Methods of Measuring Laryngeal Muscle Tension in Patients with Muscle Tension Dysphonia: A Scoping Review

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Summary: Background. In clinical practice and research relating to Muscle Tension Dysphonia (MTD), several laryngeal muscle tension measurement methods are used to diagnose, to identify specific muscle strengths and deficits, and to measure therapeutic outcomes. The variety and reliability of available measurement methods presents challenges within diagnosis and treatment. The lack of methodical standardization presents a barrier to homogeneous practice in this area. There is a need for a comprehensive scoping review of laryngeal muscle tension measurement methods.

Study Design. Scoping review.

Objectives. (1) To identify current methods of laryngeal muscle measurement which have been developed or tested with people with MTD; and (2) To identify the construct/s measured, reliability, validity, ability to detect change, efficiency and accessibility of identified methods.

Method. This scoping review was conducted using the Arksey and O'Malley framework. Studies were identified through searches of 4 major databases. The reviewer independently assessed titles, abstracts, and full-text articles.

Results. Twenty seven papers published from 2000 to 2022 that satisfied the inclusion criteria were selected from 194 studies. The papers showed a variety of approaches with regards to the measurement of laryngeal activity and tension in subjects with MTD. Just over a quarter (25.9%) were reviews of the validity of assessment methods of MTD, including surface electromyography (sEMG), while 22.2% discussed surface electromyography as a measurement of muscle activity in subjects with MTD. 96.3% used a published methodological framework.

Conclusions. Assessment methods for Primary MTD are multifaceted, including patient history, laryngoscopic examination, and voice-related musculoskeletal features. Potential use of objective measurement methods, including sEMG, Real Time Elastosonography, Magnetic Resonance Imaging was noted. Due to variability in assessment methods and results, there is a need for greater objective practical methodological standardization to ensure accurate diagnosis, appropriate care, and chart patient progress.

Key Words: Laryngeal−Muscle−Tension−Dysphonia−Measurement.

INTRODUCTION

Laryngeal tension has been identified as a primary factor in the development of muscle tension dysphonia (MTD) in singers. The concept of MTD has been described by Altman et al[1] as "a compensatory adaptation to glottal insufficiency" and by Koufman and Isaacson[2] as "altered laryngeal biomechanics" caused by "inappropriate or abnormal muscle tension." The term muscle tension dysphonia is a general term for an imbalance in the coordination of the muscles and breathing patterns needed to create voice. This imbalance can be seen without any anatomical abnormality (primary MTD) or in the presence of an anatomical abnormality (secondary MTD). In the case of secondary MTD, the muscle tension is thought to be the body's natural compensatory process to adjust for the vocal injury.[3]

In Muscle Tension Dysphonia (MTD) diagnosis and rehabilitation, laryngeal tension is measured in many ways and for many reasons; to screen and diagnose, to identify areas of deficit and strength, and to assess outcomes, the changes in status following treatment.[4] Currently the process of measuring laryngeal muscle tension is complicated by considerable variation in what is measured and how best to measure it. Morrison et al[5] developed a set of diagnostic criteria and definitions in this area in the hope that *"some form of system could be devised that would permit establishment of diagnostic criteria for the various voice disorders."*

Irrespective of what a measurement method is called, choosing one, or the optimum combination of methods, requires consideration of the following factors: (1) Reliability (2) Validity (3) Ability to detect change and (4) Feasibility and Acceptability of using the measurement method within a given context/population.[6]

In diagnosis, reliability (achieving the same response on repeated measurements) and validity (the degree to which the content and scores are an adequate reflection of the construct to be measured) are essential. In outcome assessment, responsiveness (the ability to detect change) is also crucial.[6] Feasibility will depend on the context in which the measurement instrument is being used, for example, clinical practice versus research.[7] Considerations may span factors including cost, time, and resources required for administration.[8] It may be important to consider acceptability to the patient or client, such as whether the task or assessment is something they are willing to do.[9] The choice of a measurement

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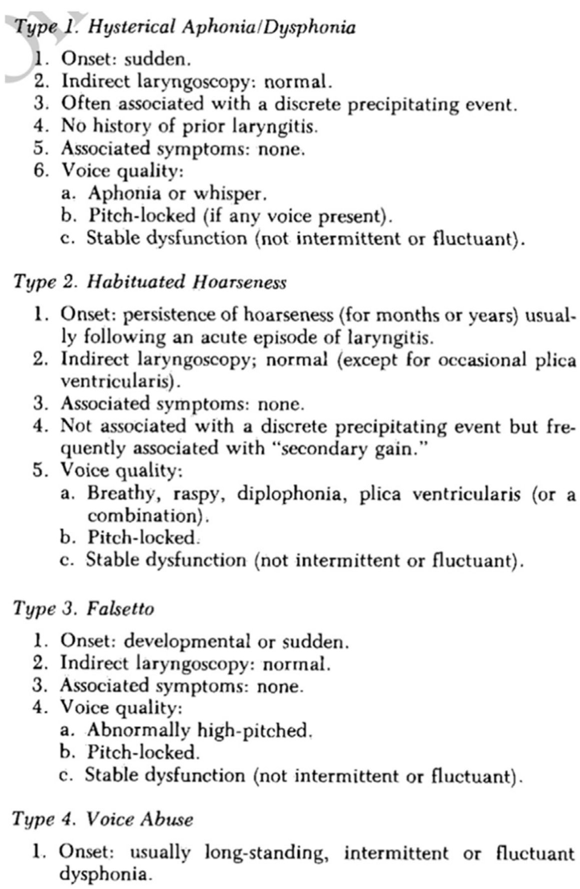
method has become increasingly examined in recent years, with a proliferation of measurement methods being developed for diagnosis and charting progress of those with MTD.[10–22] The number of available methods, combined with a lack of agreement on what should be measured and how, presents challenges for the ENT, SLT and researcher.

The first to develop the term muscle tension dysphonia were the team of Morrison et al[5] who analyzed the diagnostic criteria used over a 4-year period of treating 1000 patients. Prior to this data collection, Koufman and Blalock[23] distinguished 5 types of functional voice disorders based on a study of 52 patients (Figure 1).

That said, Morrison & Mathieson[24] developed a 5-point assessment which continues to form the broad basis for current consultation (Table 1). Further, Morrison & Mathieson[24] categorized MTD into different "types" (Table 2).

Within the categorization of subjects presenting as type 1, 81% of the 1000 presented with a posterior glottal gap (previously termed "posterior glottal chink"), 67% of subjects presented with a high larynx, 71% of subjects presented with suprahyoid tension and 81% with breathiness (Morrison et al[5]). In both clinical practice and MTD research, consideration must be given to the relevance of what is measured (Dworkin-Valenti et al[25]). Across all types of MTD, high incidences of high larynx, suprahyoid muscle tension and a


Type 1. Hysterical Aphonia/Dysphonia
1. Onset: sudden.
2. Indirect laryngoscopy: normal.
3. Often associated with a discrete precipitating event.
4. No history of prior laryngitis.
5. Associated symptoms: none.
6. Voice quality:
   a. Aphonia or whisper.
   b. Pitch-locked (if any voice present).
   c. Stable dysfunction (not intermittent or fluctuant).

Type 2. Habituated Hoarseness
1. Onset: persistence of hoarseness (for months or years) usually following an acute episode of laryngitis.
2. Indirect laryngoscopy; normal (except for occasional plica ventricularis).
3. Associated symptoms: none.
4. Not associated with a discrete precipitating event but frequently associated with "secondary gain."
5. Voice quality:
   a. Breathy, raspy, diplophonia, plica ventricularis (or a combination).
   b. Pitch-locked.
   c. Stable dysfunction (not intermittent or fluctuant).

Type 3. Falsetto
1. Onset: developmental or sudden.
2. Indirect laryngoscopy: normal.
3. Associated symptoms: none.
4. Voice quality:
   a. Abnormally high-pitched.
   b. Pitch-locked.
   c. Stable dysfunction (not intermittent or fluctuant).

Type 4. Voice Abuse
1. Onset: usually long-standing, intermittent or fluctuant dysphonia.

FIGURE 1. Five Types of functional voice disorders—Koufman and Blalock.[23]

TABLE 1.
Morrison & Mathieson (1993) Assessment Methods.

Assessment Method	
1	Patient History
2	Laryngoscopic examination
3	Perceptual-acoustic assessment (including GRBAS)
4	Voice-related musculoskeletal (assessed via palpation and observation)
5	Psychological evaluations

posterior glottal gap were present. (Morrison et al[5]) These characteristics are summarized in (Table 3).

In contrast to Morrison & Mathieson,[24] The European Laryngological Society (ELS) protocol includes 5 methods (Table 4).

While the diagnostic process related to MTD is often assessed in adherence to clinical guidelines, outcome measurement methods are usually selected and administered by individual clinicians.[26]

Although many measurement methods are of a complex and varied nature, it appears that the most successful diagnoses are the result of several methods used in conjunction to allow substantiation of the overall result/diagnosis.[10,12,13,14,15,18,24,27,28,29,30] The various assessment methods used to evaluate MTD have not yet been extensively reviewed simultaneously with regards to their interrater reliability. Comparison studies, focused on two approaches at most, including laryngeal palpation vs surface electromyography,[11] vocal fatigue index vs videostroboscopy,[31] surface electromyography vs videostroboscopy[32,33] and laryngeal aerodynamic analysis vs videoendostroboscopy[22] agreed that there was a need for combination methodologies in diagnosis as hyperfunctional features are not always acoustically or visibly perceptually distinguishable between typical and atypical voices.

The purpose of each method of laryngeal assessment is to identify the presence or absence of known symptoms of MTD, seeking to present a diagnosis which can then form the basis of treatment.[10,28] Assessment methodology generally includes several different approaches, often relying on one method to support the findings of the previous.[12]

TABLE 2.
Morrison & Mathieson (1993) Description of MTD Types

Type	*Description*
1	Structurally normal larynx with open posterior chink left between the arytenoid cartilages on phonation.
2a	Vocal Nodules
2b	Chronic Laryngitis
2c	Polypoidal Denegation

TABLE 3.
Diagnostic Features of MTD[5]

Muscle Tension Dysphonia	Will have	May have
1. HISTORY		
1 = Simple	Increased dysphonia with vocal use	Increased dysphonia with psychological stressors
2a = with vocal nodules	Significant vocal identity	Throat pain and/or tightness
2b = with chronic laryngitis	Income related voice use	Organic trigger
2c = with polypoidal degeneration	Prolonged and/or intensive voice use (2a,b,c)	Inhibition of voice use Smoking (esp. 2c)
Psychogenic "functional" dysphonia		
Vb = ventricular band	Varying dysphonia	Increased dysphonia with stresses
B = with bowing	Voice effortful	An organic trigger (eg, Virus, reflux)
Ha = hypo adducting (aphonia)	Voice fatigue with minimal use	Recognisable psychological precipitant of voice disorder
Ns = non specific		Periods of normal voice
2. LARYNGOSCOPIC FEATURES		
1 = Simple	Open posterior glottic chink No mucosal changes	Reduced posterior chink with masked resonance
2a = with vocal nodules	Open posterior glottic chink Vocal nodules	Lesser amounts of erythema and oedema
2b = with chronic laryngitis	Open posterior glottic chink Erythema, oedema and thickening	Less open posterior chink
2c = with polypoidal degeneration	Open posterior glottic chink Polypoid degeneration	Lesser amounts of erythema and oedema
Psychogenic "functional" dysphonia		
Vb = ventricular band	False fold adduction Altered true fold tension	Some erythema, edema or early polypoidal degeneration Triangular open posterior glottic chink
B = with bowing	False fold adduction Altered true fold tension	Triangular open posterior glottic chink Hyper adducted vocal processes
Ha = hypo adducting (aphonia)	False fold adduction Altered true fold tension Full fold movement with inhalation and cough	Hyper adducted vocal processes
Ns = non specific	False fold adduction Altered true fold tension	
3. PERCEPTUAL-ACOUSTIC FEATURES		
1 = Simple	Breathiness Glottal Attack Glottal Fry	Inappropriate pitch
2a = with vocal nodules	Glottal Attack	Pitch breaks
2b = with chronic laryngitis	Glottal Fry	Mono pitch Inappropriate pitch
2c = with polypoidal degeneration	Stridency/harshness	Inappropriate pitch
Psychogenic "functional" dysphonia		
Vb = ventricular band	Breathiness Stridency	Pitch breaks Glottal Attack
B = with bowing	Stridency	Reduced pitch or loudness range Inappropriate or mono pitch
Ha = hypo adducting (aphonia)	Glottal Fry Whisper Stridency	Hyper adducted onset and/or release
Ns = non specific	Stridency	Glottal Attack

(*Continued*)

TABLE 3. (*Continued*)

Muscle Tension Dysphonia	Will have	May have
4. MUSCULOSKELETAL FEATURES		
1 = Simple	Palpable increased suprahyoid tension Atlanto-occipital extension with increased pitch (jaw jut) Tongue retraction Reduced mandible use with phonation	Rise of larynx in neck with rising pitch Inappropriate posture of head, neck, and shoulders (shoulders raised and retracted) Increased intrathoracic phonatory pressure
2a = with vocal nodules		
2b = with chronic laryngitis		
2c = with polypoidal degeneration		
Psychogenic "functional" dysphonia		
Vb = ventricular band	Restricted mandibular movement	Larynx rise with pitch rise Visible/palpable strap muscle or suprahyoid tension Jaw jut
B = with bowing		Larynx rise with pitch rise Visible/palpable strap muscle or suprahyoid tension
Ha = hypo adducting (aphonia)		
Ns = non specific		
5. PSYCHOLOGICAL FEATURES		
MTD – all types	An intense attitude, generally uptight Voice function highly valued	Identifiable psychological stress factors
Psychogenic "Functional" Dysphonia	Recognisable etiological psychological stressors Stressors lead to feed-forward mechanism which participates in and promotes dysphonia	Psychological conflict recognised to be outside patient's awareness and definitively symbolised by voice dysfunction Denial that voice disability affects their life

Assessment methodologies also aim to provide a descriptive overview of the reported and observed symptoms while amalgamating evidence from different assessments and can be classified into two distinct groups:

1. Non-instrumental methods which require training, but do not need any equipment for examination. (eg, case history, palpation)
2. Instrumental methods which use tools for objective diagnosis of conditions and include laryngoscopic and videostroboscopic assessment, radiography and electromyography.

In recent years, there has been an increased focus on the measurement of laryngeal muscle activity with regards to quantifying the success of different therapeutic approaches. Several research studies and reviews have been published across a range of disciplines relating to the speaking voice and associated fields of study[12,13,14,15,28,34] These include the attempt to determine protocols for the assessment of voice,[35] the examination of reliable laryngoscopic features with which to determine MTD,[10] study of aerodynamic profiles in patients with MTD,[36] description of glottal aerodynamic measures in patients with MTD,[37] study of the parameters of compression of the supraglottis in dysphonic patients,[38] the establishment of protocols relating to sEMG signal in phonation evaluation[39] and the determination of strain elastosonography measurements in patients with primary MTD.[17] To date, however, little has been published with regards to the standardization of methods of measurement of MTD in the singing voice, suggesting the need for different measures to assess MTD while singing. Studies of clinical practice in this area also reveal considerable heterogeneity in the assessment methods used.[12,14,30] Performance-based and clinician-reported measures predominate, while the use of objective outcome measures remains limited.

TABLE 4.
European Laryngological Society Assessment Protocol

1	Laryngeal imaging
2	Auditory-perceptual evaluation
3	Aerodynamic measures
4	Acoustic analysis
5	Self-evaluation by the patient

In research, it is critical that the effects of treatment are quantified through considered measurement.[26] Outcome measurement methods must be carefully selected to ensure that change because of treatment can be detected.[15] If an outcome measurement instrument is not equipped to reliably detect change in the area of interest, significant research wastage can occur.[4] To this end, it has been increasingly recommended that approaches to outcome measurement be standardized. Several studies agree that objective and standardized determinants of physiology are critical for the differential diagnosis of MTD and its effective treatment, recommending further research be undertaken using standardized assessment methods.[11,12,13,14,17,18,28,29,30,34,40,41]

As heterogeneity in measurement methods produces incompatible data[33] which is not easily synthesised,[42] this may limit opportunities to amass treatment evidence across trials. In systematic reviews and meta-analyses of MTD treatments, variability in measurement instruments is frequently cited as a key factor limiting the combination and comparison of research results.[13]

There is a need for standard measurement protocols and synthesized information to assist clinicians and researchers to make informed choices in the selection of laryngeal muscle measurement instruments. To date, several reviews of laryngeal muscle tension assessment methods have been performed.[12,14,34] The majority undertake to compare 2 or more methods and assess the reliability and success of each. Reviews have been completed for: (1) vocal parameters, muscle palpation, self-perception of voice symptoms, pain and vocal fatigue[27]; (2) laryngeal electromyography[20]; (3) comparison of neck tension palpation rating systems with sEMG and acoustic measures[13]; (4) evidence-based clinical voice assessment[14]; (5) assessment methods of laryngeal muscle activity in MTD[12]; (6) sEMG as a useful tool in identifying MTD[34], (7) comparison of sEMG and laryngeal palpatory scale,[11] and (8) reliable laryngoscopic features for diagnosis.[10]

The purpose of this paper is to provide a contemporary perspective of the available literature on laryngeal muscle tension measurement methods relating to MTD. The addition of this study to current literature may provide useful information regarding subjective and objective methods of diagnosis and progress. It is hoped that this study may be used to encourage the standardization of assessment methods in practice and future studies relating specifically to MTD in the singing voice. To this end, it seeks to; (1) Identify all available methods of laryngeal muscle measurement which have been developed or tested with people with MTD; and (2) Identify the construct/s measured, reliability, validity, efficiency and accessibility of the identified methods.

METHODS AND PROCEDURES

Study design

Within the context of developing therapeutic tools to aid transition back to performance for singers who have experienced MTD, this scoping review was undertaken after an initial investigation into the muscles of the singing voice was collated into a compendium to be published later. The reviewer identified the broad research question to be addressed and the overall study protocol, including identification of search terms and selection of databases to search.

The methodology for this scoping review was based on the framework outlined by Arksey and O'Malley[43] and subsequent recommendations made by Levac et al.[44] The review included the following five key phases and final optional phase: (1) identifying the research question, (2) identifying relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing, and reporting the results. The final optional "consultation exercise" was not undertaken due to time constraints. The scoping review protocol was not registered in advance of completion.

For the purposes of this study, a scoping review is defined by Daudt et al,[45] as a type of research synthesis that aims to "map the literature on a particular topic or research area and provide an opportunity to identify key concepts; gaps in the research; and types and sources of evidence to inform practice, policymaking, and research."

Step 1. Identifying the research question

This review was guided by the question, "*What are the most successful and accessible methods of measuring muscle tension dysphonia?*"

Data management

Step 2. Identifying relevant studies

After identifying the principal methods of muscle tension measurement as non-instrumental assessment (case history, palpation) and instrumental assessment (observation, radiography, electromyography),[12] an initial broad search was undertaken to identify the various types of instrumental measurement of muscle tension available and implemented on February 06, 2022, across five electronic databases: NHI/PubMed (National Centre for Biotechnological Information), Wiley Online Library (multidisciplinary), Elsevier (multidisciplinary) ResearchGate (multidisciplinary) and Science Direct (Voice-focused, current awareness). The databases were selected to be comprehensive and to cover a broad range of laryngeal measurement approaches. A limit on date to include studies and reviews published no earlier than 2000 was imposed to ensure that only the most recent developments in methodologies were considered. This decision was made due to the amount of literature available dealing with earlier papers. No limit on primary language was placed on the database search, if the paper had previously been translated into English. The search string was developed in 3 phases before a final string was implemented.

Initial search string: Muscle, tension, dysphonia, electromyography, measurement, methods of assessment.

Second development of search string: Muscle tension dysphonia AND laryngeal AND muscle measurement AND methods of assessment.

Final string used throughout search process: “Muscle tension dysphonia” AND laryngeal AND muscle measurement AND methods of assessment.

The search string consisted of terms considered by the author to describe the subject and its methodology: laryngeal, muscle tension, muscle, measurement, methods of assessment. The search string was repeated within each database.

The following websites were also searched manually: The British Voice Association (http://www.britishvoiceassociation.org.uk). The British Association of Laryngology (https://www.britishlaryngological.org), Science Direct (https://www.sciencedirect.com) and Google (www.google.com).

Primary searches were run using PubMed, Wiley, ResearchGate, Elsevier, and Science Direct databases in February 2022. Secondary searches of individual measurement methods, reference list reviewing, and hand searching of hard-copy publications were conducted between May and August 2022.

Eligibility criteria (Table 5)

Step 3. Study selection

The reviewer independently assessed titles, abstracts, selected full-text articles, and reference lists of the studies retrieved by the literature search. A "snowball" technique was also adopted in which citations within articles were searched if they appeared relevant to the review. A second review was not implemented due to time constraints.

RESULTS

Search results

Figure 2 shows the PRISMA flow diagram of study selection. Initial searches yielded 3426 articles. Following the removal of duplicates and non-MTD specific literature, 194 articles were screened by title and abstract: with 25 articles undergoing full-text review. Secondary searches of individual measurement instruments and hand searching of journals identified a further 22 publications. In total, 47 references for 12 measurement methods were included in this review.

Identified measurement instruments

Step 4. Charting the data

A total of 12 measurement methods were identified. All had been developed or tested with people with MTD, in that at least one study of the psychometric properties of the measurement method had been undertaken and published (Table 6).

DISCUSSION

Step 5. Collating, summarising and reporting the results

The results of this scoping review are discussed with respect to the initial aims: (1) To identify current methods of laryngeal muscle measurement which have been developed or tested with people with MTD; and (2) To identify the construct/s measured, method of report, structure (components and scoring system), efficiency and accessibility of identified methods. A total of 12 different measurement methods were identified.

MTD does not always present itself similarly from patient to patient. Behrman et al,[38] concluded that supraglottic activity can also be observed in healthy speakers and should not necessarily be deemed as excessive laryngeal muscle tension, highlighting the need for assessment methods to include patient history, laryngoscopic and videostroboscopic assessment, perceptual-acoustic assessment (including GRBAS and CAPE-V), observations, voice-related musculoskeletal features, physiological or behavioral examinations, self-report (VHI), duration of a variable, and questionnaires.[10,12,14,15,27,28,40,41,46] Perceptual voice assessment, palpation, laryngoscopic and videostroboscopic assessment can be considered as subjective diagnosis methods while instruments such as electromyography, radiography and acoustic analysis allow objective measures to describe structure and function.[11,12,17,18,20,27,29,32,39,47,48] Differential diagnosis of MTD should include both subjective and objective data.

Based on the current review of 25 publications that met the inclusion and exclusion criteria, most studies investigated the assessment method of laryngeal muscle palpation,[11,13,19,27,49–51] followed closely by those

TABLE 5.
Study Inclusion and Exclusion Criteria

Study Inclusion Criteria	Study Exclusion Criteria
Studies focusing on the development or practical evaluation of measurement methods or their cultural/linguistic adaptation/translation.	Studies evaluating the effectiveness of interventions where a measurement instrument is used as an endpoint (without studying the measurement properties).
Studies including participants with MTD.	Studies reporting normative data without examining other measurement properties.
Studies reporting standardised measurement methods (defined as measurement methods with clear procedures for administration and scoring).	
Studies reported in full-text peer-reviewed publications.	

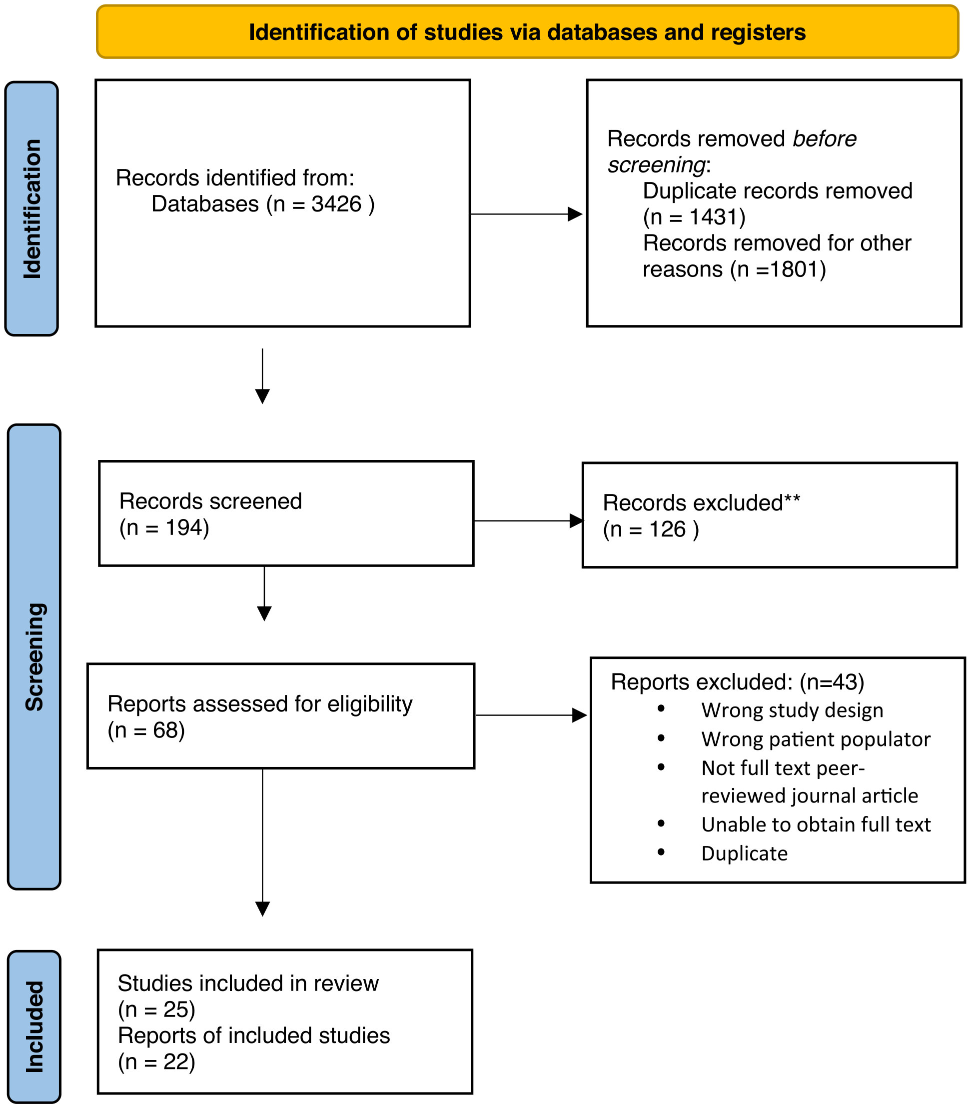


FIGURE 2. PRISMA SC-R study selection process.

discussing the use or limitations of surface electromyography as an additional objective measure.[13,32,34,39,47,52] The focus of most studies was to determine how well the test method identified the presence or absence of MTD, using a mix of healthy subjects and those diagnosed muscle tension dysphonia.[11,16,17,27,32,39,40,46,47,52]

OVERVIEW OF ASSESSMENT METHODS

Patient history

Overview

A non-instrumental, subjective method which requires confirmation by palpation, perceptual-acoustic or objective methods. Khoddami et al[12,32] highlight the *"disadvantage of history-taking associated with subjectiveness."*

Forming the initial basis of direction of diagnosis and informing the choice of subsequent assessment, the patient history allows a holistic view of the patient which can lead to more detailed questioning, the opportunity to rule diagnoses in and out, and the collation of common symptoms.[46] Good history taking allows the clinician to build a rapport with the patient, help the patient feel more comfortable about discussing their symptoms.[53] It also provides the opportunity to explore a patient's concerns and expectations *(Appendix A: Voice Case History example).*

In a study to investigate the affect of the accuracy of case histories on the interpretation of laryngoscopic and videostroboscopic assessment, Sauder et al[46] found accurate case histories suggesting specific abnormalities increased the probability of detection and percieved severity of MTD, while inaccurate case histories led to false-positive findings and failures to detect abnormalities or to interpret them as less severe. The patient histories in the reviewed studies did not provide any diagnostic support specific to MTD, but were designed for a broad range of vocal disorders. In general, case histories have been found to affect visual-perceptual judgements and contributed to decisions about clinical impressions and treatment.*(Appendix B: Patient's symptomatic complaints (aches and pains) and the practitioner's considerations[54])*

TABLE 6.
Study Characteristics

	Patient History	Self-Assessment	Laryngoscopic/ Videostroboscopy	Perceptual (a) / Acoustic (b) Assessment	Voice Related Musculoskeletal Features	sEMG/HDsEMG	RTE	Aero-dynamic Voice Analysis	LEMG
Useful papers:	Saunder et al. (2019)	Martinez et al. (2020)	Garaycochea et al. (2018), Sama et al. (2001), Morrison (1986)	Martinez et al. (2020), Latoszek et al. (2018)	Martinez et al. (2020), Kunduk (2016), Stepp (2009), Lowell (2012)	Khoddami et al. (2016), Balata et al. (2015), Van Houtte et al. (2013), Stepp (2012), Bracken et al. (2019), Wang & Yiu (2021),	Ata et al. (2020)	Gillespie et al. (2013), Espinoza et al. (2017), Garaycochea et al. (2018), Zheng (2010)	Martins et al. (2020)
What does it measure?	See Appendix 1	Patient sensation, history and impact on life	Depends on which classification system is followed – Van Lawrence (see Sama), Morrison-Rammage or Koufman.	a)GRBAS Dysphonia, roughness, breathiness, asthenia, tension. CAPE-V DSI (see Latoszek p697) AVQI b)maximum phonation times	Assesses resistance in right and left sternocleidomastoid, supralaryngeal area, laryngeal resistance to lateral pressure. Also assesses height of larynx.	The electrical potential present on the skin in consequence of a muscle contraction	The strain of Para laryngeal muscles (suprahyoid, thyrohyoid, cricothyroid on each side)	Sub-glottic pressure / laryngeal resistance	Electrical activity in specific muscles as targeted by needle measurement
How is it structured? (Components and scoring system	No scoring system included. Designed for data recording.	CAPE-V VoiSS VFI NMQ (See Martinez p 3)	Variety of vocal tasks (not standardised). Eg, Sustained "ee" and slowly breathing. Scores based on which system is used.	a)0-3 – See GRBAS template CAPE-V (see template) b)statistics via frequency and percentage	Each item ranges from 1 (minimum resistance to 5 (max resistance) – the lower the resistance, the greater mobility and flexibility the structure presents. Larynx height classified as 1 high, 2 neutral, 3 low and 4 forcibly low.	Voltage measured by electrodes on the skin. The signal increases as the muscle becomes more active.	Non-invasive imaging technique to chart the state of muscles. Produces image to be interpreted.	Sustained vowel. Data collected on air pressure, airflow and sound pressure level	Invasive imaging technique to chart the state of muscles. Produces image to be interpreted.
Efficiency?	Fair	Good	No	Fair	Yes - good	No	Yes	Fairly long, involved research type test.	No
Accessibility?	Good	Good	No	Yes	Yes	No	No	Specialist equipment required – not widely available.	No – requires needle insertion in VFs
Reliability (Same responses on repeated measures)	Dependent on patient sensation at time of completion	Dependent on patient sensation	Fair, requires same operator and relies on some subjectivity	Subject to reviewers impression	Fair, Requires same clinician	Good (if same electrode placement and operator)	Good - objective	The aerodynamic profile of a patient with MTD differs from that of a nondysphonic person. (Zheng, et al 2012)	Good - objective

(*Continued*)

TABLE 6. *(Continued)*

	Patient History	Self-Assessment	Laryngoscopic/ Videostroboscopy	Perceptual (a) / Acoustic (b) Assessment	Voice Related Musculoskeletal Features	sEMG/HDsEMG	RTE	Aero-dynamic Voice Analysis	LEMG
Validity (Are the scores a reflection of what needs measured)	Yes, but requires examination of physiology to support or clarify aspects to be measured	Subjective – requires interpretation by clinician	Laryngoscopic features commonly associated with MTD are prevalent in the nondysphonic population and sometimes fail to distinguish patients with MTD from normal subjects. (Sama)	Subjective	Not validated	Yes – objective measurement	Yes – objective measurement	Additional assessment methods are required to fully measure.	Yes – objective measurement
Responsiveness (Ability to detect change)	Dependent on patient perception – subjective only	Subjective	Yes – but this relies on the same operator	Subjective	Dependent on same clinician	Yes – objective measurement, if limited to few muscles	Yes - good	Fair to good	Good
Feasibility (Cost, time, resources, ease for client)	Good feasibility - little cost, little time required, good level of ease.	Good	High cost, high time, specialist resources, uncomfortable for client	Fair	Fair - Requires specialist training.	Low feasibility - High cost, long time, limited resources, hard to access.	High cost, high time, costly resources, hard to access	Low feasibility - High cost, high time and not easy for patient.	Low feasibility - High cost, high time and not easy for patient.

Assessment of reliability, validity, ability to detect change and feasibility

The reliability of a patient case history depends upon both the patient and clinician as history-taker[35,48] and therefore cannot be finally assessed within the studies reviewed. Accuracy of case history may be compromised by the level of communication between patient and clinician, bias due to exisiting clinician agenda, leading questioning, lack of rapport, use of closed questioning and an environment not condusive to an open sharing. The validity of the case history requires correlation with other variables, usually at a later time, few of which were included in the studies reviewed. The case history may detect change if performed at regular intervals, although this would more likely be the role of self-perception scoring due to the ease of completion. The ability to detect change is unable to be assessed within the studies reviewed. A case history is easy and fairly convenient, requiring only the patient and clinician to complete it, allowing the feasibility score to be assessed as high. In a scoping review of the heterogenous nature of case history questionnaires, Krosch et al[42] found a need for standardisation in terms of number of questions, number of categories and preference for question-type and structure across the method.

Self-assessment

Overview

Self-assessment is a non-instrumental, subjective method requiring confirmation by palpation or objective methods. The Vocal Symptoms Scale (VoiSS), Vocal Fatigue Index (VFI), Voice Handicap Index (VHI) are the most used in patients displaying symptoms of MTD. Martinez et al[27] examined self-perception in women with MTD using the vocal symptoms scale (VoiSS), the Vocal Fatigue Index (VFI) and the Nordic Musculoskeletal Questionnaire (NMQ), Each questionnaire was validated and completed without clinician interference. The study identified high scores for vocal fatigue, voice symptoms and self-perception of pain in women with MTD compared to vocally healthy women. They concluded that the results of self-assessment may assist the speech therapist in the decision, using clinical reasoning strategies, which protocol(s) and assessment resources are most suitable for the specific case of the patient with MTD.

Assessment of reliability, validity, ability to detect change and feasibility

Self-assessment relies heavily on previous vocal experience and the patient's perception of their voice and self. The reliability may be impacted by emotional factors and/or dysmorphic issues surrounding the voice. The various methods of self-assessment of voice, including VFI and VoiSS are valid and reliable in patient assessment of MTD. Nanjundeswaran et al[31] explored test-reliability for VFI and found good reliability, validity, sensitivity and specificity. Deary et al[55] found the VoiSS to be simple and easy for patients to score, while being sensitive enough to reflect the wide range of communication, physical symptoms and emotional responses implicit in MTD. The repetition of self-perception methods may easily detect change from the patient point of view which may not be observed by a clinicial with physical examination. Each method differs slightly in feasibility only with regards to the length of questioning. Any assessment in this review of the ability of self-assessment to detect change is reliant on the use of the same method, questions and clinician interpretation. The range between 12 and 30 questions may impact ease of completion slightly, but this impact can be described as minimal.

Laryngoscopic/videostroboscopy

Overview

Laryngoscopic and videostroboscopic assessment is an instrumental, subjective method, based on perception of examiner. Videostroboscopy visualizes and records vocal fold vibration to evaluate the pliability of the vocal folds to measure the health and function of the mucosal tissue. Interpretation of recordings may allow practitioners to identify some criteria such as supraglottic activity which may lead to the diagnosis of MTD.

Sama et al[30] compared the Van Lawrence[56] (Table 7) and Morrison-Rammage[5] (Table 8) features of functional dysphonia. The study, along with Stager et al[57] and Behrman et al,[38] concluded that supraglottic activity can also be observed in healthy speakers and should not necessarily be deemed as excessive laryngeal muscle tension.

Garaycochea et al[10] further evaluated the findings in subjects with MTD that had been objectively diagnosed by means of aerodynamic voice assessment. The laryngoscopic features most strongly related to an aerodynamic profile of MTD were vestibular fold contribution to phonation, anterior-posterior compression of the larynx, and lateral compression of the larynx. The results revealed a reduced number of strictly relevant laryngoscopic features and may be useful in the development of a less subjective and more straightforward classification system for diagnosing and distinguishing subtypes of MTD.

TABLE 7.
Van Lawrence Fibreoptic Features of Vocal Hyperfunction

Intrinsic	
VL1	Harsh approximation of arytenoids and poor “pointed arc”
VL2	Minimal vocal cord length visibility
VL2	Vestibular fold contribution to phonation
Extrinsic	
VL4	Excessive vertical movement of larynx
VL5	Anteroposterior compression of larynx
VL6	Lateral compression of larynx

TABLE 8.
Morrison-Rammage Classification of MTD

MR 1	Laryngeal isometry
MR2a	Glottic lateral contraction
MR2b	Supraglottic lateral contraction
MR3	Anteriorposterior compression
MR4	Incomplete adduction
MR5	Bowing

Assessment of reliability, validity, ability to detect change and feasibility

Laryngoscopic features commonly associated with MTD are prevalent in the nondysphonic population and sometimes fail to distinguish patients with MTD from normal subjects, leading to a question of reliability with regards to the results.[10] Due to the variety of laryngoscopic diagnostic criteria available to the clinician, the validity of diagnosis depends on the knowledge, experience and, to some extent, vocal specialism of the examiner, this review was unable to fully assess validity based on the studies reviewed. The ability of the laryngoscopic and videostroboscopic assessment to detect physical change through observation is good.[10] Comparison of each examination is possible, and if combined with patient self-perception and other variables, can provide evidence of progress during therapeutic intervention. The feasibility of laryngoscopic and videostroboscopic assessment may be fairly low[12] as it relies on specialist equipment, the ability of the patient to tolerate the scoping procedure (the gag reflex may be activated which can induce supraglottic constriction depending on use of ridgid or flexible scope), and time to explore a variety of phonatory tasks to allow clear diagnostic examination.

Auditory perceptual assessment

Overview

Auditory perceptual assessment is a non-instrumental, subjective method, based on perception of examiners. The auditory-perceptual evaluation of voice is one of the most traditional approaches used to analyze voice quality. The evaluation is based on the auditory impression of the evaluator when listening to altered and non-altered voices and is then compared with physiological findings. These aspects are then added to the patient’s complaints, history of dysphonia and vocal self-evaluation to allow a treatment plan to be developed.[58] CAPE-V (Consensus Auditory Perceptual Evaluation – Voice) adopts a visual scale and used predetermined vocal tasks and analysis criteria to assess overall dysphonia grade, roughness, breathiness, asthenia, strain. It also evaluates pitch and loudness, and allows the classification of resonance. (*Appendix C: CAPE-V Template*). The GRBAS scale assesses overall dysphonia grade, roughness, breathiness, asthenia and strain.[58] It is reliable, valid and offers no discomfort or inconvenience to the patient or therapist (Table 9) (*Appendix D: Overview of GRBAS Scoring*

TABLE 9.
Aspects of GRBAS Scale

GRBAS ASPECT	SCORE	NOTES
GRADE		
ROUGHNESS		
BREATHINESS		
ASTHENIA		
STRAIN		

System). Voice auditory-perceptual evaluation is one part of the multidimensional evaluation process.

Assessment of reliability, validity, ability to detect change and feasibility
Both CAPE-V and GRBAS scales are highly reliable[58] and may be used in any situation in which voice-related auditory-perceptual evaluation is relevent, including MTD assessment.[14] CAPE-V adopts a visual analog scale and has predetermined vocal tasks and analysis criteria. Results of each scale rely on the perception of the clinician, and therefore, may be impacted by experience or interpretation. Overall, Nemr et al[58] found that the GRBAS scale provides "*more promptitude and objectivity, with focus on glottic level, regardless of sample type,*" whereas the CAPE-V scale considers more detail and analytical parameters, with pre-defined voice sample collection and evaluation. validity and ability to detect change may be assessed to be good based on single clinician interpretation throughout the diagnosis and assessment of progress Evaluators found the GRBAS scale was the fastest to apply, leading to it's assessment as most feasible, while the CAPE-V was the most sensitive,[58] especially for detecting small changes in the voice. Both scales offer no discomfort or inconvenience to the patient or clinician.

Acoustic assessment

Overview
Acoustic assessment is an instrumental, objective method used to determine dysphonia classification using non-invasive techniques to derive quantitative information on vocal function. Barsties et al[41] studied the diagnostic accuracy of the software-based Dysphonia Severity Index (DSI) and the Acoustic Voice Quality Index (AVQI) for those with a variety of voice disorders including functional dysphonia (MTD). DSI includes four parameters, weighted and then tallied to quantify voice quality[59] (Table 10). AVQI requires continuous speech and sustained phonation for the analysis of six acoustic parameters (Table 11).

DSI showed slightly greater potential to evaluate dysphonia in general.

Assessment of reliability, validity, ability to detect change and feasibility
Both AVQI and DSI has been deemed to have acceptable interexaminer variability,[41] relying on software interpretation of results, rather than subjective perceptual evaluation. Both DSI and AVQI have been found to be valid means by which to objectively quantify voice quality.[59] In addition, each of the multivariate indices can recognise vocally healthy and voice-disordered subjects, including those with MTD. AVQI is able to measure vocal sound quality, and the quantitative nature of data collection enables the detection of change during therapeutic intervention.[60] DSI is considered a measure of vocal function and evaluated as feasible and useful,[58] although it relies on sustained phonation to measure outcomes, which may limit some patient participation.

TABLE 10.
Acoustic and Aerodynamic Parameters of DSI Software

1	Jitter
2	Highest fundamental frequency
3	Lowest sound intensity
4	Maximum phonation time

Voice related musculoskeletal features (including palpation*)*

Overview
A non-instrumental, subjective method, based on perception examiner**.** In cases where excess laryngeal tension has persisted for some time, additional musculoskeletal features may be present. Patients commonly report a dull to severe ache and tightness of the anterior neck, larynx, and shoulder regions which is accompanied by increased vocal effort and fatigue, episodic anterior neck "swellings/lumps" and ear "fullness," with all symptoms intensifying with extended voice use.[54,61–63] According to Morrison,[62] the inferior bellies of the omohyoid muscles where they cross the supraclavicular fossae, are often tense and prominent during speech. General body posture may be rigid with the jaw jutting forward.[63] Jaw, tongue, and respiratory movements can be restricted, reflecting the "held" nature of the voice and articulatory system.[62] Boone and McFarlane[64] observed "we see too many people with vocal hyperfunction who appear to speak through clenched teeth, with very little mandibular or labial movement" (p. 177). Similarly, Sapir[65] recognized the complex effects of laryngeal tension on both voice and

TABLE 11.
AVQI Analysis of Acoustic Measures Using Scripted Sentences

1	The smoothed cepstral peak prominence
2	Harmonics to noise ratio
3	Shimmer percent
4	Shimmer dB
5	General slope of the spectrum
6	Tilt of the regression line through the spectrum

TABLE 12.
Angsuwarangsee and Morrison Palpation System (2002)

Rating	Description
Suprahyoid muscles	
0	Soft at rest but may slightly contract on phonation
1	Soft at rest but mild low pitch and moderate high pitch on contraction
2	Some tension at rest and tense with jaw protrusion on phonation
3	Tense all the time and maximally tight on phonation
Thyrohyoid	
0	No muscular contraction at rest but mild on phonation
1	Soft thyrohyoid space at rest and some contraction on phonation
2	Tense, narrow thyrohyoid space at rest and moderate contraction on phonation
3	Very tense with closed thyrohyoid space all the time
Cricothyroid muscles	
0	Normal cricothyroid space and phonatory movement
1	Narrowing of cricothyroid space at rest and some movement on phonation
2	Anterior displacement of cricoid cartilage with narrowing of cricothyroid space at rest and closing of the space on phonation
3	Closed cricothyroid space all the time
Pharyngolaryngeal muscles	
0	Soft, easy to rotate the larynx to 90 degrees and palpate PCA muscle and arytenoid movement on sniffing
1	Slightly tense and cannot palpate posterior cricoarytenoid (PCA) muscle movement on sniffing
2	Moderately tense and difficult to rotate the larynx but still can palpate the posterior edge of thyroid cartilage
3	Very tense and cannot rotate the larynx at all

articulation. He noted *"articulatory movements may induce or exacerbate, via mechanical or neural coupling, the phonatory abnormalities"* (p. 49). Thus, abnormal peri laryngeal tension may spread to the articulatory system, or alternatively, abnormal tongue and jaw tension can affect phonatory function *(Appendix E: Postural assessment for hyperfunction dysphonia[54])*. Similarly, Angsuwarangsee and Morrison[16] suggested that hyperlordosis of the cervical spine may lead to an abnormal laryngeal posture and consequently may change into a persistently tense resting tone of laryngeal musculature.

Aronson[61] and Kunduk et al[28] suggested that chronic posturing of the larynx in an elevated position leads to cramping and stiffness of the hyolaryngeal musculature and voice mutation. Furthermore, Aronson[61] argued that *"all patients with voice disorders, regardless of etiology, should be tested for excess musculoskeletal tension, either as a primary or as a secondary cause of the dysphonia"*.

Angsuwarangsee and Morrison[16] developed a 4-point grading system based on the work of Lieberman[63] (Table 12) to document muscle tension severity of the suprahyoid, the cricothyroid, the thyrohyoid and the pharyngolaryngeal muscles.

The use of laryngeal palpation to determine the presence of hyperfunction in laryngeal muscles is one of the most widely used assessment techniques in the diagnosis of MTD. Mathieson et al[19] created a palpatory rating system to document the resistance of the supralaryngeal muscle area, thyroid cartilage and sternocleidomastoid muscles using a 5-point grading scale (Figure 3). The laryngeal position in the vocal tract is also assessed on a four-point scale.

Lieberman's protocol was initially intended to accompany the instructional course on the interdisciplinary assessment and treatment of hyperfunctional voice disorder to achieve satisfactory practitioner agreement.[63] Emphasis was placed upon the importance of accurate assessment of the laryngeal musculature and cricothyroid joints. In response to the lack of practitioner agreement, Jafari et al[11] introduced the Laryngeal Palpatory Scale (LPS) *(Appendix F: Jafari et al Laryngeal Palpatory Scale)* to provide a novel, valid and reliable instrument for assessing patients with MTD. Jafari et al[11] concluded that the use of LPS alongside surface-electromyography may provide useful evidence for researchers and clinicians to document treatment outcomes, leading to more standardized care and improved information about patient progress.

Khoddami et al[32] described the heterogeneous assessment tasks, assessed structures and difference in tension grading systems within palpation protocols as negative qualities. In addition to the issue of non-standardization, the validity and reliability of palpation techniques were found to be scarce or not reported in the reviewed articles.

Assessment of reliability, validity, ability to detect change and feasibility

Assessment of voice-related musculoskeletal features can only be as reliable as the clinician. The subjective nature of

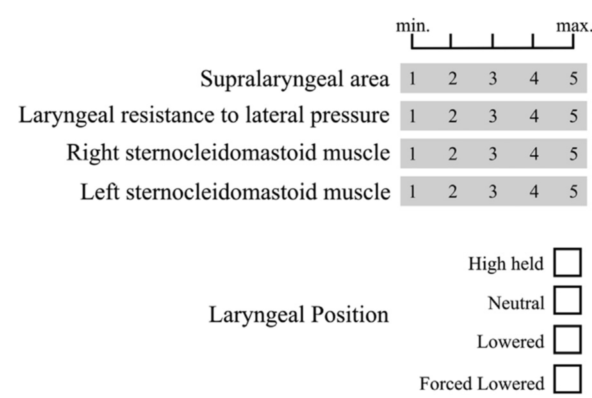


FIGURE 3. Mathieson et al. (2009) palpatory rating system.

laryngeal palpation and observation relies on practictioner experience, knowledge, and area of expertise.[13] Reliability studies of rating systems for assessing muscle tension show poor interrater reliability.[12,13] Low validity was found due to the low number of developed standardised scales by which to measure initial tension and subsequent change after therapeutic intervention.[13] Unless palpation is repeated by the same examiner who is able to descern individual muscle tension change, it may be difficult to use this method to track patient progress, resulting in low scores with regards to the ability to detect change . Palpation presents as feasibile, requiring no special equipment and is a simple way to assess muscular tension, however, successful results depend on experienced practitioners, who may be difficult to locate.

Aero-dynamic voice analysis

Overview

Aerodynamic assessment is an instrumental, objective method which has been used to discriminate normal vocal function from pathologic function to assess severity of MTD. Subjects phonate into a mask which records the subglottic pressure into computer software. Iwata[66] initially demonstrated that increased subglottic pressure was often associated with hyperfunctional voice use patterns, which could be found in MTD. Zheng et al[22] concluded that subglottic pressure could be significantly different in MTD patients when compared to healthy patients. A credible model, with subglottic pressure and maximum phonation time as predictors, was established and may assist MTD diagnosis alongside history physical examination, fibrolaryngoscopy and/or videoendostroboscopy.

Assessment of reliability, validity, ability to detect change and feasibility

Further studies are required to confirm the reliability and validity of aerodynamic voice analysis, as a result, this review was unable to determine reliability or validity from the studies reviewd. As an objective method of measurement, aerodynamic voice analysis may be able to detect change in subglottic pressure, which might suggest a release of muscle tension and reduction in "pressed" phonation, however, the use of a face mask within the measurement task may lead to tension in patients who are not able to tolerate this. Aero-dynamic voice analysis can be assessed to have low feasibility as it requires specialist equipment, software and the ability to interpret results.

Surface electromyography/high-definition surface electromyography (sEMG/HD sEMG)

Overview

Surface Electromyography (sEMG) is an instrumental, objective method measuring the electrical potential present on the skin in consequence of a muscle contraction. The voltage is detected by electrodes placed on the skin. Merlo et al[67] concluded that the voltage measured on the skin can be related to the activity of a single specific muscle. In their 2022 study using sEMG to evaluate the external laryngeal muscles of opera singers, Krasnodebska et al[29] highlighted the need for laryngeal assessment to be undertaken on different phonation and non-phonation tasks, as significant differences in the asymmetry of sternocleidomastoid muscles when phonating and swallowing were noted.

While reviewing common assessment methods of measuring muscle tension in MTD patients, Khoddami et al[12] describe history taking, laryngoscopy and palpation as "prone to subjectiveness," and point to surface electromyography as an objective instrument with which to measure the tension of extrinsic laryngeal muscles (strap or suprahyoid) in patients with MTD. Krasnodesbska et al,[29] Wang & Yiu,[34] Bracken et al[18] and Stepp,[47] describe sEMG as a valuable measure of the vocal tract as well as for diagnosis or outcome assessment in MTD. Conversely, Van Houtte et al,[52] Stepp et al,[13] Jafari et al,[11] Khodammi et al,[32] and Balata et al[39] found that sEMG was unable to detect an increase in muscle tension in patients with MTD. As patients with MTD may present with minimal symptoms, further studies are required to fully assess the value of this approach.

The lack of agreement may be a result of the heterogeneity in measurement methods. The current lack of a standardized, validated sEMG assessment method results in inconsistencies between findings, highlighting the need for homogeneity.

In response to the spatial selectivity limitations of sEMG, Bracken et al[18] studied the application of high-density sEMG (HD sEMG) in subjects with healthy voice users. The study concluded that HD sEMG was able to identify differences in anterior neck muscle activity between rest, low and high-pitched phonation.[18] The potential to diagnose and monitor therapeutic progress for pathologies of pathologies of laryngeal function was highlighted.

Assessment of reliability, validity, ability to detect change and feasibility

sEMG can provide objective and robust data on muscle activity,[12,13,18,29,32,33,34,39] however, a benchmark normal for comparison is needed if it is to be useful in tracking progression in MTD patients. sEMG can only detect extrinsic laryngeal tension, rather than intrinsic laryngeal tension, which is typically seen to impact vocal fold function in MTD. While there are a number of routinely used phonatory exercises used to assess the speaking voice, there are also currently no standardised testing methods, phonatory exercises or specific measurement protocols for the singing voice during measurement. The may reduce the future validity of sEMG measurements in assessment of the singing rather than spoken voice. Current research provides conflicting conclusions with regards to validity,[18,33] future standardisation may ensure greater validity. Change can be detected using sEMG if electrodes are placed with precision at each measurement session,[13] as this is not guaranteed between different clinicians, the ability to detect change is assessed as low. sEMG is not widely available however, requires specialist equipment and needs training to use and interpret data,[12] leading to a low feasibility assessment.

Real-time elastosonography (RTE)

Overview

Ata et al[17] found that the instrumental, objective method of real-time elastosonography (RTE) can discriminate patients with primary MTD from healthy subjects in specific laryngeal muscles, specifically the suprahyoid muscle group and cricothyroid muscles, and may be regarded as a clinical instrument in the assessment of MTD in the future.

Assessment of reliability, validity, ability to detect change and feasibility

Further studies are required to prove reliability of RTE in diagnosing and tracking recovery in those with MTD. This review was therefore unable to assess reliability. Furthermore investigations that prove validity of RTE in diagnosing and tracking recovery in those with MTD may be useful to consider. The objective nature of RTE measurement may allow the detection of change in muscle activity in the cricothyroid and suprahyoid muscle groups, which may be useful to chart progress during therapeutic treatment, however data is not currently available to allow assessment of ability to detect change. RTE requires specific treatement and training to interpret results, which reduces the feasibility and accessibility.

Radiography

Overview

Radiography is an instrumental, objective method which uses radiation to provide images of tissue, organs and bones inside the body. Lowell et al[40] undertook a study to determine whether radiographic measures for patients with primary MTD were different from those of normal subjects. Higher positions of the hyoid and larynx were reported during phonation in patients with MTD, leading to the conclusion that radiography may provide differential diagnosis for MTD. This aligns with the earlier findings of Morrison et al[5] with regards to 67% of MTD patients presenting with a high larynx.

Assessment of reliability, validity, ability to detect change and feasibility

Radiography can provide objective evidence for a raised hyoid and larynx (hyolaryngeal elevation).[40] Hyolaryngeal elevation may be present in non-dysphonic individuals, however, bringing into question the reliability and validity of findings with regards to the diagnosis of MTD. As radiography principally measures the height of the larynx and hyoid, it is unable to detect change in muscle function beyond this posture. Radiography can be assessed has having low feasibility as is not available for routine clinical use in voice clinics[12] as suggested by the literature within this scoping review.

Laryngeal **intramuscular** electromyography (laryngeal iEMG)

Overview

Laryngeal intramuscular electromyography uses needle electrodes to measure electrical activity in specific larynegal muscles. The four paired muscles relevent to LiEMG are the posterior cricoarytenoideus (PCA), the thyroarytenoideus (TA), the lateral cricoarytenoideus (LCA) and the cricothroideus (CT). At present, no data exists to support the use of LiEMG in measurement of muscle activity relating to MTD, although Sataloff et al[20] found that Laryngeal iEMG is also routinely used in the differential diagnosis of vocal fold paralysis, in addition to aid in administering Botox in Adductor spasmodic dysphonia.

Assessment of reliability, validity, ability to detect change and feasibility

Laryngeal intramuscular electromyography can provide objective evidence for activity of specific muscles in the larynx.[68] LiEMG has been validated as an objective method of measurement by the American Association of Electrodiagnostic Medicine's Laryngeal EMG Task Force in 1999.[20] LiEMG may detect a change in pressed phonation if the measurement can be undertaken using the same protocols and without causing distress to the patient.[12] LiEMG is not available for routine clinical use in voice clinics as it is a highly invasive technique, and may not be suitable for many patients[68] and also due to a lack of trained professionals to administer the method of measurement.[20]

LIMITATIONS

The searches used within the current review limited the year of study publication to between 2000 and 2022. It must be considered whether all assessments maintain relevancy in contemporary treatment research or current clinical practice. A further limitation of the current study is that as per a scoping methodology, the researcher did not seek to evaluate the quality of the measurement properties of each included measurement instrument. This research identified measurement instruments and classified them according to instrumental or non-instrumental, and subjective or objective status. Future research should evaluate these measures in terms of their full range of psychometric properties.

This scoping review was also limited by the lack of standardized criteria for each method of measurement under consideration, resulting in a lack of evidence of inter-rater reliability. Included studies were determined by only one reviewer (CT), therefore discrepancies or bias for inclusion may have occurred.

CONCLUSIONS

The aim of this scoping review was to identify the methods which have been developed or tested to measure laryngeal muscle activity in subjects with MTD. A total of 12 different measurement methods were identified from the literature included in the scoping review.

Each method was assessed as far as the literature allowed for reliability, validity, ability to detect change, and feasibility. Within the literature reviewed, patient history, laryngoscopic and videostroboscopic assessment and palpation were the most used assessment methods. The most feasible methods were patient history and perceptual and acoustic assessment.

With regards to reliability and ability to detect change, the review was unable to determine which method/s were the most successful (See Table 6), however self-assessment (specifically VFI) and auditory and perceptual assessment showed good reliability, while auditory perceptual assessment (specifically CAPE-V) and laryngoscopic and videostroboscopic assessment score well in their ability to detect change in patients with MTD. Due to the variability in assessment methods and results, this review concludes that there is a need for greater objective practical methodological standardization to ensure accurate diagnosis, determine appropriate care, and provide improved information about patient progress.

Practical implications

This scoping review provides a comprehensive overview of measurement methods for use with people with MTD. It provides a compendium of available measurement methods, which may be useful in both clinical practice and treatment research. This review provides a basis for future quality assessment of identified measurement methods and reflects the need for the development of a standardized assessment protocol for MTD treatment research. This may improve the quality of research evidence for MTD treatments, assisting clinicians in evidence-based decision making.

This study also concludes that the most reliable, valid methods of objective measurement include sEMG and RTE, both of which ensure a high level of ability to detect change, while the patient history and self-assessment remain the most feasible.

With regards to current development in practice, the nearest to standardisation may be laryngeal palpation with laryngoscopic and videostroboscopic assessment showing the greatest potential for accessible clinical standardization. Although providing objective measurement, validity and reliability, sEMG currently remains the furthest from standardization.

COLLABORATION

Dr David Rhodes, Melanie Mehta, Dr Jill Alexander.

DECLARATION OF COMPETING INTEREST

No potential conflict of interest was reported by the author.

APPENDIX A. VOICE CASE HISTORY FORM TEMPLATE, EASTERN KENTUCKY UNIVERSITY, 2013

Name:____ _________________
(Last) (First) (Middle) (Date)

Address:____
(City) (State) (Zip Code)

D.O.B.__________ Age:______ Gender:______________

Home Phone:________________ Cell Phone:_______________ Work Phone: _________________________

Occupation:___________________________________ Education: (Check one) High School___ College___

Marital Status: (check one) Single____ Married____ Widowed____ Divorced____

Spouse's Name:________________________________

Children (names and ages):____

____

Referred By: ____________________________

VOICE HISTORY

What is the problem that brings you here today?____

____

When did you first start to notice this problem? ____

____

Have you ever experienced any previous voice changes or difficulties? If yes, explain: ____________________

____

How would you describe the severity of your voice problem? ________________________________

____

Do you ever lose your voice completely? If yes, explain. ____

____

Do you ever have difficulty swallowing? If yes, explain. ____

____

Do you often get sore throats? ____

____

Do you have difficulty projecting your voice? ____

____

MEDICAL HISTORY

Have you had any major surgeries or illnesses? If yes, describe. ____

____

Have you ever been intubated (breathing tube)? If yes, describe. ____

____

Do you have any neurological conditions? If yes, describe. ____

____

Do you have any respiratory problems (e.g., asthma, allergies, postnasal drip)? If yes, describe. ____________________

____

Do you have acid reflux or heartburn? If yes, describe. ____

____

Do you have any hormonal problems (e.g., hypo- or hyperthyroidism)? If yes, describe. __________________________

____

If you are a female, do you take oral contraceptives or other hormonal medications? If yes, describe. ________________

____

List all medications you take, including prescription, over-the-counter, vitamins, and supplements. ___________________

____

____

Circle if you have ever had any of the following:

AIDS	Arthritis	Cancer
Chronic fatigue	Depression	Diabetes
Dizziness	Ear infections	Ear pain/tinnitus
Eating disorder	Headaches	Hearing loss
Heart disease	Hiatal hernia	Nasal blockage
Neck injury	Psychiatric disorder	Seizures
Sinus problems	Sleep problems	Stroke
Temporomandibular joint problems	Weight loss	Tremor
Ulcer		

OCCUPATIONAL VOICE DEMANDS

Are you a professional voice user (e.g., teacher, salesperson, customer service representative, etc.)? If yes, explain. ____

____

Are you a professional or amateur singer? If yes, explain. ____

____

On a scale of 1-5 where 1 = very little and 5 = excessive, how would you characterize your daily average voice use?

1 2 3 4 5

Is there a high level of noise in your workplace? If yes, explain. ____

____

Are you exposed to fumes, pollutants, and other irritants in your workplace (e.g., ammonia, chemicals, dust, etc.)? If yes, explain. ____

____

On a scale of 0-5, where 0 = never and 5 = always, how often do you do the following?

Shout or scream	0	1	2	3	4	5
Talk loudly	0	1	2	3	4	5
Talk a lot	0	1	2	3	4	5
Talk over noise	0	1	2	3	4	5
Use the phone	0	1	2	3	4	5
Sing	0	1	2	3	4	5

PHYSICAL SYMPTOMS

Do you have any burning, soreness, tickling, or irritation in your throat? ______________________________

____

Do you sometimes have the sensation of a "lump" in the throat? ______________________________

____

Do you have any aching or tightness in your throat? ______________________________

____

Do you ever feel tension in your neck area? ______________________________

____

Does your voice get tired easily? ______________________________

____

Do you feel as if you have to strain to produce voice? ______________________________

____

Do you feel as if you need to cough or clear your throat a lot? ______________________________

____

LIFESTYLE CONSIDERATIONS

How many people live in your house? ______________________________

How many children live with you? ________________________________

Do you have an active social life? Explain. ____

____

Does anyone in your family or your social circle have a hearing loss? ____

____

What are your hobbies? ____

____

Do you participate in activities such as debate, cheerleading, singing, etc.? If yes, explain. ________________________

____

Do you smoke? If yes, how many cigarettes/cigars per day? ____

____

If no, did you smoke previously? When? ____

____

Do you drink alcohol? If yes, how much per week? ____

____

Do you drink caffeinated beverages (e.g. tea, coffee, soda)? If yes, how many per day? __________________________

____

Do you exercise on a regular basis? If yes, how often per week? ____

____

Do you have a healthy diet? Explain. ____

____

APPENDIX B. PATIENT'S SYMPTOMATIC COMPLAINTS (ACHES AND PAINS) AND THE PRACTITIONER'S CONSIDERATIONS. LIEBERMAN, 2003

Patient's complaints	Questions in the practitioner's mind
General non-specific pain in the throat that is unrelated to voice production or swallowing	Leaves the practitioner puzzled and in need of further information
When is the voice worst (am, pm, before or after voice use, etc?)	AM – suggests the possibility of acid reflux, congestion or emotion
	PM – with voice use usually indicates muscular dysfunction
	PM – without voice use is likely to be emotional in origin
Pain or aching around the margin of the thyrohyoid muscle, or the thyrohyoid membrane and ligaments	Very typical of long-term hyper functional voice use
Discomfort during or after performance of vocal task, recovering with rest	Strap musculature, thyrohyoid Mechanism or pharyngeal constrictor hypertonicity
Voice slow to warm up in the morning	Reflux, congestion, muscle fatigue, emotional or overuse the previous day without proper rest
Pain and discomfort in the anterior aspect of the neck	When specific, the tissue of origin should be identifiable with palpation
Globus pharyngeus/hystericus (lump in the throat)	Very tight inferior strap and sternocleidomastoid muscles
Recurrent sore throat	Tonsillitis, reflux, vocal fatigue, or emotional origin. On palpation, characteristically the anterior neck muscles are hypertonic
Difficulty swallowing (initiation, noisy with laryngeal click)	Neurological, postural suprahyoid muscle hypertonicity, hypertonic geniohyoid, omohyoid tightness or thyrohyoid muscles
Dryness	May be indicative of chronic anxiety state
Cough	May be associated with a deep underlying emotional component
Heat burn (acid reflux) with associated oesophageal discomfort, sore throats, globus and throat tightness	May be associated with hiatus hernia/stomach problems, stress/emotional issues or both combined (often responds well to manipulation)
Unilateral muscle ache with the larynx deviated from the midline	The larynx moves with the torso so this condition may be associated with a rotation of the torso
Head and neck postural problems, such as neck ache, headaches, sinus pain, earache, especially around the mastoid process	May be associated with a hyper lordotic segment of the cervical spine
Emotional components	*As felt by the practitioner*
As disclosed voluntarily by the patient	What is it all about? What is the communication?

APPENDIX C. CAPE-V TEMPLATE. AMERICAN SPEECH-LANGUAGE-HEARING ASSOCIATION, 2009

Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V)

Name:______________________________ **Date:**___________

The following parameters of voice quality will be rated upon completion of the following tasks:

1. Sustained vowels, /a/ and /i/ for 3-5 seconds duration each.
2. Sentence production:
   a. The blue spot is on the key again.
   b. How hard did he hit him?
   c. We were away a year ago.
   d. We eat eggs every Easter.
   e. My mama makes lemon muffins.
   f. Peter will keep at the peak.
3. Spontaneous speech in response to: "Tell me about your voice problem." or "Tell me how your voice is functioning."

Legend: C = Consistent I = Intermittent
MI = Mildly Deviant MO = Moderately Deviant SE = Severely Deviant
Although the PDF scale is accurate, printer configurations vary. Verify that your paper copy has accurate 100-mm lines before reproducing this form.

Overall Severity ______________________________ C I ____/100
MI MO SE

Roughness ______________________________ C I ____/100
MI MO SE

Breathiness ______________________________ C I ____/100
MI MO SE

Strain ______________________________ C I ____/100
MI MO SE

Pitch (Indicate the nature of the abnormality): ________________
______________________________ C I ____/100
MI MO SE

Loudness (Indicate the nature of the abnormality): ________________
______________________________ C I ____/100
MI MO SE

__________ ______________________________ C I ____/100
MI MO SE

__________ ______________________________ C I ____/100
MI MO SE

COMMENTS ABOUT RESONANCE: NORMAL OTHER (Provide description):__________________
____

ADDITIONAL FEATURES (for example, diplophonia, fry, falsetto, asthenia, aphonia, pitch instability, tremor, wet/gurgly, or other relevant terms):

Clinician:____________________

APPENDIX D. OVERVIEW OF GRBAS SCORING SYSTEM

Grade (G) represents the overall degree of hoarseness or voice abnormality.

Roughness (R) quantifies the degree to which the listener detects the effect of irregular fluctuations in pitch-frequency and amplitude either cycle to cycle or in the short-term energy of the vocal tract excitation. Roughness is also affected by perceived randomness or "noisiness" of the spectrum. Any perception of roughness might take into account the possibility of severe irregularity due to vocal fry and double excitation (diplophonia).

Breathiness (B) arises from non-periodic sound generated by a turbulent flow of air which leaks through the glottis when it is supposed to be closed. The turbulence is created by the constriction of a partially closed glottis. Its energy will be correlated to the vocal cord activity, ie, its energy will decrease as the glottis becomes fully open and increase again as the vocal cords try to close. At its source, the turbulence will be spectrally flat (white), but it will spectrally be colored by the vocal tract resonances and maneuvers (eg, opening/closing at the lips) as it contributes to perceived speech. As the sound heard from normal breath or unvoiced speech is due to turbulent airflow caused by some constriction in its passage, the sound created by imperfectly closing vocal cords will sound like breath or unvoiced speech. The perceived quality of breathy voice quality is related to the amount of airflow. Breathy voice lacks clarity of tone and is reduced in loudness. Most voices have a degree of breathiness which contributes to their individuality and natural characteristics.

Asthenia (A) is weakness or lack of energy in the voice. The asthenic variety of hoarse voice is mostly characterized by weak intensity. It can be because of an impaired energy distribution in the glottal excitation with a spectral damping which is a sign of a lack of elasticity in the vocal cords. The higher harmonics in the perceived sound will then have a lack of brightness and richness.

Strain(S) is indicative of undue effort needed to produce voiced sound due to an inability to employ the normal functionality of vibrating vocal cords. There is often psychological stress involved in trying to overcome the disability and this is perceivable by the trained listener. The abnormally functioning vocal cords and the stress in trying to control them can produce sound with abnormally high fundamental frequency, with unnatural and constantly changing periodicity and roughness in the higher frequency range of the speech. Strain due to speaking with abnormality func- tioning vocal cords is perhaps the most subjective GRBAS measurement and the most variable effect. Strain is associated with increased and poorly regulated laryngeal muscle tension. When speech is being produced, there is the perception of an inability to control it as it fades in and out. Difficulty in initiating phonation and a struggle to maintain phonation takes place due to strain. Furthermore, constantly changing periodicity in the higher frequency harmonics is indicative of strain, giving the perception of noise or roughness in the higher frequency range of the speech.

(Hirano, 1981)

APPENDIX E. POSTURAL ASSESSMENT FOR HYPERFUNCTION DYSPHONIA. LIEBERMAN, 2003

General Considerations 1. Observations			
Observations while the patient is sitting and giving the history of the problem, etc			
Sitting			
	Is the anterior neck compartment smooth or are the muscles very conspicuous?	Smooth	Conspicuous
	Is activity in the anterior neck compartment visible? (eg, Obvious omohyoid activity)	Yes?	
	Habitual head tilting?	Left?	Right?
	Habitual head gestures (eg, Yes or no by nodding)	Yes?	
B. Observations the patient has been asked to stand passively. Frontal and lateral viewing required.			
Knee locking	Left	Right	Both
Weight distribution	Left	Right	Central
Pelvic rotation	Forwards		
Raised shoulders (rest)	Left	Right	Both
Weight bearing (centre of gravity)	Posterior	Anterior	

(*Continued*)

General Considerations 2. Palpation				
Palpate	Pelvic tilt	Left	Right	
Patient standing	Lumbar spine lordosis	Exaggerated		
	Lumbar spine scoliosis	Left	Right	
	Anterior head translocation	A. Normal posture	1-2 cms / over 3cms	
		B. Occipital contact with vertical surface	Contact Yes?	
Patient required to lie down	Thoracic/cervical spine	Contact of C7 with horizontal surface?		
Osteopathic	Thoracic spine fixed segment	Indicate level. Vertebrae		
Cervical and Laryngeal Considerations 3. Palpation				
Neck vertebrae	Cervicodorsal vertebral shelf (level of hyperplordotic segment)	C2-3(4)	C4-5	Other
Posterior Musculature	Paravertebral muscular tenderness lateral to the hyperlordotic segment	Left	Right	Both
	Occipital/Submastoid tenderness (delete if N/A)	Left	Right	Both
	TMJ tenderness	Left	Right	Both
Anterior Musculature	Sternomastoid muscles while standing erect	Lax L R	Hyperactive	
	Suprahyoid tension	Slight	Great	
	Larynx in midline	Left of midline	Right of midline	
	Infralaryngeal strap ms.	Hyperactivity	Underactive or absent	
Laryngeal musculature	Overall tension of laryngeal suspension	Tightly held	Loosely Held	
(For experienced practitioners only)	Possible to palpate structures medial to the posterior margins of the thyroid laminae?	Left	Right	Neither

APPENDIX F. JAFARI ET AL (2018) INTRODUCED THE LARYNGEAL PALPATORY SCALE (LPS)

LARYNGEAL PALPATORY SCALE (LPS)

Patient's name: ……….............. Date: …………………

Item	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

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