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Review Article

Efficacy of Cepstral Measures in Voice Disorder Diagnosis: A Literature Review

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ABSTRACT

Introduction: The acoustic analysis is one of the well-known methods for voice evaluation. In recent years, many studies have investigated the cepstral measures compared with the other former acoustic parameters. This review article evaluates the related studies in the cepstral areas to ascertain whether they are efficient in the diagnosis of dysphonia.

Materials and Methods: We reviewed the available research studies between 2009 and 2021 narratively in PubMed, Scopus, Google Scholar, and Science Direct databases. The searched keywords included "cepstral peak prominence", "smoothed cepstral peak prominence", "instrumental acoustic analysis", "acoustic", and "diagnosis". The articles that investigated the power of Cepstral Peak Prominence (CPP) and its smoothed version (CPPS) to differentiate dysphonia versus normal voice have been included. However, the interventional studies that consider CPP and CPPS as one of their adjunct variables and studies that investigated the relationship of the cepstral measure with other parameters were not included.

Results: Recent studies support the efficiency of CPP and CPPS to diagnose dysphonia.

Conclusion: It is reasonable for the voice care teams to use CPP and CPPS in the patients' initial assessment and track the effects of treatment. However, according to the relatively limited number of studies in this area, more studies are required to clarify the efficacy of cepstral measures in different voice pathologies.

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1. Introduction

The basis of an ideal voice treatment plan is to accomplish an accurate evaluation of voice disorders [1]. Since the voice production is a complex phenomenon, its evaluation must be done in a multidimensional fashion to avoid any mistakes [2-4]. A complete voice evaluation comprise auditory-perceptual assessment, laryngeal imaging, acoustic measurements, aerodynamics measurements, and patient's vocal self-assessment [5]. Because of these different components, having a trained ear and doing the auditory-perceptual evaluation is deemed as the golden standard and the most reliable factor to assess the clients [6-9]. However, auditory-perceptual evaluation has some limitations. It basically relies on the clinician's clinical experiences and this issue increases the susceptibility of emerging errors when a clinician does not have enough experience [4]. In this case, using other complementary evaluations, such as acoustic measurements, will help clinicians to be more confident about their diagnostic labels. As Roy et al. declared, a preponderance of the studies about the voice evaluation has been concentrated on the acoustic measurements [10]. Because of the technology advancements, the acoustic analysis of voice is becoming more practical in the voice clinics [1]. The auditory measurement scan provide clinicians with the objective data; however, the record and interpretation of these measurements should be performed carefully [11]. The objective data can manifest the vocal changes before and after the intervention by numerical outcomes; the voice care team can compare these numbers to make a decision in respect of discharge or continuing the treatment [12, 13]. Because the acoustic measures are low-priced, easy to perform, and non-invasive versus other instrumental voice assessments, they are popular among voice care teams [14].

The most frequent acoustic measures are frequency perturbation (jitter), amplitude perturbation (shimmer), and Noise-to-Harmonic Ratio (NHR) that depend on tracking fluctuations in fundamental frequency. However, this tracking is only possible for mild severities of voice disorders [15]. As voice becomes more dysphonic and loses its periodicity, utilizing these frequency-based measures is out of access [15]. Another flaw of using these parameters relates to their particular speech task, the sustaining vowel. In other words, it lacks some characteristics that are present in the daily connected speech, such as prosodic varieties in frequency and amplitude, pauses in connected speech, speech rate, linguistic stress, voiceless part of phonation, and impact of language and dialect [12, 14, 16, 17]. Although two kinds of speech tasks, the sustaining vowel and the connected speech, are essential to reach a better understanding of a patient's voice problem [2].

A validated acoustic measurement that does not rely on pitch tracking is the Cepstral Peak Prominence (CPP) [15]. A Fourier transformation of a spectrum has been considered a definition for the term "cepstrum" [18, 19]. The cepstral peak was defined as the highest amplitude peak in the cepstrum, and CPP is defined as the distance from cepstral peak to a linear regression line showing the average energy of a sound [15]. CPP can demonstrate the organization of harmonics in an acoustic signal [18-20]. In highly periodic voice samples, CPP values increase, but in less periodic voice samples, CPP values decrease [15, 19]. Because CPP is not dependent of tracking fundamental frequency, it can inform the voice care team of dysphonic voices with more than mild severities [19].

In 1963, the concept of cepstrum was first presented by Bogert et al. [21]. Afterwards, CPP was introduced by Noll in 1964. However, because of the shortcomings of technology in earlier years, its clinical usage deferred for years [22]. In 1996, it was realized that an alteration in the former CPP algorithm could improve the reliability of CPP; this extra characteristic was smoothing CPP (CPPS) [18]. Hillenbrand and Houde explained it as "the additional processing step involves smoothing the individual cepstra before extracting the cepstral peak and calculating the peak prominence" [18]. According to Heman-Ackah et al. CPPS values less than 4.0 are considered as dysphonia [23].

Recently the American Speech-Language-Hearing Association (ASHA) recommended the clinicians to include CPP measures in sustaining vowels and connected speech to have a comprehensive evaluation of voice [24]. Reasons for including CPP in voice evaluation could be summarized in two main advantages. First, CPP and CPPS are more reliable than the traditional perturbation measures such as jitter, shimmer, and NHR [15, 25, 26], and the recording technique and the volume of speech sample cannot impact CPP values; and this benefit leads into the more widespread use of CPP [23]. The second advantage is associated with the speech tasks demand to capture CPP; both sustaining vowel and connected speech task are at the clinicians' disposal [27].

Despite numerous studies on CPP, especially in recent years, we found no review study on the newest important points about CPP for researchers and clinicians. So we got motivated to collect information and conduct this review [2-4, 23, 27-42]. The purpose of this article is to represent a review of literature about the efficiency of cepstral measures to differentiate dysphonic voice from the normal voice in the diagnosis process.

2. Materials and Methods

Four scientific databases of the medical literature were searched in May 2021. The databases included PubMed, Scopus, Google Scholar, and Science Direct. The searched keywords were "cepstral peak prominence" ,"smoothed cepstral peak prominence", "instrumental acoustic analysis", "acoustic", and "diagnosis". The search period was between 2009 and 2021. The search covered 20 articles that were published in English in peer-reviewed journals, depending on the authors' proficiency in English [2-4, 23, 27-42]. The reference lists of included articles were hand-searched to identify supplementary articles.

The process of selecting the articles started with the investigation of their titles. At first, duplicated and irrelevant studies based on keywords were ignored. Afterward, the authors read the abstract of the remaining articles carefully. Each meta-analysis review, systematic review, case-control, cross-sectional, and cohort voice assessment study that their primary focus was finding out that whether CPP and CPPS can differentiate dysphonia from normal voice or only provided a numeric range for CPP and CPPS in dysphonia group, have been included. No participants' language and age range limitation were regarded for articles inclusion. Some interventional studies with different designs such as randomized controlled studies that used the cepstral measures as one of their variables to track the changes of patients or studies that investigated the relationship of cepstral measure with other parameters were excluded. Also, editorial notes, letters, and short surveys had the lowest level of scientific evidence, so they were excluded from the current study. In the end, each selected paper was read comprehensively and analyzed descriptively by the authors. Any differences in selecting articles process between the authors were adjusted through consent. Because the design of this review article is a traditional narrative review, no statistical operation was done.

3. Results

In this section, the detailed characteristics and results of each study are discussed. In most of these studies, cepstral values have been compared between dysphonic patients and people with normal voices and it was attempted to find out whether this comparison is significant or not. A summary of each included study is listed in Table 1.

A meta-analysis review with the highest level of scientific evidence was conducted by Maryn et al. to examine different acoustic parameters to characterize the voice quality. They found that CPPS was the most powerful among other acoustic parameters in assessing the severity of dysphonia [28].

Kumar et al. researched to obtain the CPP value in patients with nodules. They found that nodules of vocal folds can significantly lower the CPP value. The authors emphasized that otolaryngologists and speech therapists should use CPP to assess the efficacy of voice treatment [29].

A study was conducted by Balasubramanium et al. to establish CPP values in patients with Unilateral Adductor Vocal Fold Palsy (UVFP). Results suggest that CPP values were significantly lower than the normal group; the reason for this condition was attributed to the phonatory gap in UVFP patients. Moreover, the effect of gender on CPP values was clear; females had significantly lower values in both groups; a posterior phonatory gap in 80% of women was considered the reason. Therefore, the authors confirm the use of CPP by otolaryngologist and speech therapists to determine the efficiency of treatment [30].

Watts and Awan attempted to find out the efficacy of spectral measures, especially the cepstral measures to differentiate between normal versus dysphonic voice. The dysphonic group was hypofunctional speakers with one of the aforementioned etiologies: unilateral vocal fold paralysis/paresis, presbylaryngis, and Parkinson disease. Results revealed that CPP values differed significantly between two groups in sustaining vowel and connected speech. Hence, the diagnostic value of CPP has been confirmed like the previous studies in this area [31].

Moers et al. examined the correlation between the cepstral measures with roughness, breathiness, and hoarseness. Results have shown that through the cepstral measures, CPP and CPPS showed the highest correlation with the perceptual measure in connected speech. Hereupon the authors underlined that connected speech produces more reliable results relative to sustaining vowels. Although CPPS does not provide a clear picture of hoarseness per se, in combination with other methods, it does [32].

Lowell et al. compared the predictive value and the discriminant capacity of cepstral- and spectral-based

Table 1. Characteristics of the included studies

Authors and Years	Study Design	Number and Age of Participants (Including Controls)	Vocal Task	Software	Study Results
Maryn et al. (2009) [28]	Meta-analysis review	*	*	*	CPPS were identified as the most vigorous acoustic parameter to measure the dysphonia severity.
Kumar et al. (2010) [29]	Prospective case-control	Patients: 50 (25 M, 25 F) Normal: 50 (25 M, 25 F) Age: 20-40 y	Sustaining vowel /a/	CSL4150	CPP values in the nodule group were significantly lower than the control group.
Balasubramanium et al. (2011) [30]	Prospective case-control	Patients: 60 (30 M, 30 F) Normal: 60 (30 M, 30 F) Age: 20-40 y	Sustaining vowel /a/	CSL4150	CPP values in the UVFP (Unilateral Adductor Vocal Fold Palsy) group were significantly lower than the control group.
Watts and Awan (2011) [31]	Prospective case-control	Patients: 16 (5 M, 11 F) Normal:16 (5 M, 11 F) Patients mean age: 52 y Normal mean age: 53 y	Sustaining vowel /a/ Reading of the "Rainbow" passage	N/A	CPP values were significantly different between the two groups in both tasks.
Moers et al. (2012) [32]	Retrospective data analysis	Patients: 73 (24 M, 49 F) Age: 19-85 y	Sustaining vowel /e/ Reading of the "The north wind and the sun"	"cpps" and "Praat"	CPP and CPPS had the highest correlation with the perceptual measure in connected speech.
Lowell et al. (2013) [33]	Prospective, quasi-experimental	Roughness group: 14 Breathiness group:14 Normal group: 14 (F) Roughness group age: 24-78 y Breathiness group age: 19-69 y Normal group age: 24-55 y	Reading of the "Rainbow" passage	CSL4500 and ADSV	Cepstral measures were more powerful than spectral measure; CPP and cepstral CPP SD were more efficient to differentiate the normal, rough, and breathy voice qualities.
Brinca et al. (2014) [34]	Retrospective	Patients: 30 (F) Normal: 30 (F) Age: 19-66 y	Sustaining vowel /a/ Reading of the "The story of Arthur the rat"	Hillenbrand	In sustaining the vowel /a/ task, the amount of CPP and CPPS were significantly lower than the normal group. In the connected speech task, the amount of CPP was significantly lower in the dysphonic group; however, the amount of CPPS was not different between the groups.
Heman-Ackah et al. (2014) [23]	Prospective cohort study	Patients: 835 Normal: 50 Age: N/A	Reading of the "Marvin Williams"	CSL	4.0 was introduced as the cut-off point in running speech; voice samples with scores under 4.0 show dysphonia, with a sensitivity of 92.4% and specificity of 79%.
Jannetts and Lowit (2014) [35]	Prospective case-control	Parkinson group: 43 (31 M, 12 F) Ataxia group:10 (5 M, 5 F) Parkinson group age: 46-85 y Ataxia group age: 28-72 y	Sustaining vowel, Reading a passage and monologue	Multi-Dimensional Voice Program and Praat	CPP and CPPS had the most correlation with grade, breathiness, and asthenia of GRBAS (Grade, Roughness, Breathiness, Asthenia, Strain) scale.
Maryn and Weenink (2015) [36]	Comparative cohort study	Patients: 261 Normal: 28	Sustaining vowel and reading a passage	Speech Tool and Praat	There was a strong correlation between CPPS values established by both software.

Authors and Years	Study Design	Number and Age of Participants (Including Controls)	Vocal Task	Software	Study Results
Hasanvand et al. (2017) [2]	Cross-sectional	Patients: 100 (50 M, 50 F) Normal:100 (50 M, 50 F) Age: 20-50 y	Sustaining vowel reading a passage	Speech tool	CPP and CPPS in both tasks in the dysphonic group were lower. Both variables in connected speech showed reliability. In vowel sustaining task, CPPS had more reliability.
Sauder et al. (2017) [37]	Retrospective cross-sectional	Patients: 100 (37 M, 63 F) Normal: 70 (40 M, 30 F) Patients mean age: 45 y Normal mean age: 44 y	Reading of the "Rainbow" passage	ADSV with CSL 5109 and Praat	CPPS established by both software could predict dysphonia. The power of Praat was higher.
Watts et al. (2017) [27]	Prospective case-control	Dysphonic group A: 22 (5 M, 17 F) Normal: 22 (5 M, 17 F) Dysphonic group B: 30 (15 M,15 F) Normal group B: 10 (5 M, 5 F) Dysphonic group A, mean age: 28.27 y Mean of normal group A: 29.82 Mean of dysphonic group B: 49.03 Mean of normal group B: 46.5	Sustaining vowel /a/ and connected speech	ADSV and Praat	Both software showed parallel-forms reliability.
Delgado-Hernández et al. (2018) [3]	Prospective case-control	Dysphonic group: 20 Normal group: 20 Dysphonic group mean age: 47.8 Normal group mean age: 36 y	Sustaining vowel /a/ and connected speech	Praat	CPPS could differentiate dysphonic versus normal voice.
Núñez-Batalla et al. (2019) [4]	Prospective case-control	Patients: 72 (40 M, 32 F) Normal:52 (26 M, 26 F) Age: 20-60 y	Sustaining vowel /e/ and reading "CAPE" phrases	Praat	There was a correlation between CPPS and general perceptual dysphonia level, especially with breathiness. CPPS did not correlate with roughness
Aydinli et al. (2019) [38]	Prospective case-control	Patients: 27 (20 M, 7 F) Normal: 27 (20 M, 7 F) Age: 5-12 years and 7 month	Sustaining vowel /a/ and reading "CAPE" phrases	ADSV and CSL 4500	CPP the in dysphonic group was significantly lower than the control group.
Burk and Watts (2019) [39]	Prospective case-control	Patients: 32 Normal: 10 Age: N/A	Sustaining vowel /a/ and reading	ADSV and CSL	In sustaining vowel task CPP in Parkinson group with tremor was significantly lower than two other groups. In the connected speech task, there was no difference in CPP between the three groups.
Kim et al. (2019) [40]	Retrospective study	Patients: 2595 Normal: 268	Sustaining vowel, connected speech, and voice extracted connected speech	Praat and ADSV	Both the connected speech, and voice extracted connected speech were strong to differentiate dysphonia from normal voice. The extracted connected speech was less powerful.
Belsky et al. (2020) [41]	Retrospective, observational, matched cohort	Patients: 85 Normal: 85 Age: 19-60 y	Reading of the "rainbow" passage	CSL and ADSV	There was no significant difference between acoustic and aerodynamic variables between the two groups.
Mizuta et al. (2020) [42]	Prospective case-control	Patients: 95 Normal: 30	Sustaining vowel and reading sentences	ADSV and Multi-dimensional voice program	CPP and CSID could distinguish almost between 4 statuses of voice: normal, mild, moderate, and severe dysphonia.

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CPP, Cepstral Peak Prominence; CPPS, smoothed CPP; ADSV, Analysis of Dysphonia in Speech and Voice; CSID, Cepstral Spectral Index of Dysphonia measures during continuous speech. The cepstral measures were more powerful than spectral measure. Compared with spectral measures, CPP and Cepstral Pick Prominence Standard Deviation (CPP SD) expressed the higher efficiency in differentiating the normal, rough, and breathy voice qualities [33].

In a study on a group of Portuguese females, Brinca et al. tried to testify CPP and CPPS to differentiate between the normal voice versus dysphonic voice in the longitudinal gap, cyst, edema, nodules, and unilateral vocal fold paralysis. In sustaining vowel /a/ task, the amount of CPP and CPPS were significantly lower than the normal group. In the connected speech task, the amount of CPP was significantly lower in the dysphonic group relative to the normal group; however, CPPS value was not different between the groups. The authors concluded that both CPP and CPPS are valuable for clinical practices. Results also suggest that CPP and CPPS correlate with audio-perceptual judgment. In both tasks, the most robust correlation was between CPP and breathiness. So results confirm the efficacy of CPP and CPPS in differentiating dysphonic versus normal voice. However, results should be considered carefully because only females were included in the study [34].

Heman-Ackah et al. explored the cut-off point for CPPS to distinguish normal versus dysphonic voice. Four has been introduced as the cut-off point in running speech; voice samples with scores under 4.0 showed dysphonia, with a sensitivity of 92.4% and specificity of 79%. The authors stated that CPPS could distinguish the normal and dysphonic voice [24].

Jannetts and Lowit determined the relationship of some acoustic parameters with the perceptual impression of voice in hypokinetic and ataxic dysarthria. Compared with the other acoustic parameters, CPP and CPPS showed a stronger correlation with the perceptual parameters of GRBAS: grade, breathiness, and asthenia. Therefore, CPP and CPPS have been introduced as useful tools in assessing the hypokinetic and ataxic dysarthria [35].

Maryn and Weenink investigated the correspondence between the CPPS established values by two acoustic analysis software: Speech Tool, and Praat. Results pointed out a strong correlation between CPPS values established by both software. The authors concluded that CPPS established by both software could be employed clinically, and they can provide some information about the severity of dysphonia [36].

In a study on the Persian language, Hasanvand et al. attempted to confirm the power of CPP and CPPS in differentiating between the normal and dysphonic groups. Both CPP and CPPS were suggested as reliable tools in connected speech. Though, CPPS was more reliable than CPP in the sustaining vowel task. The authors also highlighted the effect of gender on CPP; results suggested that males in both the dysphonic and normal groups had higher CPP and CPPS values and consequently better voice quality. Authors assumed this phenomenon relates to the presence of a posterior phonatory gap in the normal Iranian female population; a posterior phonatory gap can reduce harmonic components of a voice signal [2, 43].

Sauder et al. tried to examine the accuracy of CPPS to predict dysphonia and compare two different software: Analysis of Dysphonia in Speech and Voice (ADSV), and Praat. Results indicated that established CPPS values by two software were not significantly different; notwithstanding, the Praat showed more predictability power to detect dysphonia. The authors suggested that clinicians use CPPS in screening and evaluation protocols [37].

Watts et al. investigated the validity of CPP established by two software: ADSV, and Praat. Results showed that both software had parallel-forms reliability. The authors concluded that CPP could describe dysphonic and normal voices [27].

Delgado-Hernández et al. examined the efficacy of CPPS to differentiate dysphonic versus normal voice in the Spanish language and determine the appropriate speech task to identify the dysphonia severity. The results denoted that CPPS could differentiate dysphonic versus normal voice. Also, a correlation was found between CPPS with the overall severity of dysphonia in both sustaining vowel and connected speech, although connected speech showed a stronger correlation [3].

Núñez-Batalla et al. explored the validity of CPPS as an objective evaluation of the quality of voice and to establish its normative data in Spanish speakers. Results indicated a correlation between CPPS and overall dysphonia in both speech tasks. Particularly, there was a strong correlation between CPPS and the breathiness parameter of dysphonia. Indeed, there was not a significant correlation between CPPS and roughness. Also, results showed that CPPS could predict dysphonic voice with 70% sensitivity and 85% specificity. Accordingly, we recommended using CPPS to complete clinical assessments and screening. The normative data of CPPS have been reported in Spanish speakers; values in the connected speech were lower than the sustaining vowel [4].

Aydinli et al. explored the efficiency of cepstral measures to differentiate dysphonic versus normal voice in Turkish children. The dysphonic group had vocal nodules. The findings indicated a difference in cepstral amounts between the two groups; the CPP amount was lower in the dysphonic group. The authors recommended the cepstral analysis be included in the evaluation of children with a voice problem. Also, findings suggested that the sentence task had better sensitivity to detect dysphonia than the sustaining vowel task [38].

Burk and Watts investigated the acoustic and aerodynamic features of phenotypes of Parkinson disease. Results indicated that the CPP value of the vowel task was significantly lower in the non-tremor dominant compared to the dominant tremor phenotype and normal group. Therefore, CPP in the vowels was sensitive to the vocal changes made in the earlier stages of the disease. Nevertheless, the connected speech CPP value was equal in both Parkinson phenotypes and the normal group. Results showed that CPP could be a valuable predicting tool to identify the vocal deficits in the early phase of Parkinson disease before the advancement of symptoms [39].

Kim et al. tried to discover the strength of the cepstral analysis, including CPP, CPPS, and low/high spectral ratio in sustaining vowel, connected speech, and voice extracted connected speech to differentiate between the dysphonic and normal voices. The results indicated that cepstral analysis in both connected speech and voice extracted connected speech could differentiate dysphonia from normal voice. However, voice extracted connected speech was less robust than connected speech [40].

A recent study was done by Belsky et al. to compare Muscle Tension Dysphonia (MTD) and normal group in terms of acoustic and aerodynamic measures. Results indicated that cepstral parameters, including CPP measured in connected speech task, were not significantly different between these two groups. Thus, normal cepstral values in connected speech have been reported for MTD patients. The authors concluded that the cepstral values could not be relied on because of a lack of differentiating power in MTD [41].

Mizuta et al. investigated the power of CPP and Cepstral Spectral Index of Dysphonia (CSID) in differentiating dysphonia versus normal voice and their ability in determining different severities of voice disorders. The results revealed that both CPP and CSID are appropriate tools to detect dysphonia. Also, both of them could distinguish almost between 4 statuses of voice: normal, mild, moderate, and severe dysphonia [42].

4. Discussion

In assessing patients with voice problems and designing their treatment plan, having an accurate diagnosis is the most important step [11]. The diagnosis of dysphonia might be a challenge for the clinicians. A tool that can complement the other routine assessments and determine the necessity of the intervention is strongly required. In recent years, a lot of researchers investigated the cepstral measures for their power in the diagnosis process of voice disorders [2-4, 23, 27-42]. Although there was a meta-analysis review article that investigated different acoustic parameters, there was no review article, systematic nor narrative, which presented a clear conclusion based on recently published papers [28]. Therefore, the lack of a new review article in CPP research studies motivated us to study most of the articles in this area and conclude a transparent outcome.

In most of the selected studies, the validity and reliability of CPP and CPPS to differentiate the normal versus dysphonic quality of voice in different pathologies have been probed, named nodule, vocal fold paralysis, polyp, and so on. Also, it was attempted to investigate the power of CPP in different age ranges and both genders. According to these research studies, CPP and CPPS can accurately differentiate the dysphonia versus the normal voice. This conclusion is true for the different age ranges of the patients, even in the children [38]. Just in one of the included studies in this review, the cepstral measures could not differentiate dysphonic patients diagnosed as MTD from control participants with a normal voice. This issue must be explored thoroughly in future studies if this weakness of the cepstral measure is reported again. However, it may relate to the methodology or the procedure which have been used in that particular study [41].

The power of CPP and CPPS was almost similar for all the voice pathologies; more specifically, these investigations have been focused on lesion-based pathologies such as nodules. CPP and CPPS established from a patient can be compared with the cut-off points introduced in the articles. For instance, according to Heman-Ackah et al., CPPS values under 4.0 are considered dysphonia [23]. Indeed, the related research studies should find cut-off points that could finally provide a conclusive normal and or dysphonic value(s) and also resolve the previous statistical issues in the published papers.

Although research has revealed that language parameter does not impact CPPS values, further studies should find the cut-off(s) in different languages to rule out the possible effect of the language on the discriminating power of CPP and CPPS [44].

Besides CPP and CPPS' applications in the assessment, they are useful in treating and tracking its efficacy. For this purpose, the obtained values in the initial session can be compared with the final session values and checked for any progress [23, 45, 46]. The treatment will be efficient if the patients' CPP or CPPS values increase relative to the first assessment session [15, 19].

Establishing CPP and CPPS values comfortably by many software applications is another convincing reason to include them in our evaluations. "Praat" (Paul Boersma & David Weenink, Institute of Phonetic Sciences, University of Amsterdam, The Netherlands; www.praat.org) is free downloadable software that calculates CPP and CPPS and helps clinicians to revise their diagnosis. There is some commercial software that is mentioned in the selected studies, such as ADSV (ADSV, PENTAX Medical, Montvale, NJ), that can be helpful too [27].

Although several studies have been published in the last decade about the clinical use of CPP and CPPS, there is an increasing necessity for additional studies to be done in different pathologies. The efficiency of CPP and CPPS should be investigated in-depth in conditions other than lesion-based pathologies, for example, in psychogenic voice disorders. The differential diagnosis of CPP and CPPS should be investigated, too. For instance, whether they can differentiate between nodules and polyps; this probable capability will help the voice care team to decide more wisely about treatment procedures. It will also help prevent unnecessary and more invasive treatments like surgery. Future research studies will help us to comprehend more about CPP and CPPS.

Therefore, we can conclude that to reach a certain diagnosis in the assessment session of a voice patient and also to track the efficacy of treatment, it is necessary for voice pathologists, otorhinolaryngologists, and laryngologists to use CPP and CPPS.

5. Conclusion

Based on the results of several articles conducted in earlier years, CPP and CPPS have strong validity and reliability to discern the dysphonia from the normal voice in a lot of pathologies. The literature review suggests that CPP and CPPS do not present a detailed clinical picture of one's voice per se, but voice pathologists, laryngologists, and otorhinolaryngologists should consider their measurements important adjunct in evaluating patients' voice. Establishing CPP and CPPS values easily and without spending a lot of time (by many available software such as "Praat" does) suggests using these measures in the voice clinics. Also, the non-invasive nature of utilizing CPP and CPPS is another reason which urges researchers and clinicians to employ them. As the authors recommend, subsequent research studies in the cepstral area should be directed toward the differential diagnosis power of CPP and CPPS between variant pathologies. This mentioned trend can help the voice care team, especially SLPs, to diagnose structurally voice pathologies more properly and reliably in addition to conventional laryngeal imaging such as videolaryngostroboscopy and videolaryngoscopy.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical implications of this work.

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Authors' contributions

Mahshid Aghajanzadeh and Saeed Saeedi contributed equally to the manuscript.

Conflict of interest

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