Consensus for voice quality assessment in clinical practice: guidelines of the European Laryngological Society and Union of the European Phoniatricians

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Consensus for voice quality assessment in clinical practice: guidelines of the European Laryngological Society and Union of the European Phoniatricians

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Abstract

Introduction To update the European guidelines for the assessment of voice quality (VQ) in clinical practice.

Methods Nineteen laryngologists–phoniatricians of the European Laryngological Society (ELS) and the Union of the European Phoniatricians (UEP) participated to a modified Delphi process to propose statements about subjective and objective VQ assessments. Two anonymized voting rounds determined a consensus statement to be acceptable when 80% of experts agreed with a rating of at least 3/4. The statements with ≥ 3/4 score by 60–80% of experts were improved and resubmitted to voting until they were validated or rejected.

Results Of the 90 initial statements, 51 were validated after two voting rounds. A multidimensional set of minimal VQ evaluations was proposed and included: baseline VQ anamnesis (e.g., allergy, medical and surgical history, medication, addiction, singing practice, job, and posture), videolaryngostroboscopy (mucosal wave symmetry, amplitude, morphology, and movements), patient-reported VQ assessment (30- or 10-voice handicap index), perception (Grade, Roughness, Breathiness, Asthenia, and Strain), aerodynamics (maximum phonation time), acoustics (Mean F0, Jitter, Shimmer, and noise-to-harmonic ratio), and clinical instruments associated with voice comorbidities (reflux symptom score, reflux sign assessment, eating-assessment tool-10, and dysphagia handicap index). For perception, aerodynamics and acoustics, experts provided guidelines for the methods of measurement. Some additional VQ evaluations are proposed for voice professionals or patients with some laryngeal diseases.

Conclusion The ELS-UEP consensus for VQ assessment provides clinical statements for the baseline and pre- to post-treatment evaluations of VQ and to improve collaborative research by adopting common and validated VQ evaluation approach.

Keywords Voice · Dysphonia · Assessment · Evaluation · Guidelines · Consensus · European · Otolaryngology · Head · Neck · Surgery

Introduction

The assessment of voice quality (VQ) is a multidimensional approach requiring the evaluation of subjective and objective outcomes of the patient voice. As proposed by many international societies, the basic protocol of VQ assessment includes the following dimensions: vocal fold videolaryngostroboscopy, patient-reported outcome assessment, perceptual evaluation of practitioner, and aerodynamic and acoustic measurements [1–3]. In addition to these five aspects of voice, physicians may use patient-reported outcome questionnaires or clinical instruments to document some

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conditions that may be associated with the development of dysphonia, such as laryngopharyngeal reflux (LPR), dysphagia, or dysarthria [4–6]. The multidimensional approach of VQ is important, because these several dimensions may be independent from one to another and, consequently, provided a variety of information to the practitioner [7]. From a clinical point of view, the use of a standardized and validated VQ assessment is an important issue for the evaluation of treatment effectiveness [1]. From a scientific standpoint, the consideration of a basic consensus protocol makes particularly sense to compare the findings of published studies. In 2001, the committee on phoniatrics of the European Laryngological Society (ELS) established a basic protocol for functional assessment of voice, which considered subjective and objective VQ outcomes [1]. Since then, there was no update of the protocol despite evolution of practice and the availability of new clinical instruments.

The aim of the present study was to update the European guideline protocol for the assessment of voice quality in clinical practice through a consensus between ELS and Union of the European Phoniatricians.

Table 1 Expert features

Expert outcomes	$N = 19$
Gender	
Males	13 (68)
Females	6 (32)
Place of work	
Academic/university hospital	18
Private practice	10
Public non-university hospital	1
Experience	
1–10 years	3 (16)
11–20 years	4 (21)
21–30 years	7 (37)
> 30 years	5 (26)
Mean (SD, years)	21.4 ± 10.0
Characteristic of practice place	
VQ assessment is performed by M.D	17
VQ assessment is performed by CCC-SLP	19
VQ assessment is performed by nurse	1
Expert never/rarely performed VQ assessment	4

The gender, and experience data were expressed in numbers (%)

SD standard deviation; *VQ* voice quality

Methods

The establishment of new guidelines for the voice quality assessment combined evidence-based medicine and a modified Delphi approach [8]. Nineteen laryngologists–phoniatricians from the European Laryngological Society (ELS) and Union of the European Phoniatricians (UEP) were invited to vote anonymously on a series of proposed statements through SurveyMonkey® (San Mateo, California, USA). Each participant completed the survey round only once.

The statements were written and proposed by a statement committee including active members of the above-mentioned scientific societies. The experts agreed to organize the Delphi process through a maximum of 4 voting rounds. The rounds were separated by discussion and revision of statements that did not reach validation on prior voting. From the 2d to the 3d voting round, a virtual meeting of the experts was proposed in case of remaining unvalidated statements.

Statement committee and expert panel

The statement committee was composed of 4 European experts (F.G.D., L.C.B., J.R.L., and A.G.) who are members of ELS and UEP. The statements were based on selected relevant papers in the literature, including the initial European consensus paper dating from 2001 [1]. The panel of experts and the statement committee were organized by the first co-authors and the last co-authors.

The voting panel included 19 experts from 13 countries. A first email was sent to members of the scientific societies to list potential experts who were interested to participate. Based on the 61 responses, the committee selected 19 experts who have both clinical and academic activities.

The statement committee developed an initial list of 90 statements, which covered the baseline subjective and objective voice quality assessment for clinical laryngologists and phoniatricians. The demographic data of experts are available in Table 1. There were 6 females and 13 males. Nine experts work only in Academic/University hospital, while 9 others work in both private and Academic/University hospital. One expert work in both private and public/non-University hospital (Table 1). The mean experience of experts was 21.4 ± 10.0 years. In the institutions of experts, the voice quality assessment is commonly carried out by speech therapist ($N = 19$), speech therapist and physician/laryngologist ($N = 17$), or speech therapist, physician/laryngologist, or nurse ($N = 1$), or phonetician ($N = 1$). In 4 cases, the laryngologists recognize making rarely or never the entire voice quality assessment him/herself, including subjective evaluations, and aerodynamic and acoustic measurements.

Literature search

The PubMed, Cochrane Library, and Scopus database literature search was conducted by two authors (J.R.L. and L.C.B.) for relevant peer-reviewed publications in the English language using relevant keywords (Voice; Dysphonia; Evaluation; Assessment) to identify publications dedicated

to the voice quality assessment. The literature search was conducted according to the PRISMA Statements [9]. Relevant publications were identified, especially for the establishment of initial statements and the discussion of the present paper, and references of the included papers were further screened for additional research. The two experts reviewed each of the abstracts and selected articles for further review.

Voting rounds and discussion

The Delphi process lasted 12 months and included 2 voting rounds. Judges needed to rate each statement from 1 (strongly disagree) to 4 (strongly agree). Consensus acceptance was defined as a Likert rating of ≥ 3/4 by at least 80% of experts. The analyses of the results of the voting round were performed by the first author of the study who were blinded regarding the judge I.D. The level of agreement was communicated to the panel as the percentage of experts who voted ≥ 3/4 for each proposed statement. Statements that returned with only 60–80% of scores ≥ 3/4 were discussed and revised, based on feedback and comments provided by the voting panel. The revised statements were then subjected to the next voting round. Statements that did not reach at least 60% agreement of ≥ 3/4 were discarded.

Grades of evidence

The assignment of the grade of evidence was performed by the statement committee with the GRADE system [10], which aimed to give a practical indication of the likely impact of further research on confidence in the estimate effect. The following grading were proposed by the statement committee: High (A): future investigations are unlikely to change our confidence in the estimate effect; moderate (B): future investigations are likely to have an important impact on our confidence in the estimate effect and may change the estimate effect; low (C): future investigations are likely to have an important impact on our confidence in the estimate effect and are very likely to change the estimate effect; very low (D): any estimate of effect is uncertain. The assessment of grade was performed by the statement committee after a consensus discussion.

Endorsement

The results of the Delphi process and the present publication were endorsed by the ELS and the UEP committees as the European consensus guidelines for the voice quality assessment.

Results and discussion

The statement committee proposed 90 statements included in the following 7 chapters: overview of the baseline VQ assessment ($N = 15$), endoscopic examination of the vocal folds, ($N = 19$) patient-reported VQ assessment ($N = 3$), VQ perception ($N = 9$), aerodynamics ($N = 7$), acoustics ($N = 32$), and clinical instruments associated with voice comorbidities ($N = 5$). Most of the statements consisted of outcomes to include in the subjective or objective VQ evaluation (for example, an acoustic parameter) or specified the methods for the outcome recording. Of the 90 statements, 35 statements were validated after the first round. Sixteen statements with > 60% of agreement did not reach the cutoff of validation and were improved by the statement committee. After the second round, the 16 remaining statements were validated (Fig. 1). At the end of the Delphi process, the 51 validated statements were formatted into the 7 chapters to improve readability and application in clinical practice, consisting of 38 summarized statements/recommendations (Table 2). The template of VQ assessment is available in Fig. 2 and Appendix 1.

Overview of the voice quality assessment

The baseline laryngology consultation and voice quality evaluation must include (i) the medical history, (ii) allergy, tobacco or alcohol histories, (iii) current treatments, (iv) patient job, voice use, and posture, (v) singing practice, (vi) laryngopharyngeal symptoms, (vii) videolaryngostroboscopy, (viii) patient-reported voice quality evaluation, (ix) perceptual voice quality evaluation, and (x) acoustic measurements. For some conditions, the VQ assessment should be completed with aerodynamic measurements (e.g., glottic insufficiency), phonetogram (e.g., for singing students or singers with complains in singing specially with negative stroboscopy), or an assessment of cough during videoendoscopy (patient with cough as an important symptom).

The medical and surgical histories, medication, allergy, or addictions are common findings included in the medical record of patient in medicine and surgery. In laryngology, allergy, tobacco, or alcohol overuse may directly or indirectly influence the VQ through laryngopharyngeal tissue inflammation and symptoms [11, 12]. The patient job, singing practice, and voice use are additional common important outcomes of basic VQ protocols [1, 13–15] documenting the voice use in daily life. The posture and the features of videolaryngostroboscopy examination are evidence-based findings included in the multidimensional set of VQ measurements, which also includes perceptions,

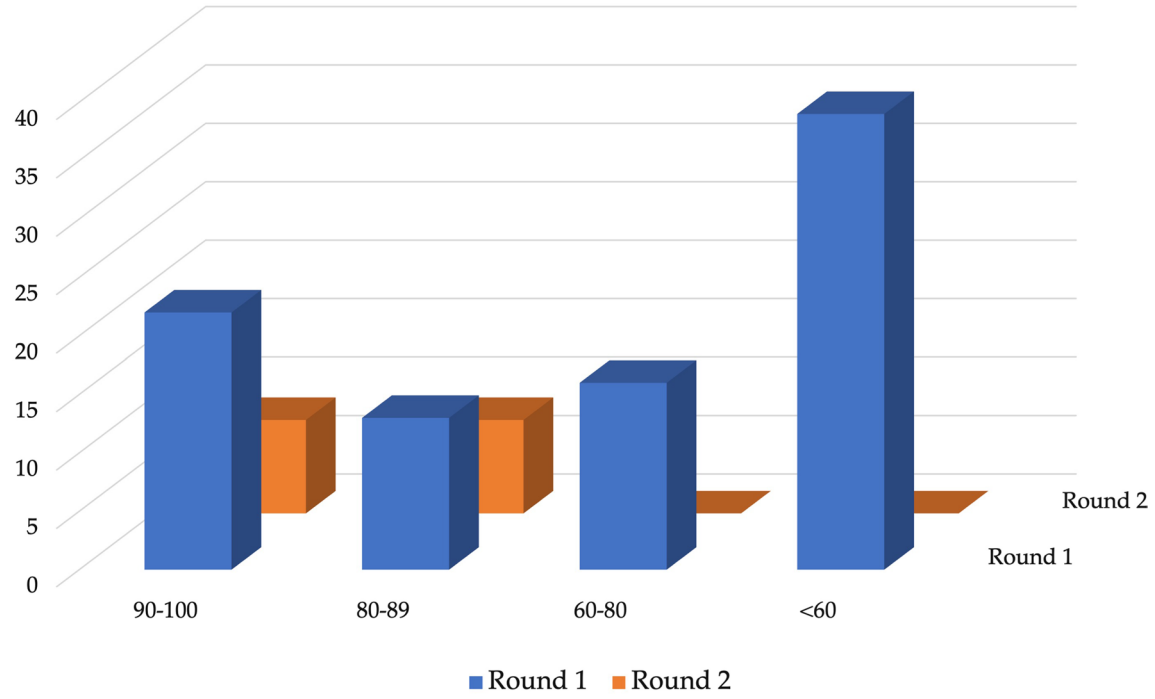

Fig. 1 Validated statements at Rounds 1 and 2. The agreement increased from the first to the second round

patient-reported VQ evaluation, aerodynamics, and acoustics [14, 16]. The present consensus also proposed the use of some clinical instruments in cases of common conditions associated with dysphonia [i.e., laryngopharyngeal reflux (LPR), or dysphagia]. The choice of these instruments was based on their good psychometric properties and their availability in many European languages.

The endoscopic examination of the vocal folds

1. The endoscopic examination of vocal folds needs to be performed with flexible or rigid videolaryngostroboscopy.
2. The following features must be assessed with a 4-point Likert scale [no (0), mild (1), moderate (2), and severe (3) alteration]: i) mucosal wave symmetry, ii) mucosal wave amplitude, iii) regularity, closure, movement, and mobility of the vocal folds and cord joint, and iv) morphological characteristics of the vocal cords (color, vascularization, lesions, etc.).
3. The following tasks need to be performed during the examination: sustained vowel /i/ and sniff.
4. The following tasks should be performed for selected patients/conditions: Glissando (singers, actors, or other voice professionals) and speak short sentences (e.g., hyperkinetic behavior, glottic insufficiency, especially to analyze speaking glottic and supraglottic behavior).

The availability of high-speed camera is limited in Europe due to its cost and, consequently, it is most used in research rather than in clinical practice [17]. For this reason, experts recommended rigid or flexible videolaryngostroboscopy for the vocal fold evaluation. The stroboscopy is the main clinical tool for the etiological diagnosis of laryngeal diseases [17, 18]. It has been estimated that up to 28% of laryngeal diseases may be diagnosed with the stroboscopy examination only, while for 32% of cases, stroboscopy offered additional information regarding the cause of dysphonia [18]. The choice of the vowel /i/ is related to the better view of the anterior commissure when the vocal apparatus is in the position of the /e/ production compared to the position of the other vowels [19]. Such position brings the vocal folds upwards and forwards offering better vision of the glottal area during phonation. The stroboscopy outcomes proposed by experts in the present consensus paper (symmetry, amplitude, closure, regularity, movements, and morphology) allow a detailed description of the vibratory process of the vocal folds [1, 14, 19, 20]. For each parameter of the stroboscopy examination, the practitioner may use a 4-point Likert scale ranging from no symmetry/important disorder (0) to perfect symmetry/regularity (4) (Fig. 2, Appendix 1).

The cricoarytenoid joint function is commonly evaluated with the sniff or a repetition of alternating phonation of /e/ and sniffing at the flexible laryngostroboscopy, which may detect vocal cord mobility disorder, including partial or total laryngeal recurrent nerve paralysis, or

Table 2 Statements

N	Statements	%	Grade
1	The baseline laryngology consultation and voice evaluation have to include:		
1.1	Medical history	100	A
1.2	Allergy history	94.7	A
1.3	Tobacco use and history	100	A
1.4	Alcohol use and history	94.7	A
1.5	Current treatments	94.7	A
1.6	The job of the patient	100	A
1.7	Patient vocal use/posture	100	A
1.8	Singing practice	100	A
1.9	Other laryngopharyngeal symptoms	100	A
1.10	Videolaryngostroboscopy	94.7	A
1.11	Perceptual voice quality assessment	100	A
1.12	Patient-reported voice quality assessment	100	A
1.13	Aerodynamic measurements on indication, e.g., glottic insufficiency	100[a]	A
1.14	Acoustic measurements	94.7	A
1.15	Phonetogram on indication, e.g., for singing students or singers with complains in singing and with negative stroboscopy	94.4[a]	B
1.16	An assessment of cough during videoendoscopy if patient present cough as an important symptom	89.5[a]	B
N	Statements	%	Grade
2	Endoscopic examination of the vocal folds		
2.1	The endoscopic examination of vocal folds may be performed with flexible or rigid videolaryngostroboscopy	89.5	A
2.2	The following characteristics must be assessed through the examination with a 4-point Likert scale (no (0), mild (1), moderate (2 and severe (3) alteration)		
	Mucosal wave symmetry	100	A
	Mucosal wave amplitude	100	A
	Regularity/closure/movement and mobility of the vocal folds and cord joints	100	A
	Morphological characteristics of vocal cord (color, vascularisation, presence of lesions, etc.)	100	A
2.3	The following tasks need to be performed during the examination:		
	Sustained /e/ (Bee)	100	A
	Sniff	89.5	B
2.4	The following tasks should be performed during the examination for the following patients:		
	Glissando should performed for singers, actors or other voice professionals	100[a]	A
	Speak short sentence for hyperkinetic behavior or glottic insufficiency to analyze speaking glottic and supraglottic behavior	94.4[a]	B
3	The perceptual voice assessment needs to be performed with GRBAS scale on speak short sentence or counting (4-point ordinal scale)	84.2	A
	Additional tasks should be considered to complete the perceptual voice assessment such as sustained vowel /a/, like in Bath, or /i/	94.4[a]	B
4	The patient perception of voice may be performed with VHI-30 or VHI-10	89.5	A
5	The maximum phonation time is the aerodynamic parameter that needs to be included in the voice assessment	100	A
	The patient needs to be performed 3 sustained vowel /a/ and the final MPT is the longest MPT	100	A
N	Statements	%	Grade
6.1	The following acoustic measurements need to be included in the voice quality assessment:		
	Mean F0, percent jitter, percent shimmer, noise-to-harmonic ratio	84.2–89.5	B
	The following acoustic measurements should be included in the voice quality assessment of voice professionals:		
	Standard deviation of F0 (STD), range of intensity (dB), minimal intensity (dB), and maximal intensity (dB)	83.3–94.4[a]	C
6.2	The acoustic parameters need to be measured on a sustained vowel /a/ considering the 3-middle sec on same dB level when the patient acts as own control,	100[a]	B
	possibly also at different levels of 60, 70, and 80 dB		

Table 2 (continued)

N	Statements	%	Grade
6.3	The recording may be performed in a quiet room or a quiet consultation office or, if available, a soundproof booth	84.2[a]	A
6.4	The voice sample recording may be performed with computer with analysis acoustic software	89.5	A
6.5	If it is available, the voice sample should be performed preferably with professional high-resolution sound microphone (at 4 cm from the mouth)	83.3[a]	B
7	The following patient-reported outcome questionnaires need to be considered in the assessment of additional disorders:		
7.1	For reflux: Reflux Symptom Score (RSS) and Reflux Sign Assessment (RSA)	89.5[a]	B
7.2	For dysphagia: eating-assessment tool-10 (EAT-10) or Dysphagia Handicap Index (DHI)	89.5[a]	B

GRBAS grade, roughness, breathiness, asthenia, strain; *VHI* voice handicap index

[a]Statements that were validated after the second round

posterior glottic stenosis [20]. The movement analysis includes the evaluation of the abduction and adduction of the vocal cord during the phonation and the breath. The glottic physiology may be characterized and some glottal closure abnormalities may be detected, such as longitudinal, posterior, anterior, oval, hourglass, or irregular glottis [1, 19].

The asymmetry of the vocal fold vibration is commonly related to a limited vibratory quality of a lesion (e.g., nodules, scar, cyst, leukoplakia, and sulcus) and is an additional important parameter for the laryngeal disorder diagnosis [1]. The interrater reliability of glottal closure and laryngostroboscopic findings have been reported as moderate-to-high among laryngologists [21, 22]. The quantitative rating of the degree of irregularity slow motion (regularity outcome) and the quantitative rating of the quality of the mucosa wave are two additional parameters that may exhibit a lung (subglottis) or laryngeal disorder in many cases [19].

The morphology of the vocal folds (color, vascularization, and presence of lesions) is a stroboscopy outcome proposed by experts in the present consensus, which was not explicitly included in the 2001 guidelines [1]. The vocal fold mucosa is commonly characterized by longitudinal vessels on a white vocal tissue. The presence of mucosa or submucosal lesion may be characterized by disruption of the longitudinal vessel axis with transversal vessels to the lesion [23, 24]. In addition, erythema of the vocal fold may be found in some laryngeal irritative/chemical diseases, such as LPR, Reinke edema, inhaled corticosteroid intake, or chemical laryngitis [25–28].

The perceptual voice quality evaluation.

1. The perceptual voice assessment needs to be performed with GRBAS scale on speak short sentence or counting (4-point ordinal scale).
2. Additional tasks should be considered to complete the perceptual voice assessment, such as sustained vowel /a/, or /i/.

In 2001, Dejonckere et al. recommended the only use of Grade of dysphonia, Roughness, and Breathiness (GRB) for the perceptual evaluation [1], because GRB reported sufficient intra- and interrater reliability when used in a current clinical setting [1, 29, 30]. The low reliabilities of asthenia and strain parameters led authors to exclude them of the baseline VQ assessment. Since 2001, many studies have been conducted on the psychometric properties of GRBAS scale [31], especially the interrater reliability, and suggested that both asthenia and strain parameters reported similar interrater reliability than the others when used on several common voice conditions [32–35]. The strength of GRBAS scale is its multidimensional consideration of perceptual voice and the fact that is broadly used on international level. The exclusion of some parameters, such as asthenia or strain, may reduce the VQ characterization of some patients at baseline or throughout treatment course. For example, the strain parameter of GRBAS scale has been identified as an important parameter in the detection and the characterization of patients with early Reinke edema [36], or voice overuse [37], while asthenia is considered as an important component of Parkinson patients [38]. The evaluation of perceptual VQ on connected speech or counting task is considered as a standard approach in many VQ assessment protocols [14, 15, 39]. The connected speech was chosen by experts, because studies demonstrated that the perceptual evaluation on connected speech provided a better approximation to everyday conversation than sustained vowels. The use of sustained vowel may reduce the perception of the effect of co-articulation on VQ [14], while it has been showed that the average GRBAS scores were significantly worse when performed on sustained vowel [35]. In practice, the sustained vowel /a/ may be

Fig. 2 Template of VQ assessment

Voice Quality Assessment of ELS – UEP

Patient ID

Physician: ……

Associate……...

Date……

Medical history

Allergy: Tobacco: Alcohol:

Patient job: Vocal use: /8 Posture:

Singing practice:

Videolaryngostroboscopy:

Mucosal wave symmetry: 0 - 1 - 2 - 3

Mucosal wave amplitude: 0 - 1 - 2 - 3

Movement/ mobility of joint: 0 - 1 - 2 - 3

Morphological characteristics of the vocal cords:

Others (Glissando, cough, etc.):

Perception: G R B A S

Voice Handicap Index: Functional:…./30 Emotional:…/30 Physical: :…/30 Total:…../120

Voice Handicap Index-10:…./30

Maximum Phonation Time:

Acoustic measurements (60-70-80 dB):

Mean F0: Percent Jitter: Percent Shimmer: NHR:

Optional: STD (F0): Range of intensity: Minimal/Maximal intensity:

Additional evaluations

Reflux Symptom Score: Reflux Sign Assessment: EAT-10 : DHI :

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considered in case of insufficient voice material with connected speech/counting task. Nowadays, the development of artificial intelligence and robot able to evaluate the perceptual VQ with perfect intra- and interrater reliability [40] is a promising issue supporting the need to keep all useful component of GRBAS scale.

The patient-reported voice quality assessment

The patient perception of voice should be performed with either 30-Voice Handicap Index (VHI) or 10-Voice Handicap Index (VHI-10).

The VHI [41] is one of the most used patient-reported outcome questionnaires [42]. The VHI and the related short versions (e.g., VHI-10 [43]) consider cultural and social characteristics of VQ, which are important aspect for the patient perception [42]. In the present consensus paper, experts only recommended VHI or VHI-10 for the patient VQ evaluation, because VHI and VHI-10 reported high reliability and validity [42], and they are validated in several European languages [44], including English [41, 43], French [45, 46], German [47], Spanish [48, 49], Italian [50], and Dutch [51]. In 2001, Dejonckere et al. have proposed the addition of a double visual analog scale of 100 mm in the patient VQ assessment [1]. We did not keep this tool in the present consensus due to redundance with the VHI and the poor used of this scale in the current literature [14]. The other clinical tool for patient VQ assessment, e.g., VHI-9 or vocal tract discomfort scale, voice symptom score, were not considered according to the lack of language-validated versions, or the lack of studies demonstrating their superiority over the VHI [42].

The aerodynamic measurements

1. The maximum phonation time (MPT) is the aerodynamic parameter that needs to be included in the voice assessment.
2. The patient needs to perform 3 sustained vowel /a/ and the final MPT is the longest MPT.

Aerodynamic measurements of air pressure, airflow, or air volume provide useful information about lung function, laryngeal efficiency, and change regarding the opening and closing patterns of the vocal folds [14]. In the literature, the MPT, the phonation quotient, the mean flow rate, and the subglottal pressure are the most used aerodynamics [14, 16, 52].

There is an agreement in the literature to measure MPT by selecting the best results of 3 sustained vowel /a/ at comfortable pitch and loudness [1, 14, 53]. In 2001, Dejonckere et al. proposed the phonation quotient as the aerodynamic parameter of the baseline VQ assessment [1]. From a theoretical standpoint, the consideration of phonation quotient makes sense, because it considers the vital capacity of patient, and, consequently, the lung anatomy and physiology. In the present consensus paper, experts only proposed MPT for aerodynamics, because the measurement of vital capacity requires spirometer, which is poorly available in laryngology office or otolaryngological departments. Moreover, most patients consulting in laryngology have laryngeal disorders without lung disorders [54], which supports the only use of MPT. Patients with lung dysfunction that may be influenced by the treatment of the laryngeal disorders may benefit from lung function tests, including vital capacity, forced vital capacity, forced expiratory volume in the first second, FEV1/FVC ratio, peak expiratory flow, and maximum mid-expiratory flow. In these cases, the phonation quotient may be used and based on the vital capacity found at the lung evaluation. Similarly to phonatory quotient, experts did not recommend glottal flow or subglottic pressure in the baseline VQ assessment due to poor availability of their measurement instruments in Europe.

The acoustic measurements

1. The following acoustic measurements need to be included in the voice quality assessment: mean F0, percent jitter, percent shimmer, and noise-to-harmonic ratio.
2. The following acoustic measurements should be included in the voice quality assessment of voice professionals: standard deviation of F0 (STD), range of intensity (dB), minimal intensity (dB), and maximal intensity (dB).
3. The acoustic parameters need to be measured on a sustained vowel /a/ considering the 3-middle sec on same dB level when the patient acts as own control, possibly also at different levels of 60, 70, and 80 dB.
4. The recording may be performed in a quiet room or a quiet consultation office or, if available, a sound proof booth.
5. The voice sample recording may be performed with computer with analysis acoustic software or with professional high-resolution sound microphone (microphone at 4 cm from the mouth).

Voice quality may be acoustically analyzed in time, frequency, and amplitude domain [14]. Acoustic measurements are one of the most widely used objective parameters, because they are very sensible for the detection of subtle voice changes, which may remain inaudible to humans [55]. Acoustic measurements are particularly used as indicators of the effectiveness of surgical, medical, or speech language therapies or they are included in the calculation of some multidimensional scores, such as the dysphonia severity index [56] or the acoustic voice quality index [57], that are used in some public health systems to obtain reimbursement of speech therapy [58]. It has been demonstrated that acoustic parameters are

sensible to the method used to measure the acoustic cues irrespective to the disease [59, 60]. Precisely, according to the vowel types, number of samples, and selection of the time interval over which the acoustic parameters are measured, the impact of treatment may or may not be statistically demonstrated [59]. In the same way, acoustic parameters appear instable according to the intensity of the voice sample on which they are measured [61]. It is commonly recommended to measure acoustic parameters on a comfortable sustained vowel /a/, but the definition of what is a comfortable pitch remains unclear. Precisely, the acoustic measurements may significantly vary in the same patient at the same time when considering measurement at 60, 70, or 80 dB [62].

According to the sensitivity of acoustics, the ELS-UEP group provided detailed recommendations for the measurement of acoustic parameters. The choice of mean F0, percent jitter, percent shimmer, and noise-to-harmonic ratio in all patients was based on their availability in most software, including Praat® [63] or multidimensional voice program (MDVP®, Kay Elemetrics Corporation, Lincoln Park, NJ, USA). A debate occurred about the consideration of standard deviation of F0 (STD). In the present study, some experts supported that the range of F0 should be more useful to highlight the voice range capacity. Although the validation of STD as a baseline acoustic parameter, future studies should be important to compare these parameters in clinical practice.

From a recording standpoint, experts proposed the use of computer with analysis acoustic software or professional high-resolution sound microphone for the recording of voice sample, which corroborates some recommendations in the literature [14, 39]. The reliability of voice sample recorded with the microphone of the smartphone was debated in the present Delphi process, and, the statement was rejected. This issue needs future discussions, because recent findings of the literature support the non-inferiority of voice recording performed with smartphone microphone compared to professional microphone [64].

Comorbidities and other laryngopharyngeal conditions

1. In case of laryngopharyngeal reflux (LPR), the use of Reflux Symptom Score (RSS) and Reflux Sign Assessment (RSA) needs to be considered for the assessment of laryngopharyngeal symptoms and findings.
2. In case of dysphagia, eating-assessment tool-10 (EAT-10) and dysphagia handicap index (DHI) should be considered for the assessment of dysphagia.

Laryngopharyngeal reflux is an inflammatory condition of the upper aerodigestive tract mucosa [65], which was found in more than 50% of patients in laryngology office [66]. Macroscopically, LPR may be associated with vocal cord granuloma [67], mucosa ulcerations [68], or keratosis [69]. Microscopically, the refluxate pepsin or bile salts may induce vocal fold dryness [70], microtraumas [71, 72], inflammatory infiltrate [73], and mucosa thickening [74]. These macro- and microscopic mucosa changes lead to modification of the biomechanical properties of the vocal fold [68], and related impairment of aerodynamic and acoustic measurements [75]. The assessment of LPR in patients consulting in laryngology office makes sense regarding its high prevalence and its impact on voice quality. To date, many patient-reported outcome questionnaires or clinical instruments have been developed for documenting LPR-symptoms and signs [76–78]. Among them, RSS [78] and RSA [79] reported the best psychometric properties [80], which supports the recommendation of the present paper. Moreover, RSS and its short version, RSS-12 [81], are validated or available in several languages, including English [78, 81], German [82], French [78, 81], Chinese [83], Persian [84], and Korean [85].

Up to 30% pf patients with dysphonia reported dysphagia or eating disorders [86]. Because both symptoms are often associated, the evaluation of dysphagia makes sense in laryngology practice. EAT-10 [87] and DHI [88] are both patient-reported outcome questionnaires that exhibited high psychometric properties. EAT-10 is available in English [87], French [89], Spanish [90], Italian [91], Dutch [92], and German [93, 94]. In the same vein, DHI was validated in English [88], Arabic [95], Japanese [96], Italian [97], and French [98]. The reliability and the availability of EAT-10 and DHI in many languages support the recommendations found in the present paper.

Conclusion

The set of multidimensional evaluations of the present consensus may be considered as the minimum voice quality assessment in clinical and phonosurgical practice. These statements may guide general otolaryngologists, laryngologists, or phoniatricians in their clinical practice and may improve collaborative research by adopting common and validated VQ evaluation approach.

Appendix 1

Voice Quality Assessment of ELS – UEP

Patient ID

Physician: …….

Associate……...

Date……

Medical history

Allergy: Tobacco: Alcohol:

Patient job: Vocal use: /8 Posture:

Singing practice:

Videolaryngostroboscopy:

Mucosal wave symmetry: 0 - 1 - 2 - 3

Mucosal wave amplitude: 0 - 1 - 2 - 3

Movement/ mobility of joint: 0 - 1 - 2 - 3

Morphological characteristics of the vocal cords:

Others (Glissando, cough, etc.):

Perception: G R B A S

Voice Handicap Index: Functional:…./30 Emotional:…/30 Physical: :…/30 Total:…../120

Voice Handicap Index-10:…./30

Maximum Phonation Time:

Acoustic measurements (60-70-80 dB):

Mean F0: Percent Jitter: Percent Shimmer: NHR:

Optional: STD (F0): Range of intensity: Minimal/Maximal intensity:

Additional evaluations

Reflux Symptom Score: Reflux Sign Assessment: EAT-10 : DHI :

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JEB: data analysis & interpretation, agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. JA: data analysis & interpretation, agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. GC: data analysis & interpretation, agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. GD: data analysis & interpretation, agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. 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