (right)	
			Tightness	Submental area	
				Infrahyoid area (left)	
				Infrahyoid area (right)	
				SCM (left)	
				SCM (right)	
	Limitation in lateralmovement of larynx				
	Limitation in hyoid movement			(1) Lateral movement	
				(2) Anterioposterior movement	
	Laryngeal space/gap reduction			(A) Cricothyroid	(1) Static
					2) Dynamic: (vowel extension /i/ with habitual pitch, low pitch, high pitch, gliding from low to high pitch and VS counting 1–10)
				(B) Thyrohyoid	(1) Static
					(2) Dynamic: (vowel extension /i/ with habitual pitch, counting 1–10)

TABLE 3.
Calculating of CVR for the Laryngeal Palpatory Scale (LPS)

Number	Items	1. Not Necessary	2. Useful But Not Essential	3. Essential	CVR	Interpretation
	Observation					
1	Head and neck extension		1	9	0.8	Remained
2	Geniohyoid pull (double chin)		1	9	0.8	Remained
3	Head tilt (from midline: left or right)		1	9	0.8	Remained
4	Raised shoulders during rest/speaking (left, right, or both)		1	9	0.8	Remained
5	Deviated larynx (from midline: left or right)		1	9	0.8	Remained
6	Obvious activity in the anterior neck (omohyoid, SCM) (during counting)	6		4	0.2*	Eliminated*
	Palpation					
	Muscle condition					
	Tenderness (static)					
7	Submental area			10	1	Remained
8	Infrahyoid area (left)			10	1	Remained
9	Infrahyoid area (right)			10	1	Remained
10	SCM (left)			10	1	Remained
11	SCM (right)			10	1	Remained
	Tightness (static)					
12	Submental area			10	1	Remained
13	Infrahyoid area (left)			10	1	Remained
14	Infrahyoid area (right)			10	1	Remained
15	SCM (left)			10	1	Remained
16	SCM (right)			10	1	Remained
	Tenderness (dynamic: counting 1–10, vowel extension /i/)					
17	Submental area			10	1	Remained
18	Infrahyoid area (left)			10	1	Remained
19	Infrahyoid area (right)			10	1	Remained
20	SCM (left)			10	1	Remained
21	SCM (right)			10	1	Remained
	Tightness (dynamic: counting 1–10, vowel extension /i/)					
22	Submental area			10	1	Remained
23	Infrahyoid area (left)			10	1	Remained
24	Infrahyoid area (right)			10	1	Remained
25	SCM (left)			10	1	Remained
26	SCM (right)			10	1	Remained
27	Limitation in lateral movement of larynx			10	1	Remained
28	Limitation in vertical movement of larynx (deep breathing)	7		3	0.4*	Eliminated*
29	Limitation in vertical movement of larynx (swallowing)		1	9	0.8	Remained
30	Limitation in vertical movement of larynx (vowel extension /i/)		1	9	0.8	Remained
31	Limitation in lateral movement of hyoid		1	9	0.8	Remained
32	Limitation in anterioposterior movement of hyoid	7	1	3	0.4*	Eliminated*
	Laryngeal space/gap reduction (static)					
33	Cricothyroid		1	9	0.8	Remained
34	Thyrohyoid		1	9	0.8	Remained
	Laryngeal space/gap reduction (dynamic)					
35	Cricothyroid visor (vowel extension /i/ with habitual pitch, low pitch, high pitch, gliding from low to high pitch and VS counting 1–10)		1	9	0.8	Remained
36	Thyrohyoid (vowel extension /i/ with habitual pitch, counting 1–10)		1	9	0.8	Remained

Note: In regard to number of experts ($N = 10$), the items with the CVR bigger than 0.62 remained on the scale and the rest eliminated*.Abbreviation: CVR, content validity ratio.

TABLE 4.
Calculation of I-CVI and S-CVI Using the S-CVI/Ave Approach of the Laryngeal Palpatory Scale (LPS)

Number	Items	1. Not Relevant	2. Item Need Some Revision	3. Relevant But Need Minor Revision	4. Very Relevant	Number in Agreement	I-CVI	Interpretation
	Observation							
1	Head and neck extension	1	1		9	9	0.9	Appropriate
2	Geniohyoid pull (double chin)	1	1		9	9	0.9	Appropriate
3	Head tilt (from midline: left or right)	1	1		9	9	0.9	Appropriate
4	Raised shoulders during rest/speaking (left, right, or both)	1	1		8	8	0.8	Appropriate
5	Deviated larynx (from midline: left or right)	1			9	9	0.9	Appropriate
	Palpation							
	Muscle condition							
	Tenderness (static)							
6	Submental area				10	10	1	Appropriate
7	Infrahyoid area (left)				10	10	1	Appropriate
8	Infrahyoid area (right)				10	10	1	Appropriate
9	SCM (left)				10	10	1	Appropriate
10	SCM (right)				10	10	1	Appropriate
	Tightness (static)							
11	Submental area				10	10	1	Appropriate
12	Infrahyoid area (left)				10	10	1	Appropriate
13	Infrahyoid area (right)				10	10	1	Appropriate
14	SCM (left)				10	10	1	Appropriate
15	SCM (right)				10	10	1	Appropriate
	Tenderness (dynamic: counting 1–10, vowel extension /i/)							
16	Submental area				10	10	1	Appropriate
17	Infrahyoid area (left)				10	10	1	Appropriate
18	Infrahyoid area (right)				10	10	1	Appropriate
19	SCM (left)				10	10	1	Appropriate
20	SCM (right)				10	10	1	Appropriate
	Tightness (dynamic: counting 1–10, vowel extension /i/)							
21	Submental area				10	10	1	Appropriate
22	Infrahyoid area (left)				10	10	1	Appropriate
23	Infrahyoid area (right)				10	10	1	Appropriate
24	SCM (left)				10	10	1	Appropriate
25	SCM (right)				10	10	1	Appropriate
26	Limitation in lateral movement of larynx		1	1	8	9	0.9	Appropriate
27	Limitation in vertical movement of larynx (swallowing)		1	1	8	9	0.9	Appropriate
28	Limitation in vertical movement of larynx (vowel extension)		1	1	8	9	0.9	Appropriate
29	Limitation in lateral movement of hyoid		2	1	7	8	0.8	Appropriate
	Laryngeal space/gap reduction (static)							
30	Cricothyroid				10	10	1	Appropriate

(*Continued*)

TABLE 4. (*Continued*)

Number	Items	1. Not Relevant	2. Item Need Some Revision	3. Relevant But Need Minor Revision	4. Very Relevant	Number in Agreement	I-CVI	Interpretation
31	Thyrohyoid *Laryngeal space/gap reduction (dynamic)*				10	10	1	Appropriate
32	Cricothyroid visor (vowel extension /i/ with habitual pitch, low pitch, high pitch, gliding from low to high pitch and VS counting 1–10)				10	10	1	Appropriate
33	Thyrohyoid (vowel extension /i/ with habitual pitch, counting 1–10)				10	10	1	Appropriate
	I-CVIs							**0.97**

Note: Number of terms = 33; number of experts = 10, S-CVI/Ave or average of I-CVIs = 0.97. Interpretation of I-CVIs: if the I-CVI is higher than 79 percent, the item will be appropriate; if it is between 70 and 79 percent, it needs revision; if it is less than 70 percent, it is eliminated*.Abbreviations: I-CVI, item-content validity index; S-CVI, scale-level content validity index; CVIs, average of item-level content validity index.

Inter-rater reliability

The inter-rater reliability estimates for each item are presented in Table 6. As shown in Table 6, the weighted kappa ranged from 0.41 for the item "high and back position of hyoid," suggesting moderate inter-rater agreement to 1 for the item "pain in the anterior/posterior neck," indicating almost perfect agreement.

DISCUSSION

The purpose of this study was to develop and validate a new laryngeal palpatory scale to grade the tensioned structures in MTD with a quantitative measurement.

The current version of the LPS contains 45 items in three subscales: "patient's symptomatic complaint," "observation," and "palpation." The parts consist of classified target anatomical structures created by item generation and psychometric evaluation, using content validity (qualitative and quantitative) and face validity (qualitative). Scoring is done based on a four-point Likert-type scale.

Insufficient target anatomical structures and a lack of categorization are major flaws of previous scales.[24] These limitations have been considered in the LPS. Anatomical structures included in the LPS are head and neck, shoulders, larynx, submental area, infrahyoid area, cricothyroid muscles, sternocleidomastoid muscles, hyoid bone, cricothyroid space, and thyrohyoid space (Figure 2). These structures are assessed during observation and palpation by the clinician.

In the LPS, pain is questioned (yes/no) and rated (0–10) without applying pressure. Many previous methods assessed pain in response to pressure on the larynx and hyoid bone. Among available palpation methods, only that of Lieberman[37] included patient's qualitative complaint of pain using yes/no responses. Based on clinical experience and literature, there is an association between pain and dysphonia, especially in professional voice users.[38] Therefore, this item is probably crucial and helpful to improve patient's clinical diagnosis procedure.

Although clinically recognized, the relationship between cervical problems[10,39] and laryngeal muscle tension has rarely been considered in palpation scales. In 2005, Kooijman et al[10] evaluated body posture by modifying the method of Angsuwarangsee and Morrison.[8] Kooijman et al[10] assessed posterior weight bearing, anterior weight bearing, and anteroposition of the head using a qualitative judgment. To our knowledge, there is no palpatory rating system that gave a quantitative assessment of the head, neck, and shoulder components.[12] The LPS attempts to acknowledge this shortcoming.

According to Lieberman,[37] the suspensory muscles resting length can be influenced by an incorrect head position (ie, forward neck extension, tilted head).[37,40,41] Also, based on a simple model suggested by Kooijman,[10] the geniohyoid muscle is involved in the horizontal movement of the larynx in a ventral direction, which likely permits to assess the geniohyoid pull.[10,40] Moreover, left or right extra superior laryngeal muscle activity, originated from functional posture abnormalities, can lead to a laryngeal deviation from the midline and in turn influence the vocal mechanism.[37] Additionally, shoulder alignment can inform the clinician about increased muscular tension in patients with MTD.[4,42,43] These examples originate from clinical observations and may justify the inclusion of neck and shoulder evaluation in the LPS.

The "palpation" subscale contains four distinct categories: ""muscle condition," "laryngeal and hyoid position,"

TABLE 5.
Calculation of I-CVI and S-CVI by the S-CVI/Ave Approach of the Laryngeal Palpatory Scale (LPS) (12 Suggested Items by Experts)

Number	Items	1. Not Relevant	2. Item Need Some Revision	3. Relevant But Need Minor Revision	4. Very Relevant	Number in Agreement	I-CVI	Interpretation
1	Pain in the anterior/ posterior neck during rest/speaking (pain area: . . .)				7	7	1	Appropriate
2	Cricothyroid left (tenderness (static))				7	7	1	Appropriate
3	Cricothyroid right (tenderness (static))				7	7	1	Appropriate
4	Cricothyroid left (tightness (static))				7	7	1	Appropriate
5	Cricothyroid right (tightness (static))				7	7	1	Appropriate
6	Cricothyroid left (tenderness (dynamic))				7	7	1	Appropriate
7	Cricothyroid right (tenderness (dynamic))				7	7	1	Appropriate
8	Cricothyroid left (tightness (dynamic))				7	7	1	Appropriate
9	Cricothyroid right (tightness (dynamic))				7	7	1	Appropriate
10	Limitation in vertical movement of larynx (during counting)		1		6	6	0.86	Appropriate
11	High position of larynx		1		6	6	0.86	Appropriate
12	High and back position of hyoid		1	1	5	6	0.86	Appropriate
	I-CVIs							**0.96**

Note: Number of items = 12; number of experts = 7, S-CVI/Ave or average of I-CVIs = 0.96. Interpretation of I-CVIs: if the I-CVI is higher than 79 percent, the item will be appropriate; if it is between 70 and 79 percent, it needs revision; if it is less than 70 percent, it is eliminated*.Abbreviations: I-CVI, item-content validity index; S-CVI, scale- level content validity index; CVIs, average of item-level content validity index.

"movement limitation," and "laryngeal space/gap reduction." Palpation evaluates physiologic core traits such as increased extrinsic laryngeal muscle activation that keeps the larynx in a well-balanced and natural position.[3] Accurate identification of extrinsic muscles is difficult across patients. As a result, the terms "submental area" and "infrahyoid area" muscles are considered for palpation in the LPS. According to clinical observations, imbalanced muscle conditions can result from vocal hyperfunctionality and muscle asymmetry.[24] Nevertheless, there is no differentiation between right and left muscle patterns in the available palpatory methods, with the exception of the right and left SCM of the Mathieson et al scale.[9,24] Apart from the submental muscles, the LPS considers the left and right muscle behaviors of each muscle group separately.

Tenderness and tightness, which are both considered in the current scale, are the proposed factors to assess muscle condition. Pain,[6,13–18] resistance,[9] nodularity,[15] hypertonicity,[6,14,16,18] tenderness,[3,6,11,14,19,23] and tightness[3,11,23] have been used as criteria to measure larynx and neck muscle tension, with the last four being most widely used.[12] There is little information on which factor is most suitable to measure tension.[12] The impression of muscle tightness can occur with or without pain and may be perceived as "restricted range of motion" or "excessive soft tissue resistance" of muscles.[44,45]

Understanding the area of muscle tightness will help both speech/voice and physical therapists to develop an accurate treatment program. Moreover, it is necessary to evaluate target structures for tenderness or discomfort before applying increased pressure for tightness evaluation. Otherwise, this might lead to undesired discomfort for the patient and increased tightness in the affected area. In accordance with most previous palpation methods, the LPS examines tenderness and tightness of muscles during both static and dynamic tasks.[3,6,8,11,13,14,16,19,20,24] Data support the

TABLE 6.
Weighted Kappa for Each Item of the Laryngeal Palpatory Scale (LPS)

Items	Weighted Kappa	Std. Error
Patient's symptomatic complaint		
Pain in the anterior/posterior neck during rest/speaking	1	0.00
Observation		
Head and neck extension	0.94	0.54
Geniohyoid pull	0.64	0.09
Head tilt	0.509	0.174
Raised shoulders	0.79	0.203
Deviated larynx	0.74	0.09
Palpation		
Muscle condition		
Tenderness (static)		
Submental area	0.93	0.06
Infrahyoid area left	0.79	0.09
Infrahyoid area right	0.69	0.11
Cricothyroid left	0.67	0.11
Cricothyroid right	0.63	0.11
SCM left	0.74	0.13
SCM right	0.77	0.12
Tightness (static)		
Submental area	0.78	0.76
Infrahyoid area left	0.69	0.09
Infrahyoid area right	0.69	0.09
Cricothyroid left	0.64	0.09
Cricothyroid right	0.64	0.09
SCM left	0.608	0.09
SCM right	0.61	0.09
Tenderness (dynamic)		
Submental area	0.82	0.09
Infrahyoid area left	0.77	0.09
Infrahyoid area right	0.69	0.106
Cricothyroid left	0.57	0.12
Cricothyroid right	0.68	0.11
SCM left	0.74	0.13
SCM right	0.77	0.12
Tightness (dynamic)		
Submental area	0.61	0.09
Infrahyoid area left	0.65	0.09
Infrahyoid area right	0.62	0.09
Cricothyroid left	0.54	0.101
Cricothyroid right	0.52	0.102
SCM left	0.603	0.09
SCM right	0.68	0.09
Laryngeal and hyoid position		
High position of larynx	0.63	0.09
High and back position of hyoid	0.41	0.107
Movement limitation		
Limitation in lateral movement of larynx	0.705	0.087
Limitation in vertical movement of larynx (swallow)	0.57	0.08
Limitation in vertical movement of larynx (vowel extension)	0.67	0.08
Limitation in vertical movement of larynx (number counting)	0.59	0.09
Limitation in lateral movement of hyoid	0.607	0.09
Laryngeal space/gap reduction (static)		
Cricothyroid space (visor)	0.71	0.08
Thyrohyoid space	0.69	0.08
Laryngeal space/gap reduction (dynamic)		
Cricothyroid space (visor)	0.72	0.08
Thyrohyoid space	0.67	0.09

$P < 0.05$.

possibility that excessive tension can continuously be detected in patients with vocal nodules, even at rest[46] (tonic pattern of contraction),[11] while some MTD patients revealed increased muscle tension only during dynamic tasks[11,14] (phasic pattern of contraction).[11]

In the present study, additional indicators such as cricothyroid and SCM muscles were included to measure the tension. The cricothyroid muscle is usually considered an intrinsic laryngeal muscle but is actually extrinsic and easy for palpation.[40] It is important to assess the cricothyroid muscle for tenderness and tightness on both sides in both resting and dynamic tasks because there are sometimes differences in muscle bulk between the sides.[37] Abnormal contraction of the cricothyroid muscle can affect the function of the cricothyroid visor and consequently result in a voice disorder.[47] So, it is likewise possible to assess the action of the cricoid and thyroid (cricothyroid visor) in relation to each other, especially in terms of range of movement.[48] It is clinically possible to see both diminished movement range and locked cricothyroid visor in different positions,[37] which can be assessed and compared at rest and during pitch maneuvers.[11] In addition, many voice patients have increased tension in the SCM muscles, especially during dynamic tasks. The SCM muscles are included in the LPS because they have an indirect impact on phonation and might indicate a postural problem.[10]

Hyolaryngeal elevation is another core trait to describe MTD,[13,15,49–51] and some researchers assess objectively the increased laryngeal height. Radiographic measures in the study of Lowell et al[52] revealed a significantly higher position of both hyoid and larynx for people with MTD compared with no voice disorders. These findings got support from palpation studies.[12] Most available palpation methods determine the hyolaryngeal position indirectly, for example, by evaluating the high and back position of the hyoid, the high position of the thyroid, excessive tension in the thyrohyoid muscles or suprahyoid muscles, and a reduced thyrohyoid space. In the LPS, palpatory findings are derived from the high and back hyoid position and high laryngeal position from the distance between the clavicles and the lower edge of the cricoid cartilage. This procedure is adapted from Mathieson's[9] palpation system, the only one to examine the height of the larynx directly.

Moreover, extralaryngeal tightness and changed length can be perceived as resistance to the lateral movement of the larynx.[13,37] It is important to observe the range of vertical laryngeal movements during different types of tasks such as swallowing and phonation.[37] Paralaryngeal muscle tension can influence the flexibility of vertical laryngeal movement, especially when it is associated with severe forward neck hyperextension.[37] In addition, it seems that restricted laryngeal movement leads to more physical effort during phonatory tasks, in particular vowel /i/ extension, which can reflect the held nature of the voice production apparatus. The last item in the LPS evaluates thyrohyoid gap/space, which can be reduced or completely faded in patients with excessive para/extralaryngeal muscle tension.[37] It is sometimes associated with pain or tenderness during phonatory tasks, particularly vowel extension.

To date, there is no adequate information on psychometric properties, reliability, and content validity of the available palpatory rating methods,[12] apart from two studies that determined reliability.[8,24] Angsuwarangsee and Morrison[8] reported good inter-rater and intra-rater reliability for the method introduced by Lieberman, with the exception of pharyngolaryngeal muscle tension. Angsuwarangsee and Morrison interpreted that due to the relatively short time gap between the two examinations, the intra-rater reliability might not be valid. In another study by Stepp et al,[24] generally poor inter-rater reliability, measured with Pearson's correlation, was found for both the grading systems of Angsuwarangsee and Morrison[8] and Mathieson et al.[9] In the present study, inter-rater reliability, as measured with the weighted kappa statistic, ranged from 0.41 to 1 for the different items of the scale. The highest inter-rater agreement value ($k^* = 1$) was seen for "pain in the anterior/posterior neck during rest/speaking" and the lowest value ($k^* = 0.41$) was seen for "high and back position of hyoid." It is hypothesized that the moderate agreement for this last item is related to a variability in suprahyoid muscle tension. Greater suprahyoid muscle tenderness and tightness make it difficult to maneuver for finding the hyoid position. In the study by Van Lierde et al,[17] palpation of the hyoid bone was unachievable in one of the subjects, which was probably due to hypertonicity of the geniohyoid muscle and stylohyoid muscle.

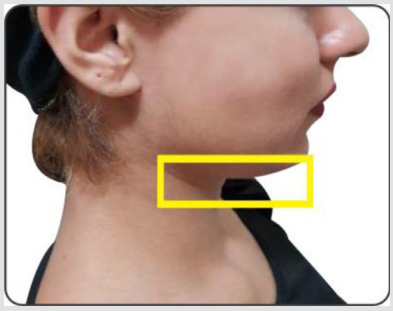
Generally, moderate to almost perfect agreement for each single item indicates that the accompanying text behind the scale is appropriate to guide the examiners in the rating procedure. However, a noteworthy omission is the issue of subjectivity of the palpation methods. The subjectivity feature of items is attempted to reduce in LPS using quantifiable criteria. Finding criteria for all presented items in LPS was challenging and was not completely realized. It is important to acknowledge that this scale is measuring a clinician's findings of a physical state. Therefore, factors such as training and experience might affect scoring. These factors, along with respecting the defined criteria, can increase reliability among clinicians. Furthermore, the current scale assumes that raters are correct in their detection and ratings based on the inter-rater reliability findings; however, accuracy testing with other, more objective, tools such as surface EMG may increase the validity and utility of the scale. Larger sample sizes are needed in future studies to provide adequate data on sensitivity, specificity, concurrent validity, and cutoff scores.

CONCLUSION

The LPS is a valid and reliable instrument for assessing patients with MTD, which encourages its use in routine clinical voice assessment.

Future studies are needed to provide adequate data on sensitivity, specificity, concurrent validity, and cutoff scores.

APPENDIX A. TECHNIQUE OF LARYNGEAL PALPATORY SCALE

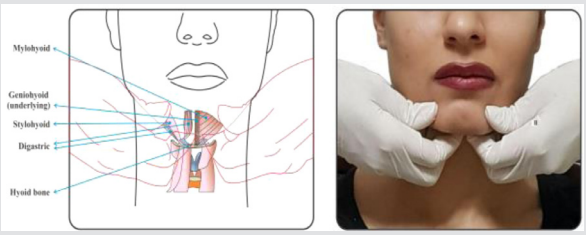
Patient's symptomatic complaint	
Pain in the anterior/posterior neck at rest or during speaking (pain area: . . .)	➢ To rate the patient's pain, as well as increasing the feasibility and objectivity of this item, ask the patient to consider a degree of pain from 0 to 10 and choose a number, which shows the degree of his or her pain, where 0 demonstrates the absence of pain (rate 0), numbers 1 to 3 show mild (rate 1), 4 to 7 moderate (rate 2), and 8 to 10 severe pain (rate 3). Specify rest or speaking condition. Write the pain area.
Observation	
Head and neck extension 	➢ Judge in an upright standing position in sagittal view. ➢ Ask the patient to stand comfortably. Look for a forward head position or extension of neck. With good head and neck position, the vertically alignment of the earlobe over the acromion process can exist. In head or neck extension, the earlobe seems to be forward of the acromioclavicular (AC) joint. In the sagittal view, align the plumb line with the AC joint, and notice its position relative to the ear. Circle 0 when the earlobe aligns approximately over the acromion process. ➢ **Note:** In extreme cases, the patient will find it difficult to swallow. In these cases, besides presenting of the head or neck extension, the patient needs extra extension of the head during swallowing. Circle 2 in moderately forward head or neck extension; sometimes combined with moderately extra extension of head during swallowing. Circle 3 if the patient will find it severely difficult to swallow.
Jeniohyoid pull (double chin) 	➢ Stand on the right side of the patient who is seated in a low-backed chair to examine jeniohyoid pull (double chin). ➢ Circle 3 if severe forward laryngeal movement exists.
Head tilt from midline (left or right) 	➢ Stand in front of the patient. Seek asymmetry such as displacing of the head toward one shoulder or slight rotation of the head. Use a straight and thin tool to complete the evaluation. The vertically alignment of the nose with the middle of the chin should be noticed. ➢ Rate 0 when the nose aligns with the middle of the chin. Rate 3 when severe head tilt is present (look for the symmetrically placement of the sternocleidomastoid muscles without existing of one more prominent in comparison with the other).

(*Continued*)

Raised shoulders at rest/during speaking (left, right, or both) 	➢ Stand behind the patient, determine whether the shoulder blades are level using a straight and thin tool. Put the tool on the shoulders line, from one acromioclavicular (AC) to another one. ➢ Rate 0 when the shoulders are in a symmetrical and neutral level. Rate 3 when the shoulders are severely in an asymmetrical (left or right) or symmetrical raised level. Specify rest or speaking condition.
Deviated larynx (from midline: left or right) 	➢ Look for laryngeal deviation while standing in front of the patient. Align the plumb line from the midline of the chin to the suprasternal notch. ➢ Rate 0 when the line deviated both sides in two parts equally. Rate 3 when the larynx severely deviated to left or right side. ➢ Specify the larynx deviated side.
Palpation	
Muscle condition	➢ Evaluating the muscles, which have been signified as the left, and right, must be carried out simultaneously. ➢ Rate the tenderness and tightness, by circling a number, during the static and dynamic (counting from 1 to 10 and sustaining vowel /i/) procedures.
Tenderness (static and dynamic)	➢ During evaluation, the pressure is a light pressure (about one-third of the pressure needed during tightness evaluation). ➢ To rate the patient's tenderness, as well as increase the feasibility and objectivity of this item, ask the patient to consider a degree of pain or discomfort (in response to light pressure) from 0 to 10 and choose a number, which shows the degree of his or her pain or discomfort, where 0 demonstrates the absence of pain or discomfort (rate 0), numbers 1 to 3 show mild (rate 1), 4 to 7 moderate (rate 2), and 8 to 10 severe pain or discomfort (rate 3) (patient may "jump" when the area palpate).
Tightness (static and dynamic)	➢ After evaluating the tenderness, the pressure is increased gradually, until the muscle can be palpated firmly and excessive tightness (may be perceived as "restricted range of motion" or "excessive soft tissue resistance") of muscles can be defined by clinician but without causing the patient distress. ➢ During the evaluation of muscle tightness, part of the assessing muscle, which has been circled to have 2 or 3 tenderness score (in case of resulting moderate to severe discomfort for patient), will not palpate to evaluate the tightness to avoid increased muscle tension. Rate score similarly to a tender score in this condition. ➢ Examiner should be reminded not to include areas where patient reported to have severe symptomatic pain.
	➢ The submental muscle area is palpated using the clinicians' both hands. ➢ During the evaluation, clinician stays behind the patient and applies pressure upward and backward from the midpoint of the

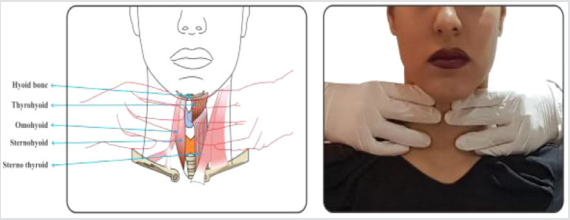
(*Continued*)

Submental muscle area



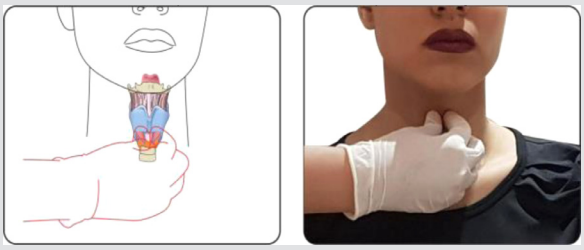
mandible toward the hyoid bone by using the three fingers (index, second, and third fingers). The entire submental area is then palpated.

Infrahyoid area (left), infrahyoid area (right)



➢ The procedure is continued on the left and right infrahyoid muscle areas, simultaneously. The clinician using the index and third fingers of the both hands carries it out. During the evaluation, clinician stays behind the patient. Evaluation starts from the inferior part of the hyoid bone, ending at the sternal attachment.

Cricothyroid left, cricothyroid right



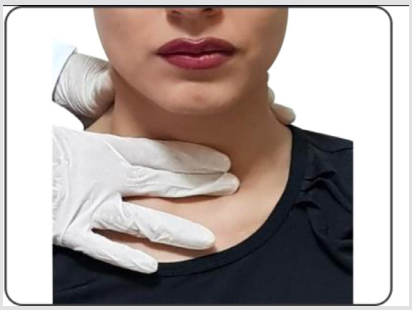
➢ Palpate cricothyroid left and right muscles simultaneously using index and thumb fingers of the right hand. During the evaluation, the clinician stays on the right side of the patient. First, palpate the cricothyroid gap anteriorly, and then move index and thumb fingers laterally around and above the anterior third of the cricoid ring, feeling for the bellies of the muscles.

SCM left, SCM right

➢ Palpate the SCM muscles bimanually by using the three fingers (index, second, and third fingers). Evaluation starts at the point of attachment of the SCMs to the mastoid processes ending at the sternal attachment (put the thumbs of each hand on the back of the patient's neck).
➢ During tightness evaluation, special care should be taken to avoid sustained or vigorous carotid artery compression during these maneuvers in elderly patients.

Laryngeal and hyoid position

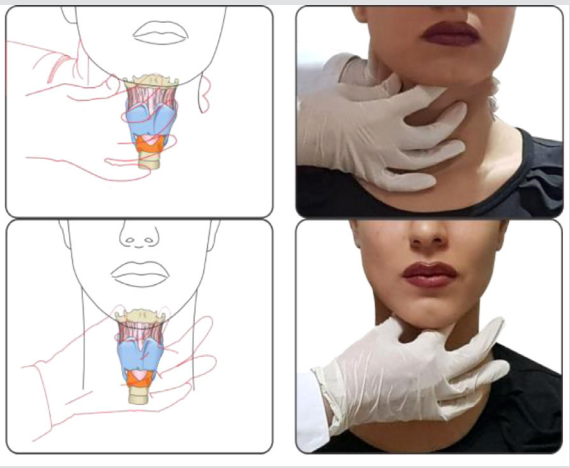
High position of larynx



➢ The right-handed clinician stands on the right side of the patient, then carries out this procedure by placing the fingers of one hand, held horizontally, with the lowest finger at the level of the clavicles (Mathieson laryngeal manual therapy palpatory evaluation scale).[9]
➢ Circle 0 if position allows two fingers. Circle 1 as mild high held position of larynx if two and a half fingers placed between the clavicles and the lower edge of the cricoid cartilage. Circle 2 when high held larynx allows to place three fingers between the clavicles and the lower edge of the cricoid cartilage. Circle 3 if high held larynx allows to place more than three fingers between the clavicles and the lower edge of the cricoid cartilage.

(*Continued*)

High and back position of hyoid



➢ First find the body of the hyoid bone with the index finger, and then slide the index and thumb fingers back along the greater horns.
➢ Circle 0 if the superior border of the hyoid bone is palpable and the posterior horns easily palpate bilaterally. Circle 1 if mildly difficult to palpate the superior border of the hyoid bone and the posterior horns without tenderness or discomfort for patient. Circle 2 if it is difficult to palpate the superior border of hyoid or greater horn posteriorly and palpation of the structure combined with tenderness and moderately making discomfort for patient. Circle 3 if the hyoid bone is tucked up under the mandible and cannot palpate without making sever discomfort for patient.

Movement limitation

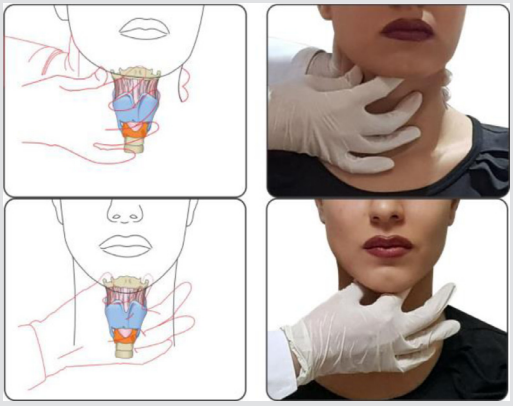
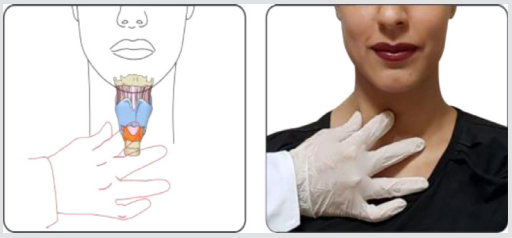
Limitation in lateral movement of larynx

➢ To assess the degree of lateral displacement of the larynx away from midline, pressure is applied to the thyroid cartilage lamina and shifts the larynx laterally using the pads of three fingers (index, third, and thumb) of one hand.
➢ Circle 0 if the lateral displacement of the larynx away from midline is possible easily, without making any discomfort for patient. Circle 1 if the lateral displacement of the larynx away from midline is mildly associated with resistance or limited range of motion but without making discomfort for patient. Circle 2 if the lateral displacement of the larynx away from midline is moderately associated with resistance or limited range of motion (maybe) combined with making moderately discomfort for patient. Circle 3 if resistance to lateral movement makes severe discomfort for the patient and it is impossible to carry out a forceful maneuver in the process of this evaluation and the patient might "jump" against lateral displacement of larynx.

Limitation in vertical movement of larynx

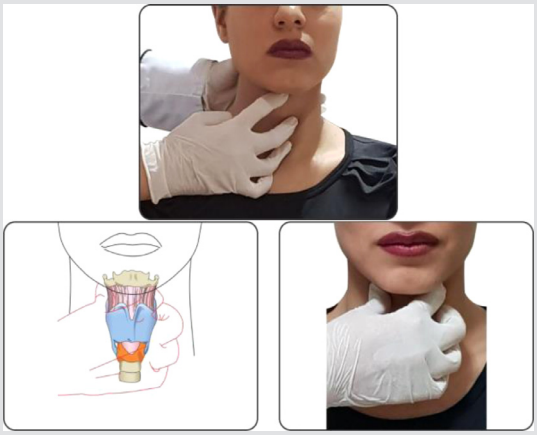
➢ During the evaluation, the examining clinician uses index, second, and third fingers to evaluate the vertical movement of the larynx as follows: index finger on the superior border of thyroid, third finger on thyroid lamina, and second (ring) finger on anterior cricoid rim (depending on the size of the examiner's hands and the dimensions of the patient's neck).
➢ Do not press your fingers, just put them as loose as possible.
➢ Normal swallowing evokes near-maximal hyolaryngeal elevation at a typical vertical elevation of larynx and for the hyoid, measured as the change from resting position, and produces greater laryngeal elevation than other tasks. During swallowing task, larynx moves upward and then returns to the neutral position. Circle 0 if you can feel freely elevation of larynx, when cricoid rim moves up about the upper edge of your third (middle finger in the photo) finger. Ask the subject to extend vowel /i/ for around 5 seconds without taking deep breath. During vowel extension, larynx moves upward. Circle 0 if you can feel freely elevation of larynx, when cricoid rim moves up about the upper edge of your second (ring)

(*Continued*)

	finger. Ask patient to count from 1 to 10. Circle 0 if you can feel freely movement of larynx during counting. Rate the limitation in the range of vertical laryngeal movement, by circling numbers from 1 to 3, on the basis that 1 represents mild limitation in vertical laryngeal movement and 3 represents severe limitation in the range of vertical laryngeal movement.
Limitation in lateral movement of hyoid 	➢ First find the body of the hyoid bone with the index finger, and then slide the index finger and thumb back along the greater horns while waggling the bone from side to side. ➢ Circle 0 if the greater horns of hyoid bone move freely without making any discomfort for the patient. Circle 1 if you can find mildly difficult to palpate both greater horns of hyoid bone with mildly limited resistance to the lateral movement of hyoid presence, without making discomfort for patient. Circle 2 if it is difficult to palpate the grater horn posteriorly and maybe palpation of the structure combined with tenderness and moderately making discomfort for patient. Circle 3 if palpation of the hyoid bone is impossible and it is tender and make severe discomfort for patient.
Laryngeal space/gap reduction	
Cricothyroid space/visor 	➢ **Note:** Palpate the anterior gap between the cricoid arch and the thyroid cartilage with the index finger during static and dynamic tasks. ➢ ***Static:***Circle 0 if both the gap and the anterior cricoid rim can be clearly palpated. Finding can range between full opening and closure. Circle 1 if the gap is reduced, but the anterior cricoid rim can be clearly palpated. Circle 2 if the gap is reduced and the cricoid arch projects anteriorly beneath the lower border of the thyroid cartilage, which has made it moderately difficult to palpate cricoid cartilage. Circle 3 if the gap is completely closed and (mostly) combined with tenderness and discomfort. ➢ ***Dynamic:*** Palpate the anterior gap between the cricoid arch and the thyroid cartilage with the index finger while asking the patient first to sustain vowel /i/ with habitual pitch, low pitch, high pitch, gliding from low to high pitch and vice versa, then to count from 1 to 10. Circle 0 if both the size of cricothyroid space and its range of motion are normal during all dynamic tasks. Circle 1 if the anterior gap is slightly reduced, but has movement during dynamic tasks. Circle 2 if the cricoid arch projects anteriorly beneath the lower border of the thyroid cartilage, but has slight movement during tasks. Circle 3 if the gap is completely closed and there is no movement during tasks, which (mostly) combined with tenderness and discomfort.

(*Continued*)

Thyrohyoid space



➢ **Note***:* Examiner evaluates the relative size of the thyrohyoid space. While evaluating, the clinician puts the index finger in the mid part of the space and then examines the amount of narrowing, statically and dynamically (vowel extension /i/ with habitual pitch, counting 1−10) by using the index and thumb fingers and also by moving the fingers in the two directions of the space. Experience is important to determine the reasonable space.

➢ ***Static:*** Circle 0 if a reasonable space exists between these two structures and it is soft and there is not any tightness. Circle 1 if thyrohyoid space is reduced mildly but it is possible to move in the length of the space and there is no effect of tenderness or discomfort. Circle 2 if thyrohyoid space is reduced and it is difficult to move along the space (maybe) combined with tenderness and discomfort. Circle 3 if thyrohyoid space is completely diminished along its entire length, (mostly) combined with tenderness and discomfort.

➢ ***Dynamic:*** Circle 0 if thyrohyoid space is reasonably open during vowel extension /i/ with habitual pitch and counting 1−10 and it is possible to move easily along the space. Circle 1 if thyrohyoid space's range of motion is reduced mildly during tasks, but there is no effect of tenderness or discomfort. Circle 2 if thyrohyoid space is tight moderately during tasks, which make it difficult to move in the length of the gap easily (maybe) combined with tenderness or discomfort. Circle 3 if thyrohyoid space is absent during tasks (mostly) combined with tenderness or discomfort.

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