Analyzing the Effect of Vocal Cord Dysfunction on Voiced Sound Production: A case of Clinicals in the City of Erbil

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Abstract

The current study aims at unveiling the impact of vocal cord dysfunction on the production of voiced sounds that are shared in Kurdish and English sound system. To achieve the aim of the study, a total of 7 patients aged between 15- 30 years old voluntarily participated in the study. The participants' speech tokens were analyzed using the PRAAT software to examine the fundamental frequency, duration, pitch, and voice onset time characteristics of voiced consonant sounds. The results of the spectrum analysis demonstrated that the production of all the voiced sounds was affected by the presence of defected vocal cords although its effect was more evident and greater in the pronunciation of velar voiced sounds. The results further revealed that patients with vocal cord dysfunction experienced difficulties in pronouncing voiced sounds, particularly those with inflammation and irritation of the Maghreb nodes in the glottal area.

Keywords: vocal cord dysfunction, acoustic analysis, voiced sounds, fundamental frequency, pitch, VOT

تحليل تأثير اضطراب الأحبال الصوتية على إنتاج الأصوات المجهورة: دراسة حالة سريرية في مدينة أربيل

الملخص

تهدف الدراسة الحالية إلى الكشف عن تأثير خلل الحبال الصوتية على إنتاج الأصوات المجهورة المشتركة بين النظام الصوتي الكوردي والإنجليزي. لتحقيق اهداف البحث، شارك سبعة مرضى تتراوح أعمارهم بين 15–30 عامًا طوعًا في الدراسة. تم تحليل التسجيلات الصوتية للمشاركين باستخدام برنامج PRAAT لفحص التردد الأساسي، المدة، النغمة، وخصائص زمن بدء الصوت للأصوات الساكنة المجهورة. أظهرت نتائج التحليل الصوتي أن إنتاج جميع الأصوات المجهورة تأثر بوجود خلل في الحبال الصوتية، على الرغم من أن تأثيره كان أكثر وضوحًا وأكبر في نطق الأصوات المجهورة الخلفية (الحنكية). بالإضافة إلى ذلك، كشفت النتائج أن المرضى الذين يعانون

من خلل في الحبال الصوتية واجهوا مشاكل في نطق الأصوات المجهورة بشكل صحيح، وخاصة أولئك الذين يعانون من التهابات وتهيج في العقد المغربية في منطقة المزمار.

الكلمات المفتاحية : خلل الحبال الصوتية، التحليل الصوتي، الأصوات المجهورة، التردد الأساسي.

1.1 Introduction

The mechanism of producing and pronouncing sounds correctly depends mainly on the health and safety of the speech organs, and any problem in these organs leads to a defect in pronouncing sounds. One of these problems that some people may suffer from is a dysfunction of vocal cords (henceforth VCD). Voiced sounds and vowels are among the sounds are produced with vocal cords vibration. In other words, producing these sounds involves breathe passing through the vocal cords accompanied by a kind of acoustic vibration similar to a buzzing sound.

VCD which is also known as paradoxical vocal fold motion disorder is "an intermittent extra thoracic airway obstruction mainly during inspiration leading to dysphonia and varying intensity." (Kenn and. Balkissoon, 2011, p194). The symptoms, in such condition, is similar to those of asthma, the patient mostly suffers from wheezing and labored breathing (Aaronson, 2022). VCD is defined by Tilles (2003) as an obstruction in air passage and sound disturbances mainly during breathing due to uncertain problem leading to a kind voice disorder. The vocal cords do not function properly during breathing and it may cause a disorder may affect the voice quality, for example it decreases human's control on his sound phonatory and increases vocal effort.

VCD can affect individuals of all ages for various reasons. While many studies have investigated this condition, its exact causes remain uncertain. (Parnell, Brandenburg ,1972; Goldberg and Kaplan 2000; Tilles, 2003; Kenn and Hess,2004; and Morris Allan and Perkins,2006). Although many studies have been conducted to explore the physiological factors of VCD, limited attention has been given to the acoustic characteristics of voiced sounds produced by individuals diagnosed with VCD. The current study aims at investigating and understanding the effects of VCD on the pronunciation of sounds produced with vocal cord vibration, more precisely, the voiced consonant sound. It tries to provide an insight into the nature and severity of VCD to find out which voiced sound you are most affected by the vocal cord disorder, taking into consideration the place of articulation, manner of articulation, as well as the spectral characteristics of these sounds. To achieve these aims the following research questions have been generated.

1. What are the effects of VCD on the articulatory and acoustic quality of voiced sounds?
2. Which voiced sound is most affected by the VCD?

2. Literature Review

2.1 Types of focal cord Dysfunction

VCD, as mentioned earlier, is a condition caused by underappreciated sporadic, and discordant vocal cord amplification. It can cause extra thoracic obstruction in the air flow, during inhalation and exhalation, in addition to problems in producing vocalic, voiced sounds, as well as a short duration in the production of onset sounds. Clinically, VCD presents with distinct symptoms such as throat tightness, breathing difficulties, and changes in voice quality. (Dunn, Katial, and Hoyte, 2009). The following figure shows the difference between a normal vocal cord and dysfunctions in the vocal cord.

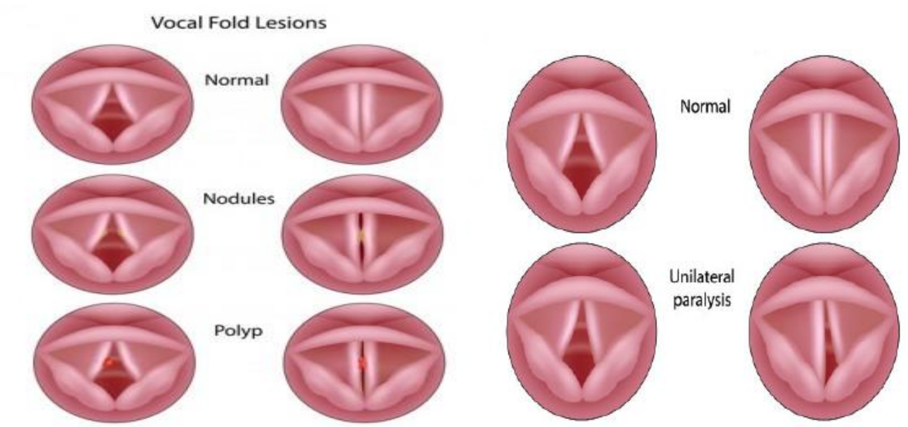

Figure 1 normal and dysfunction vocal cord (cited from Sounderic, 2023)

1. Paralysis. This s disease is caused by irritants in the environment. The symptom of this disease is that the edges of the vocal cords move toward the middle and become stiff during inhalation and exhalation also causes difficulties in producing the voiced and vocalic segments.
2. Laryngitis usually occurs due to an acidic reflux (GERD) and leads to seize or contract in the vocal cords. The patient may experience shortness of breathing and sometimes the patient loses the ability to speak. The symptoms of acidic reflex are similar to those of Asthma.
3. Laryngitis happens due to stress and anxiety. Ulceration and tightness in the vocal cord are among the symptoms of the disease.
4. Asthma is another disease that causes vocal cords dysfunction. Tightness in chest and vocal cords, problems in exhaling, and shortness

of breath are among its symptoms which directly affect speech production.

5. Nodule and Polyp are different types of throats noncancerous. They are also known as vocal cord cysts. A patient with these diseases suffers from symptoms such as, growth of bumps on the edges of focal cords that cause a hoarse or harsh in sound. Also, a difficulty in vocal cords vibrating. The following figures show the different types of the mentioned vocal cords dysfunction respectively.

Figure 2
Samples vocal cord dysfunctions' types (adopted from the British **voice** association -voice care articles & Adventis advanced ENT services)

In brief, the diseases mentioned above affect the vocal cords and cause dysfunctions in the vocal cords. The effects of these diseases are evident on the speech production and sounds pronunciation, especially sounds that are pronounced with vocal cords strings, such as vowels and voiced sounds.

2.2 Articulatory and acoustic properties of voiced sounds of English and Kurdish sounds

To examine the articulatory and acoustic features of the voiced sounds in English and Kurdish, several of studies in both languages were utilized like (Behrens and Blumstein, 1988; Ohala, 1994; Nissen, and Fox, 2005; McCarus,1958; Asadpour and Muhammadi, 2014, Ali et al, 2018). Both languages have almost stock of voiced sounds with very similar characteristics. The Kurdish language contains 13 voiced consonant sounds that are comparable to those in English, including [v], [d], [z], [b], [ʒ], [g], [ð], [l], [m], [n], [ʤ], and [r]. In Kurdish, the consonant sounds [j] and [w] are considered vowels and there in no equivalent to the English E voiced sound [ŋ]. Besides, there is another Kurdish velar voiced consonants [ʔ], that has no counterparts in English as in the words *Agha* { lordman} and *Ghardan*{ running}.

According to several Kurdish studies on the spectral analysis of Kurdish voiced sound, (Farhady,2013, 2016, Othman, 2020, Kamil and Salih, 2023) the articulatory and the acoustic properties of Kurdish consonants are similar to those of English consonants. The sound systems of both languages reveal that [v] is a labiodental fricative consonant sound; the sound [d] is an alveolar, fricative. [m] and [n] are nasal sounds according to their manner. However, the former is a labial sound and the latter is an alveolar one. The [ð] is a borrowed interdental, fricative sound in Kurdish that has an equivalent counterpart in the English sound system with the same place and manner. [ʒ] and [z] are two fricative sounds produced in the post alveolar region in both languages. Additionally, the sound [g] has similar pace and manner in both languages, being velar and fricative. The articulatory features of the sound [b] in both languages are bilabial and fricative. Regarding the voiced sounds [ʤ], [r], and[l], the first is considered as an affricate palatal sound, the second is a retroflex gliding, and the third one is a lateral, alveolar sound. Moreover, the Kurdish sound [ʔ], which has no counterpart in English sound system and pronounced similar to French thrill sound [r] is a velar voiced consonant affricate consonant sound. The visual representation of the voiced consonants, classified under the acoustic branch of phonetics, describes the spectral feature of the voiced sounds **[ð]** and **[z]** as a relatively consistent spectrometric underneath “10 kHz” with no prominent peaks. The range of the fundamental frequency (F0) (**Jitter absolute),** and pitch variation (**Shimmer dB**) is 75 dB with a total duration (3.44 seconds for [ð] and 3.36 seconds for the sound [z]. Sounds’ onset duration **(VOT**), which was less than 18 ms before the sound pronunciation? For the voiced sound **[b],** the onset time duration and the silence that precede the sound burst] is less than 25ms. Additionally, the spectral energy of the fundamental frequency (F0) is 5-6 kHz at a higher frequency. It has relatively a short amplitude and pitch derive which scores 53 dB and the time duration 3.12 seconds. The spectral prosperities of the sound **[d]** show a flat spectral which is 4-6 kHz. The fundamental frequency (F0) and pitch divers score 58.42 dB. The onset of voiced stop is 34ms, which is higher in comparison to fricative voiced consonants. The time duration for producing this sound is 5.68 seconds. The acoustic features of the voiced sound **[v]** show lower overall amplitudes and derived pitch (6-8 kHz and 52.3dB) with a shorter duration of 2.44 seconds. The onset VOT scores 13ms (see figures 3a & 3b).

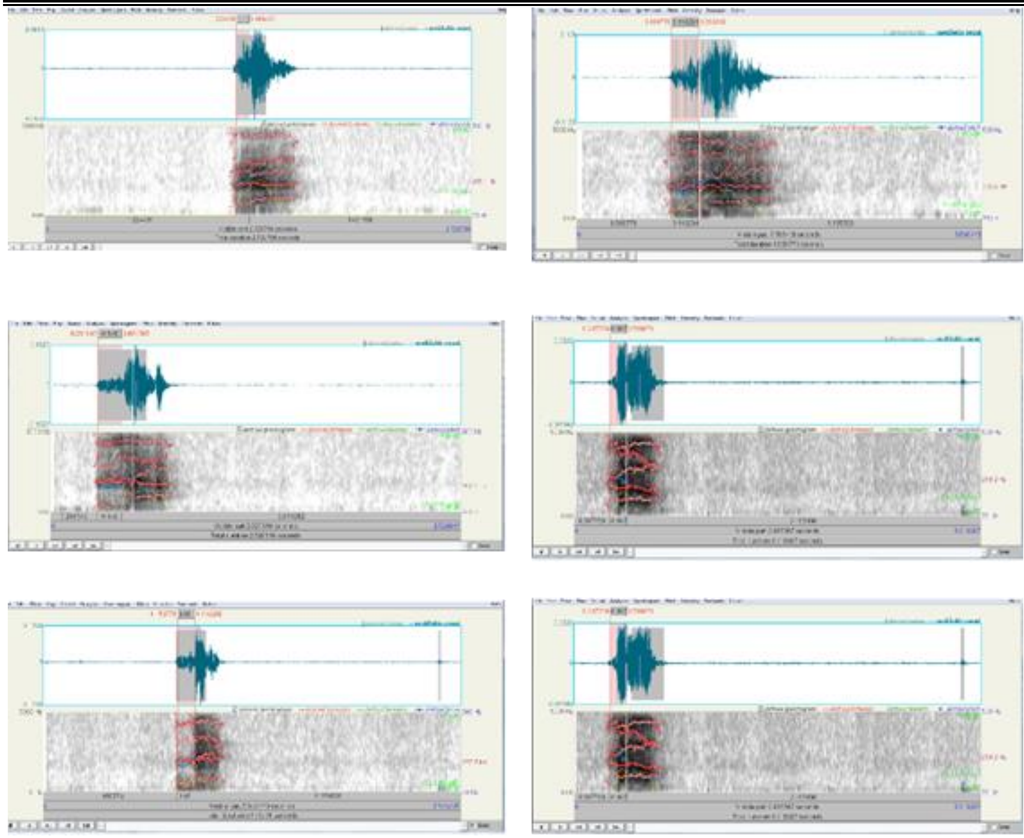

Figure (3a) The spectrograph

The spectral prosperities of the nasal voiced sound**[n]** and **[m]** show relatively similar scores. Both sounds have relatively low frequencies and damping vibration which are 2.5-3 kHz for [n] and 2.3-3 kHz for the sound [m]. The pitch diver in the production of the sound [n] is 56.28 dB and for [m] is 52.15dB. The VOT of both sounds are as follow respectively 16.2 ms and 15.9ms. The duration of the sound production is 2.39 second for [n] and 2.72 seconds for the sound [m].

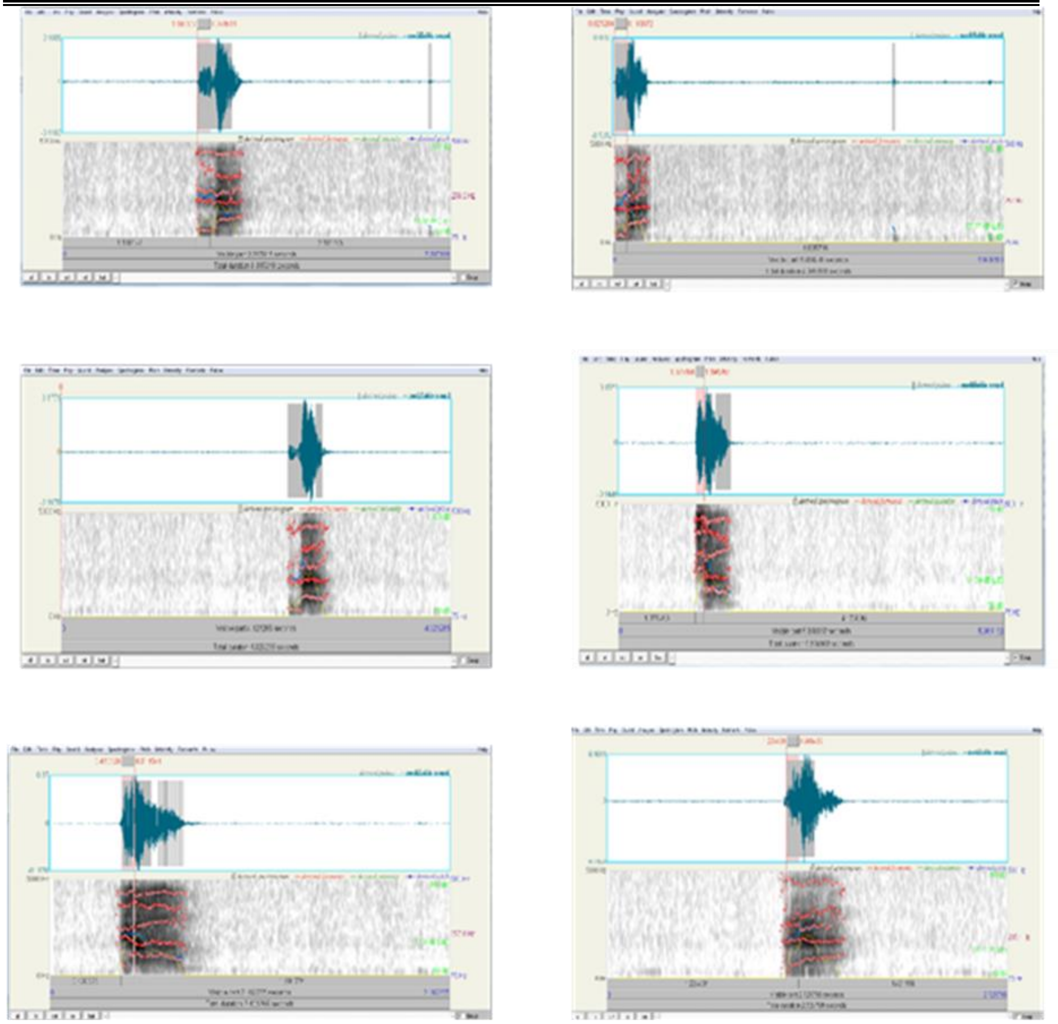

Figure (3b) the spectrograph of selected voice sounds

Regarding the lateral voiced **[l];** the duration for sound production is 2.78 seconds. The fundamental frequency (F0) is 3.5-4 kHz, the pitch derive score is 52.8dB. The VOT is 14. 4ms.The time duration needed for producing the mono voiced **[r]** is 2.91 second and its fundamental frequency is 2.3-4 KHz. moreover, the pitch derives and amplitudes score 63.46dB. The acoustic features of the velar vocalic sound **[g]** shows that the time needs 3.40 second to be produced separately. It is characterized by having a spectral energy above 4 kHz with a derived pitch 52.23 dB. The VOT is 21ms.The sound **[ʒ]** requires 3.13 seconds for production. The fundamental frequency and variability of F0 is3-4kHz, as well as, 66.52dB is scored for the pitch variation.in addition to 18ms, the score of VOT. The acoustic analysis of the Kurdish velar voiced sound **[ʔ]** indicated, that that the duration of the sound production by a normal person takes (4.12 seconds) with (29.2 ms) VOT. The measure of the fundamental frequency read (6-7 kHz). The variation of the pitch and intensity, as stated by (Kamil and Salih, 2023) and based on Shimmer measurement was (66 dB), The last voiced sound is**[ʤ]** needs 2.70 second for producing it in isolate. The peak deviation of the amplitude is 55.59 dB and the pure tone of the observed the onset of F0 scores 6-8 kHz and 33ms.

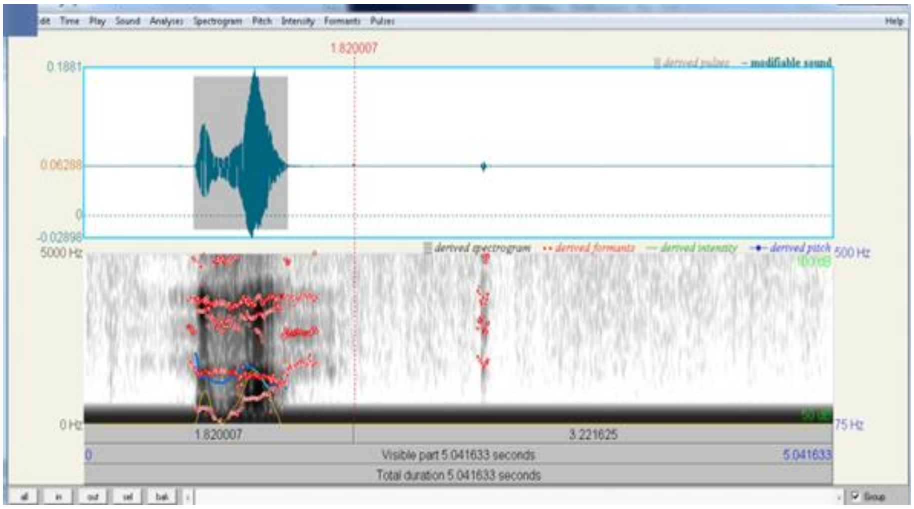

Figure (4) the spectrograph of the Kurdish voiced sound[ʔ]

3. Methodology
3.1 Participants

Seven patients diagnosed with vocal cord dysfunction (VCD) by two ENT specialists, aged between 15 and 30 years, voluntarily participated in the study. The first participant was a 17-year-old female whose VCD was caused by asthma. The second participant was a 20-year-old woman with noncancerous vocal cord cysts that disrupted her vocal cord function. The third participant was a 26-year-old male whose vocal cord dysfunction was attributed to gastroesophageal reflux disease (GERD), as diagnosed by an ENT specialist. The fourth participant was a 19-year-old female suffering from laryngitis. The fifth and sixth participants were males aged 22 and 30, respectively, diagnosed with vocal cord nodules and polyps. The final participant was a 19-year-old male whose vocal cord dysfunction was associated with emotional stress. Seven patients diagnosed with vocal cord dysfunction (VCD) by two ENT specialists, aged between 15 and 30 years, voluntarily participated in the study. The first participant was a 17-year-old female whose VCD was caused by asthma. The second participant was a 20-year-old woman with noncancerous vocal cord cysts that disrupted her vocal cord function. The third participant was a 26-year-old male whose vocal cord dysfunction was attributed to gastroesophageal reflux disease (GERD), as diagnosed by an ENT specialist. The fourth participant was a 19-year-old female suffering from laryngitis. The fifth and sixth participants were males aged 22 and 30, respectively, diagnosed with vocal cord nodules and polyps. The final participant was a 19-year-old male whose vocal cord dysfunction was associated with emotional stress.

3.2 Materials

To data collect data, 13 voiced sounds ([b], [d], [ð], [v], [ʒ], [g], [ʡ], [z], [l], [m], [n], [ʤ], [r]) were evaluated from the participants' token records with the exception of the voiced nasal sound [ŋ] which does not is not occur in Kurdish language. Furthermore, the two English semi- consonants were also omitted because they are considered as vowel sounds in Kurdish Language. The study also includes the Kurdish voiced consonant [ʡ], which has no counterpart in English sound system. Each sound segment was recorded in isolation as well as in simple syllable CV in conversational settings to collect clear speaking styles for evaluation. The structure of the selected syllable was short zero coda syllables (ba, da, tha .va, cha, ga, ma, na, la, ra, zha, gha, and za). This structure of syllable was selected to assist the researcher to have simple clear record and to assure the existence of VOT in the participants' token records.

3.3 The tool and Procedures

Content analysis was employed to analyze the participants' audio recordings. According to Lie Lu et al. (2002), "audio classification and segmentation can provide useful information for both audio content understanding and video content analysis" (p. 504).

Recruiting patients with VCD presented significant challenges. The researcher collaborated with two ENT specialists to examine participants' vocal cords and confirm their diagnoses. Following diagnosis, the researcher explained the purpose and procedures of the study to the participants. Upon obtaining their informed consent, the data collection process commenced.

Recordings were conducted digitally in a private room at a hospital under controlled conditions. The room measured 3 × 3 feet and was lined with sound-insulating and echo-proof materials. A 128GB voice recorder with noise reduction capabilities was used to capture audio at a 44.1 kHz sampling rate. The microphone was positioned 15–20 cm from the participants' mouths to ensure clear recordings. Each recording session lasted 15–20 minutes, with a 5-minute break halfway through.

The recorded audio data were analyzed using Praat software (version 6.3), which provided detailed insights into the participants' vocal characteristics.

3.4 Ethical Considerations

To maintain confidentiality, the researcher prepared a written consent form for all participants. The form specified that personal information would remain confidential and accessible only to the researcher. It also outlined that any breach of confidentiality or deviation from the agreed terms would be the responsibility of the researcher.

4.0 Results and Discussion

4.1 Results

To address the research questions and achieve the objectives of examining the effects of vocal cord problems on the pronunciation of resonant sounds and identifying which sounds are most affected by vocal cord dysfunction, the researcher employed audio content analysis. Participants' audio recordings were analyzed using the Praat software.

Case 1: The analysis of the audio recordings of a 17-year-old female participant suffering from asthma revealed significant effects of her chronic lung disease on her vocal cords. Comparisons with the vocal sound features of healthy individuals, as outlined in Chapter 2, showed that inflammation and congestion in her vocal cords impaired her ability to produce voiced sounds. The inefficiency of her vocal cords, exacerbated by throat soreness, resulted in difficulty pronouncing resonant sounds properly and extended the duration of sound production, as detailed in Table 1 (e.g., 3.00, 3.04, 2.89, 3.06, 2.17, 3.10 seconds). The frequency (F0) variability of her voiced sounds ranged between 3 kHz and 7.3 kHz, while the intensity of her voice was lower than the acceptable pitch levels, as shown in Table 1 (e.g., 50.5 dB to 68 dB). These variations made her voice resemble non-resonant sounds more closely. Additionally, the voice onset time (VOT) for plosive and affricate sounds was shorter than that of a healthy individual, with coarse sound quality observed (e.g., 17 ms to 27 ms).

Case 2: The spectral analysis of a 20-year-old female participant with non-cancerous vocal cord cysts revealed that her vocal cord disorder impacted her pronunciation of voiced sounds. Although the time required for sound production was comparable to that of a healthy individual (e.g., 3.10, 3.29, 2.65, 2.29 seconds as shown in Table 1), significant differences were observed in intensity, loudness variation, and VOT. Her pitch intensity ranged from 45 dB to 62.4 dB, lower than that of a healthy speaker, while the frequency variability (F0) was reduced, ranging from 2 kHz to 5.5 kHz. The VOT for voiced plosives [b], [d], and [g] was longer than expected for a healthy individual (e.g., 27 ms, 36 ms, 20 ms), as shown in Table 1.

Case 3: The third participant, a 26-year-old male, suffered from vocal cord dysfunction caused by gastroesophageal reflux disease (GERD), leading to inflammation along the edges of his vocal cords. This resulted in changes in vocal quality, irregular vocal cord vibrations, and abnormalities in sound production. The participant's recordings exhibited low intensity and abnormal pitch variations for his age, with values ranging from 54.3 dB to 80.3 dB, as shown in Table 1. The frequency variability was notably irregular, ranging from 2 kHz to 6.5 kHz. Additionally, the time required to produce sounds was reduced (e.g., 2.89, 2.93, 3.22 seconds), and the VOT for voiced sounds, particularly [b], [d], [g], and [ʔ], was significantly shorter compared to that of a healthy individual (e.g., 18 ms, 30.1 ms, 14 ms). These findings indicated that GERD had a significant impact on vocal sound production and quality.

Table(1) The spectral analysis of kurdish young childern with vocal cord dysfunction

Sound features	Sounds	Case 1 A	Case 2 B	Case 3 C
VOT	[b]	17ms	27 ms	18ms
	[d]	27ms	36ms	29ms
	[g]	16ms	20 ms	19ms
	[ð]	15ms	17ms	17ms
	[ʤ]	27ms	32.3ms	30.1ms
	[ʒ]	15ms	19 ms	16.7ms
	[z]	15ms	18.2ms	16.9ms
	[m]	11ms	16.9ms	14ms
	[n]	11.3ms	15ms	13.6ms
	[l]	14.2ms	19.2ms	10.5ms
	[r]	9.1m2	13.3.2ms	10ms
	[v]	13ms	14.4ms	18.7ms
	[ʔ]	19ms	17.5ms	21ms
Sound duration	[b]	3.00seconds	3.10seconds	2.89 seconds
	[d]	3.04 seconds	3.09 seconds	2.93 seconds
	[g]	2.89seconds	3.29 seconds	3.22 seconds
	[ð]	3.06 seconds	3.41 seconds	3.24 seconds
	[ʤ]	2.17seconds	2.65seconds	2.35 seconds
	[ʒ]	3.1 seconds	3.09 seconds	3.oo seconds
	[z]	3.01seconds	3.06 seconds	2.84 seconds
	[m]	2.18 seconds	2.69 seconds	2.43 seconds
	[n]	2.09 second	2.29 second	2.13 seconds
	[l]	2.24 seconds	2.67 seconds	2.61 seconds
	[r]	2.13 seconds	2.88 seconds	2.84 seconds
	[v]	2.14seconds	2.39seconds	2.12 seconds
	[ʔ]	3.55secon	3.35 seconds	3 seconds
Frequency (*F)KHZ*	[b]	5 kHz	3.9-4 kHz	5kHz
	[d]	3-3.5 kHz	2.7-3 kHz	5.5kHz
	[g]	3.8 kHz	3.2 -3.5kHz	4-4.5 kHz
	[ð]	4.5-5.5 kHz	4-4.5.5kHz	5 kHz
	[ʤ]	6-7 kHz	5.5 kHz	5.5-6 kHz
	[ʒ]	3-3.5 kHz	2.5-3 kHz	3.5 kHz
	[z]	3-3.5 kHz	3 kHz	5.6 kHz
	[m]	2-3 kHz	2 kHz	2 kHz
	[n]	2-2.9 kHz	2,5 kHz	2.5 kHz

	[l] [r] [v] [ʔ]	3-4 kHz 2.8 kHz 6-7.3 kHz 6.5 kHz	2.8-3.2kHz 2 kHz 5.5-6kHz 5.5 kHz	3 kHz 2.4 kHz 6.5 kHz 6 kHz
Amplitude dB	[b] [d] [g] [ð] [ʤ] [ʒ] [z] [m] [n] [l] [r] [v] [ʔ]	50.5dB 54.2dB 48.1dB 68dB 53.1dB 65.9dB 62.6dB 50dB, 50.01dB 50.o2dB 56.5 dB 51.8 dB 63 dB	50dB 55.2dB 45dB 61 dB 49-3dB 62.4 dB 58.6 dB 57dB 49dB 58.9 dB 55 dB 48.8 dB 59.5 dB	54.3dB 64.5dB 57.6 dB 80.3 dB 59.3 dB 69.6 dB 60.8 dB 55 dB 58.4dB 55.5dB 68.5 dB 57.3 dB d 61.3dB

Case 4: The fourth patient presented with vocal cord dysfunction caused by inflamed and irritated nodes in the glottal area, a condition clinically known as laryngitis. Spectrographic analysis of her voiced sound recordings revealed a significant loss of qualities essential for proper resonant sound production, including accurate pronunciation, vocal frequency, sound duration, stress, and vocal tone, as illustrated in Table 2. The analysis indicated an increase in the fundamental frequency (F0) measurements, ranging from 3 kHz to 8 kHz (e.g., 6–6.5 kHz, 4.5 kHz, 7 kHz, and 7.5–8 kHz). Similarly, pitch intensity measurements were elevated, ranging from 50.01 dB to 78 dB. Conversely, the duration of voiced sounds was reduced, as shown by the acoustic analysis, with values ranging from 2.19 seconds to 12.7 seconds. Reductions were also observed in the voice onset time (VOT) for plosive and affricate voiced consonants, ranging from 16.5 ms to 31 ms (see Table 2).

Cases 5 and 6: The fifth and sixth cases involved patients suffering from vocal cord dysfunction caused by nodules and polyps, respectively. Although the conditions in both cases were similar, the acoustic analysis indicated that the fifth case, involving vocal cord nodules on both sides, exhibited greater impairment in the pronunciation of voiced sounds compared to the sixth case.

For Case 5, acoustic parameters showed that the presence of nodules significantly impacted vocal pitch and intensity, with consistently low intensity levels (e.g., 48.2 dB, 47 dB, 66.3 dB) and reduced durations of sustained voiced sounds (e.g., 3.3 seconds, 2.34 seconds, 2.11 seconds). The fundamental frequency (F0) ranged from 2.7 kHz to 7.5 kHz, with notable irregularities in pitch. Additionally, the VOT preceding voiced and affricate sounds was reduced, ranging from 15.8 ms to 28.5 ms, as shown in Table 2.

For Case 6, which involved vocal cord polyps, the results demonstrated relatively less impact on vocal parameters compared to Case 5. The variation in pitch intensity ranged from 48.5 dB to 69 dB, and the F0 measurements ranged from 3 kHz to 7.9 kHz. However, similar to Case 5, the durations of voiced sounds were shortened (e.g., 3.08 seconds, 2.33 seconds, 2.40 seconds), and the VOT for voiced and affricate consonants ranged from 19.1 ms to 29.9 ms, as detailed in Table 2.

These findings highlight the differing impacts of vocal cord nodules and polyps on vocal sound production, with nodules having a more pronounced effect on acoustic parameters**.**

Table(2) spectral analysis of kurdish young childern with deep-bite malocclusion

Sound features	**Sounds**	**Case 4**	**Case 5**	**Case 6**	**Case 7**
VOT	[b]	22 ms	21 ms	22ms	23.1 ms
	[d]	31ms	28.5 ms	28.8 ms	32.1 ms
	[g]	16.5ms	15.8 ms	19.1 ms	20.5 ms
	[ð]	16ms	14.5 ms	16.3.5ms	17.35ms
	[ʤ]	29ms	28.2 ms	29.9 ms	32 ms
	[ʒ]	17.6ms	17.2 ms	16.8 ms	17.4 ms
	[z]	15.8ms	15ms	16 ms	17.8 ms
	[m]	15ms	13.7 ms	14.4 ms	14.8 ms
	[n]	14.9ms	14.8 ms	15 ms	15 ms
	[l]	14ms	13.3 ms	14 ms	113.5 ms
	[r]	10.5ms	10 ms	10 .5 ms	10 ms
	[v]	12ms	11.9ms	12 .2 ms	12 .6 ms
	[ʕ]	23.7ms	20.6ms	22 ms	27.3 ms

Sound duration	[b] [d] [g] [ð] [ʤ] [ʒ] [z] [m] [n] [l] [r] [v] [ʔ]	12.7 seconds 5.43 seconds 2.28 sconds 3.20secnds 3.12 seconds 2.55seconds 3.03 seconds 2.38 seconds 2.50 seconds 2.19 seconds 2.55 seconds 2.30 second 3.57 seconds	3.03 seconds 4.50 seconds 3.12 seconds 2.36 seconds 2.11 seconds 2.57 seconds 2.55 seconds 2.30 seconds 2.15 seconds 2.01 seconds 2.48 seconds 2.11 seconds 3.44 seconds	3.08 seconds 5.10 seconds 3.18 seconds 3.20 seconds 2.33 seconds 3.01 seconds 2.48 seconds 2.40 seconds 2.52 seconds 2.55 seconds 2.57 seconds 2.14 seconds 3.58 seconds	3.57 seconds 5.49 seconds 3.31 seconds 3.29 seconds 2.40 seconds 3.09 seconds 3.00 seconds 2.53seconds 2.20 seconds 2.59 seconds 2.57 seconds 2.20 seconds 2.59 seconds
Frequency (*F*)*KHZ*	[b] [d] [g] [ð] [ʤ] [ʒ] [z] [m] [n] [l] [r] [v] [ʔ]	6-6.5Khz 6 kHz 4.5 kHz 6-6.5.5kHz 7 kHz 4 kHz 3.5-4 kHz 3-3.5 kHz 3-3.5 kHz 4.2 kHz 7.5-8 kHz .5-4 3kHz 6- 6.5 kHz	6.5 kHz 5 kHz 7.5 kHz 3.5 - 4.5kHz 3.5 kHz 3.5-4 kHz 4 kHz 2.7 kHz 3.5 kHz 3.8 kHz 7 kHz 6 kHz 6.4 kHz	6.8 kHz 5.5 kHz 7.9 kHz 4.5 kHz 4. kHz 4 kHz 4.5 kHz 3 kHz 3.8-4 kHz 4 kH 4.8 kHz 7.5 kHz 6.4 kHz	5.8 kHz 5.5 kHz 6 kHz 5.9 kHz 5.5 kHz 5.3 kHz 5.5 kHz 4.8 kHz 3.8-4 kHz 4.6 kHz 6 kHz 5 kHz 5.8 kHz
Amplitude dB	[b] [d] [g] [ð] [ʤ] [ʒ]	55.5dB 60dB 54dB 78 dB 62.5dB 67.8 dB 61 dB	48.2 dB 51.5dB 47 dB 66.3 dB 52.8dB 62 dB 53.3 dB	50 dB 53.5 dB 48.5 dB 69 dB 53.6dB 53.9 dB 54 dB	52 dB 56.3 dB 50..5 dB 73 dB 54.1 dB 56.5 dB 56 dB

	[z]	50.0dB	46.6 dB	49.9 dB	51 dB
	[m]	50.2dB	53 dB	54.3 dB	54.5 dB
	[n]	60 dB	48.2 dB	49 dB	50.6 dB
	[l]	56.5dB	59.5 dB	60.1 dB	61.4 dB
	[r]	51.8 dB	48.6 dB	49.2 dB	50 dB
	[v]	64.1 dB	62.5 dB	64 dB	64.4 dB
	[ʔ]				

Case 7: The seventh and final case involves a patient whose voice disorders were due to emotional stress and depression. According to the results of the patient's voice analysis, emotional stress led to stiffness and tension in laryngeal muscles, voice hoarseness, and dysphonia, which in turn affected the quality of patient's voiced sounds. The acoustic analysis of his tokens showed that his voiced sounds lost their vocal vibration and turned into devoiced sounds compared to the sounds produced by person with heathy voice. The acoustic analyses indicated noticeable statistical differences in the fundamental frequencies, sound duration and pitch variation between the patient's voiced sound productions and those of a person with normal vocal cords. The results showed a high tendency in the patient sound frequencies of voiced sounds (5.8 KHz, 5.5 kHz, 6 kHz, 5.9 kHz, and 5.5 kHz, 5.3 kHz. 5.5 kHz, 4.8 kHz, 3.8-4 kHz, 4.6 kHz, 6 kHz, 5 kHz, and 5.8 kHz). Additionally, the pitch variations were low based on shimmer parameter (52 dB, 56.3 dB, 50.5 dB, 73 dB, 54.1 dB, 56.5 dB, 56 dB, 51 dB, 54.5 dB, 50.6 dB, 61.4 dB, 50 dB, and 64.4 dB). Furthermore, he spent fewer time than usual producing the target sounds production (3.57 seconds, 5.49 seconds, 3.31 seconds, 3.29 seconds, 2.40 seconds, 3.09 seconds, 3.00 seconds, 2.53seconds, 2.20 seconds, 2.59 seconds, 2.57 seconds,2.20 seconds, and 2.59 seconds). The VOT of the plosive and affricate sounds also decreased (23.1 ms, 32.1 ms, 20.5 ms, 32 ms, and 27.3).

The analysis of the mean values and the overall average of the acoustic sound features across the cases demonstrate how significantly vocal cords disorders affect the production of the voiced sound features. Additionally, the data in Table 3 provides clear indication of the case most affected by vocal cord dysfunction, based on the investigated acoustic features. The overall average for measuring the time before the production of the plosive and affricate voiced sounds, the results indicate that case1shortend The VOTs to 17.36 ms. For sounds that take longer duration to pronounce, case 4 shows the longest duration (3.01 seconds). The mean value in the below table also shows increased pitch frequencies in case 4(5.15 kHz), indicating that the dysfunction in her vocal cords causes increased tension in the laryngeal area compared other cases. The mean value of the recorded sounds intensities demonstrates that case 4 (60.98 dB) has inconsistent voice quality with reduction resonance.

Table (3) mean values and the total means of the sound acoustic features

	Participants							
Sound features	Case1 Mean	Case2 Mean	Case 3 Mean	Case 4 Mean	Case 5 Mean	Case 6 Mean	Case 7 Mean	Total Mean
VOT	17.36	24.03	18.33	20.42	19.70	22.01	23.18	20.13
Voiced sound duration	2.54	2.89	2.73	3.01	2.56	2.80	2.88	2.84
Pitch	4.33	4.42	4.37	5.15	4.27	5.07	4.76	4.51
Intensity	57.03	55.59	62.32	60.98	57.11	55.62	62.02	58.68

4.2 Discussion

The analysis of sound recordings indicates that the seven participants, all diagnosed with vocal cord dysfunction stemming from various illnesses, exhibited impaired production of voiced sounds, with the severity of the impairment varying among cases. This provides an answer to the first question that was previously posed, which asks whether there is a relationship between the vocal cords' dysfunctions and the pronunciation of voiced sounds. The results of the acoustic analysis confirm that the dysfunction of the vocal cords negatively affects the pronunciation of voiced sounds. To obtain the answer to the first question, the researcher selected purposive sample in consultation with two specialists in ENT. After recording participants' token, they were analyzed via using the Jitter and Shimmer criteria in the Praat software. This analysis aimed to determine how the voiced sounds' characteristics might be affected, including frequency, intensity, pitch, and sound's duration to producing the target sounds individually and within short syllables.

The results demonstrated that the speed rate of the voice, vocal repetition, softness, and the duration of extracting letters were affected by vocal cord dysfunction. Moreover, the results revealed that the pronunciation of the voiced sounds, particularly, in the fourth case, who suffered from inflammation and irritation Maghreb nodes in the glottal area in both sides of the vocal cords, was more significantly influenced compared to the other six cases, and this was likely due to the irritations which have an insight effect on acoustic voice characteristic. Spectral sound analyses of her voice showed hoarseness in her voice and produced undetectable sounds.

The results of the sound wave analysis, also, confirmed that the thirteen resonant voiced sounds lost their voiced quality and became weak voice or devoiced when pronounced by the participants, due to their vocal cord dysfunctions, especially the velar sounds [g] and [ʔ]. The sound features of these two sounds, as it is seen in the in pitch and intensity analysis, were closer to the features of the sound [k] and [x].

Conclusions

It is concluded from this study the following points:

1. There are several diseases that negatively affect the function of the vocal cords and thus affect the correct pronunciation of the voiced sounds, especially resonant sounds.
2. The vocal cords dysfunction, regardless of the type of disease that causes this problem, affects the correct pronunciation of voiced sounds but to different degrees.
3. Also, based on the phonetic analysis of voiced sounds' production, the patients who suffer from problems in the function of the vocal cords have negatively affected the duration of extraction and pronunciation of sounds, vocal frequency, as well as sounds 'pitch and intensity, in addition to the VOT of sounds.
4. By comparing the causes of the disease that led to vocal cords dysfunctions, the patients who suffered from the inflamed and irritated Maghreb nodes in the glottal area and on the vocal cords' edges, which causes the vocal cords dysfunction, had a more affected pronunciation of voiced sounds compared to other patients.
5. To find out which of the thirteen resonant sounds is more affected by vocal cord damage, a phonetic analysis of the different sounds in the seven patients showed that the pronunciation of the sounds velar stop voiced sound [g], [ʔ] and the sounds African voiced sound [ʤ]were more affected by this problem compared to the other sounds.

References

- Ali et al (2013) Phonetics, Dihoh, Nalband Publishing Ltd.
- Asadpour,H. and Mohammadi,M. {2014), "A comparative study of phonological system of Kurdish varieties. *Journal of Language and Cultural Education, 2(3). pp,104-119,* ISSN 1339-4045 (print), Slovak Edu
- Behrens, S. J., and Blumstein, S. E. (1988). "Acoustic characteristics of English voiceless fricatives: Descriptive analysis," J. Phonetics16, 295–298.
- Boersma, P., and Weenink, D. (2000). "Praat, a system for doing phonetics by computer, version 4.406," Institute of Phonetic Sciences, University of Amsterdam, available at http://www.fon.hum.uva.nl/praat/
- Chen, F. R.(1980) "Acoustic characteristics and intelligibility of clear and conversational speech at the segmental level," MS thesis, Massachusetts Institute of Technology, Cambridge, MA
- Dunn et al. (2015) Vocal cord dysfunction: A review. *Asthma Research and Practice*, vol 9 (1), pp2-8. https://doi.org/10.1007/springer_crossmark_policy

- Goldberg BJ, Kaplan MS. Non-asthmatic respiratory symptomatology. Curr Opin Pulm Med 2000; 6: 26–30.
- Lie Lun et a l (2002) Content Analysis for Audio Classification and Segmentation. IEEE TRANSACTIONS ON SPEECH AND AUDIO PROCESSING, VOL. 10(7). Pp 504-5-5
- Johnson, K. (2003). Acoustic and Auditory Phonetics. Blackwell Publishing Ltd.
- Kamil, W.A. and Salih S.F (2023) Voice onset time of plosive consonants in initial position in badidni dialect *Humanities Journal of University of Zakho* (HJUOZ)Vol. 11, No. 2, pp. 469–490.
- Kenn K, and Balkissoon,. R.(2011) Vocal cord dysfunction: what do we know? *European Respiratory Journal* .Vol 37(1). PP, 194–2011
- Kenn K, Hess M. (2004) Vocal cord dysfunction– a purely pneumological disease *HNO* journal vol. 52, pp. 103–109
- Morris MJ, Allan PF, Perkins PJ. Vocal cord dysfunction: aetiologies and treatment. Clin Pulm Med 2006; 13: 73–86
- Nissen, S. L., and Fox, R. A.(2005). “Acoustic and spectral characteristics of young children’s fricative productions:Adevelopmental perspective,” J. Acoust. Soc. Am.118, 2570–2578.
- Ohala, J. J.(1994). “Acoustic study of clear speech:Atest of the contrastive hypothesis,” Proceedings of the International Symposium on Prosody, Pacific Convention Plaza Yokohama, Japan, pp. 75–89..
- Parnell FW, Brandenburg JH. Vocal cord paralysis. A review of 100 cases. Laryngoscope 1970; 80: 1036–1045.
- Tilles SA. Vocal cord dysfunction in children and adolescents. Curr Allergy Asthma Rep 2003; 3: 467–472. 35