Kulak Burun Boğaz ve Baş Boyun Cerrahisi Dergisi
*Journal of Ear Nose Throat and Head Neck Surgery*

ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

DOI: 10.24179/kbbbbc.2023-99536

# Investigation of Voice Change in Stroke Individuals in the Subacute Period Compared to the Acute Period

## İnme Geçiren Bireylerin Subakut Dönemde Akut Döneme Göre Ses Değişiminin İncelenmesi

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**ABSTRACT Objective:** The aim of this study was to compare the results of voice assessment in stroke survivors with the results of voice assessment in the subacute period and to examine spontaneous voice changes. **Material and Methods:** The study was carried out with 37 (22 males, 15 females) individuals with a mean age of 66,65±9,63 years. Acoustic and aerodynamic voice assessments [maximum phonation time (MPT) and s/z ratio] were performed. Voice Handicap Index-10 (VHI-10), and Voice-Related Quality of Life (V-RQOL) were applied. All assessments were performed within 1 week and 1 month after the stroke. **Results:** MPT was 6.279±3.544 in the acute period and 7.461±4.875 in the subacute period. There was no statistically significant difference in aerodynamic measurement results or V-ROQL in the subacute period compared to the acute period (p>0.05). The fundamental frequency value increased statistically significantly in women, men, and all participants. VHI-10 decreased statistically significantly (p<0.05) in all participants. **Conclusion:** To the best of our knowledge, this is the first study to evaluate the voice of stroke patients in the acute phase using both subjective and objective methods. It was found that the MPT of stroke patients was limited, and the Shimmer values of acoustic parameters were above normal limits. In the subacute phase, it was observed that phonation durations were still low and Shimmer values tended to increase. Therefore, acoustic, aerodynamic, and specific voice evaluations, especially maximum phonation durations, should be performed in stroke patients in the acute period.

**Keywords:** Stroke; voice; quality of life; voice disorders

**ÖZET Amaç:** Bu çalışmanın amacı, inme geçiren hastalarda ses değerlendirme sonuçlarını subakut dönemdeki ses değerlendirme sonuçları ile karşılaştırmak ve spontan ses değişikliklerini incelemektir. **Gereç ve Yöntemler:** Çalışma yaş ortalaması 66,65±9,63 yıl olan 37 (22 erkek, 15 kadın) birey ile gerçekleştirildi. Akustik ve aerodinamik ses değerlendirmeleri [maksimum fonasyon süresi (MFS) ve s/z oranı] yapıldı. Ses Handikap İndeksi-10 [Voice Handicap Index-10 (VHI-10)] ve Sesle İlgili Yaşam Kalitesi Ölçeği (SİYKÖ) uygulandı. Tüm değerlendirmeler hastalar inme geçirdikten 1 hafta içinde ve 1 ay sonraki dönemde tekrar yapıldı. **Bulgular:** MFS akut dönemde 6,279±3,544 ve subakut dönemde 7,461±4,875 idi. Akut döneme kıyasla subakut dönemde aerodinamik ölçüm sonuçlarında veya SİYKÖ'de istatistiksel olarak anlamlı bir fark yoktu (p>0,05). Temel frekans değeri kadınlarda, erkeklerde ve tüm katılımcılarda istatistiksel olarak anlamlı şekilde arttı. Tüm katılımcılarda VHI-10 istatistiksel olarak anlamlı şekilde azaldı (p<0,05). **Sonuç:** Bildiğimiz kadarıyla bu çalışma, akut fazda inme hastalarının sesini hem subjektif hem de objektif yöntemler kullanarak değerlendiren ilk çalışmadır. İnme hastalarının maksimum fonasyon süresinin sınırlı olduğu ve akustik parametrelerin Shimmer değerlerinin normal sınırların üzerinde olduğu bulunmuştur. Subakut fazda ise fonasyon sürelerinin hâlâ düşük olduğu ve Shimmer değerlerinin artma eğiliminde olduğu görülmüştür. Bu nedenle akut dönemde, inme hastalarında başta maksimum fonasyon süreleri olmak üzere akustik, aerodinamik ve spesifik ses değerlendirmeleri yapılmalıdır.

**Anahtar Kelimeler:** İnme; ses; yaşam kalitesi; ses bozuklukları

**TO CITE THIS ARTICLE:**
Parlak MM, Saylam G, Bizpınar Munis Ö, Alıcura Tokgöz S. Investigation of Voice Change in Stroke Individuals in the Subacute Period According to the Acute Period. Journal of Ear Nose Throat and Head Neck Surgery. 2023;31(4):213-22.

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Peer review under responsibility of Journal of Ear Nose Throat and Head Neck Surgery.

***Received:*** 18 Sep 2023 ***Received in revised form:*** 28 Sep 2023 ***Accepted:*** 02 Oct 2023 ***Available online:*** 06 Oct 2023

Acute cerebrovascular accident (CVA), or stroke, is a medical emergency that is the third leading cause of disability worldwide and the 2nd leading cause of death. It is also the most common cause of long-term disability in adults. It is a socio-economic health problem that has significant effects on the patient and his/her family and has an important place in hospital admissions and health expenditures.[1-3]

Individuals with stroke often have more than one comorbidity and may be accompanied by feeding and swallowing difficulties.[4,5] One of the complications that may develop in individuals with stroke is communication problems. Communication, which is a necessity in the life of a healthy individual, is a very important activity in cases of adaptation to a new situation and a new environment. Stroke is a problem that can directly affect communication skills. Abnormal mouth, tongue, or lip movements and weak, slow, and uncoordinated speech symptoms may increase verbal communication problems. In these individuals, aphasia, dysarthria, dysphonia, and aphonia may develop depending on the region and severity of the cerebrovascular event.[6,7] Dysphonia refers to voice disorders such as hoarseness, weakness, or fatigue.[8] Although changes in voice quality are reported in both bilateral and unilateral lesions, some prosodic elements may be more impaired in left-sided lesions.[9] However, clinical observations and patient and relative reports suggest that stroke patients with aphasia may experience altered voice quality or even a complete loss of ability in voice production.[10-12]

The human voice is a complex mechanism that enables individuals to express various emotions and feelings through verbal communication. The voice is produced by a complex sequence of respiration, vocal fold movement, voice shaping, and articulation involving multiple cranial nerves. The respiratory system provides cephalad airflow across the vocal folds, converting aerodynamic energy into acoustic energy. The vocal folds form the vocal voices, and speech becomes more refined as air flows outward through the lips, tongue, and velum articulators.[5] Voice and associated speech changes in CVA are complex and largely dependent on the location of the cerebral event, especially in subcortical, upper motor neuron, pons, and cerebellar lesions; vocal fold function may also be impaired.[5,13,14] According to one study, vocal fold paresis is reported to occur in approximately 20% of stroke patients.[14,15]

Changes in voice quality, similar to other functional impairments caused by the neurological involvement of oropharyngeal muscles, can have a significant impact on the quality of life of stroke patients.[16] Objective methods that provide a measurable criterion are used to assess the voice.[17] However, the degree of speech problems can vary greatly from the patient's perspective and is influenced by individual circumstances such as occupation and social activities.[18] Self-measurement of the biopsychosocial impact of voice problems is essential for monitoring therapy effectiveness when assessing and treating patients with voice problems.[19] Although formal assessments have been made for motor speech and language problems in stroke patients, little attention has been paid to whether neurological involvement of laryngeal structures can cause voice problems and affect their quality of life, but the voice is important for recovery and reintegration into society.[16,20,21]

The post-stroke recovery framework defines 1-7 days from stroke onset as the acute phase and 7 days to 3 months as the early subacute stroke phase.[20] The fastest spontaneous recovery in stroke patients occurs in the first 3 months after stroke.[22,23] However, there are no studies that examine both objectively and subjectively the voice change due to spontaneous recovery in the subacute period compared to the acute period. Besides, it is not clearly known how acoustic and aerodynamic changes occur in the voice during these periods. Examination of voice change, which is necessary and important for effective communication; determination of spontaneous recovery; and early initiation of therapy for features that do not improve may increase the speed of therapy. In addition, early recovery indicates a better prognosis.[24] Therefore, in this study, it was aimed to compare the results of voice evaluation in individuals with acute stroke 0-7 days after stroke with the results of voice evaluation in the subacute period at 1 month and to examine the spontaneous changes related to voice.

## MATERIAL AND METHODS

This study was conducted in collaboration with the Ear, Nose, and Throat Clinic and Neurology Clinic with the ethical approval number 139/40 and ethical date June 6, 2022 obtained from the Ethics Committee of Health Sciences Dışkapı Training and Research Hospital Clinical Researches. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Before the recruitment, written informed consent was obtained from each participant.

### PARTICIPANTS

The inclusion criteria were 0-7 days since the stroke, volunteering to participate in the study, being able to phonate the vocal /a/ for 3 s, and having a cognitive level above 23 points according to the standardized Mini-Mental State Examination (MMSE) results. Those who did not volunteer to participate in the study due to having aphasia or having a disease or operation that may affect the voice between the 2 measurement periods (coronavirus disease-2019, flu infection, etc.) were excluded from the study.

A total of 58 (36 males, 22 females) stroke survivors with a mean age of 66.48±10.28 years were hospitalized at the neurology clinic. Of these individuals, 8 were excluded from the study because they had aphasia, 5 because their MMSE test result was below 23, and 8 because they did not want to participate in the second evaluation. Finally, the study was carried out with 37 (22 males, 15 females) individuals with a mean age of 66.65±9.63 years who underwent acute and subacute measurements.

### PROCEDURE

Data were collected in patients' rooms on the neurology inpatient floor. In order to prevent ambient noise during the voice analysis, windows and doors were closed, and the quietest possible environment was used. To calculate the ambient noise level of the environment, the dB level was determined to be 25 or below with the Praat (version 5.1.37, Paul Boersma and David Weenink, University of Amsterdam, Amsterdam,The Netherlands). Voice recordings were made while the patients were sitting or lying with their heads upright and their feet extended on the bed. Firstly, voice recordings were taken, and then aerodynamic measurements were made. Finally, the Voice Handicap Index-10 (VHI-10) and Voice-Related Quality of Life (V-RQOL) were evaluated. All assessments were performed within 1 week and 1 month after the stroke. The results of the first assessment were compared with the results of the second assessment 1 month later.

### AERODYNAMIC ASSESSMENT

Maximum phonation time (MPT) and s/z ratios were determined for the aerodynamic evaluation of the participants. The patients were asked to exhale in a smooth and comfortable posture with feet together, hips and shoulders symmetrical, ears at shoulder level, and the /a/ voice after maximum inspiration. This time was recorded as the MPT value of the patient as numerical data in seconds with a stopwatch. The best scores of the patients who repeated this procedure 3 times were evaluated. In order to determine the s/z ratio, the patients were asked to expire with /s/ and /z/ consonants after deep inspiration. The ratios of the /s/ and /z/ consonants whose durations were measured with a stopwatch were determined.

### ACOUSTIC VOICE ANALYSIS

Kilic et al. in a 2006 study, investigated the effect of ambient noise on perturbation analysis using three different analysis programs, Praat, methylenedioxypyrovalerone (MDVP), and Dr. Speech, and found that Praat was less affected by ambient noise than MDVP and Dr. Speech.[25] For this reason, the Praat program (version 5.1.37, Boersma & Weenink 2010), which is one of the objective methods in voice analysis, was used in our study.

The program was applied to an Asus laptop computer (China) with a Windows 10 Education processor. During the recording, a Shure MVI audio (Shure Inc., Niles, IL, USA) interface and a Shure SM48 microphone (Shure Inc., Niles, IL, USA) were used. In voice analysis, the recordings were taken by asking the patients to phonate the /a/ vocal for 3 s

after taking a deep breath. The distance between the patient and the microphone was set to 15 cm during voice recordings. In the voice analysis, the main voice parameters were analyzed: frequency (F0), Jitter (local), Jitter (rap), Shimmer (local), Shimmer (dB), and harmonic noise ratio (HNR).

### SUBJECTIVE VOICE ASSESSMENT

All patients were administered the VHI-10 and V-RQOL scales before and after therapy. The questions were read and filled in by the speech and language therapist. The validity and reliability study of the Turkish version of the VHI-10, shortened by Rosen et al., was conducted by Kılıç et al. in 2008. Each voice-related item is given a score between 0 and 4. The higher the total score, the higher the likelihood of having voice-related problems.[26,27]

### STATISTICAL ANALYSIS

The data to be obtained was analyzed with the SPSS 22 package program (IBM Corp., Armonk, NY, USA). For descriptive analyses, categorical variables were evaluated as number and percentage, normally distributed numerical variables were evaluated as mean and standard deviation, and non-normally distributed numerical variables were evaluated as median (minimum-maximum). The suitability of the data for a normal distribution was analyzed by Shapiro-Wilk. The Wilcoxon signed rank test and paired samples t-test were used for the comparison of repeated measurements (pre-test and post-test). The statistical significance level was accepted as $p<0.05$.

## RESULTS

Of the 58 people hospitalized in the neurology clinic within one month, 15 had a previous history of stroke. Of all the participants, 36 smoked and 14 drank alcohol. The maximal MPT was 6.432±4.54 and the s/z ratio was 1.318±1.682 (Table 1).

The mean age of the women (n=15) who were evaluated in both acute and subacute periods was 66.27±10.42 years and 66.91±9.30

years for men (n=22). A history of previous stroke was present in 40% of women and 27.3% of men. 33% of women and 72.7% of men had ever smoked (Table 2).

**TABLE 1:** Characteristics of the participants evaluated in the acute period and the results of the evaluation.

| | All participants (n=58) | |
|---|---|---|
| Age ($\bar{X}$±SD) year | | 66.48±10.28 |
| Gender | Male | 36 |
| | Female | 22 |
| Education years ($\bar{X}$±SD) | 6.172±3.867 | |
| Smoking status (n) | Never smoked | 22 |
| | Smoked or smokes | 36 |
| Alcohol use (n) | Never used | 44 |
| | Has used or is using | 14 |
| Presence of a previous | Yes | 15 |
| history of stroke (n) | No | 43 |
| Hypertension (n) | Yes | 47 |
| | No | 11 |
| Diabetes mellitus (n) | Yes | 27 |
| | No | 31 |
| VHI-10 ($\bar{X}$±SD) | | 4.614±8.656 |
| V-RQOL ($\bar{X}$±SD) | | 14.684±9.012 |
| MPT ($\bar{X}$±SD) | | 6.432±4.54 |
| s/z ($\bar{X}$±SD) | | 1.318±1.682 |

SD: Standard deviation; VHI-10: Voice Handicap Index-10; V-RQOL: Voice-Related Quality of Life; MPT: Maximum phonation time.

In the acute period, MPT was 5.974±2.989 in women, 6.463±3.948 in men, and 6.279±3.544 in all individuals; in the subacute period, it was 6.948±5.561 in women, 7.82±4.448 in men, and 7.461±4.875 in all individuals. There was no statistically significant difference in aerodynamic measurement results, or V-ROQL in the subacute period compared to the acute period in women or men ($p>0.05$). In males, while VHI-10 was 4.364±6.261 in the acute period, it decreased to 1.500±3.419 in the subacute period, which was statistically significant ($p=0.011$). In all participants, VHI-10 decreased statistically significantly from 3.528±5.475 to 1.556±3.229 ($p=0.005$) (Table 3).

The mean value of F0 increased statistically significantly from 195.846±44.323 to 214.666±51.881 for females, 145.611±40.44 to 157.216±40.969 for males, and 166.677±48.451 to 181.308±53.463 ($p=0.005$) from the acute to the subacute period for both male and female participants (Table 4).

**TABLE 2:** Characteristics of participants.

| | | Female (n=15) | Male (n=22) | All participants (n=37) |
|---|---|---|---|---|
| Age ($\bar{X}$±SD) year | | 66.27±10.42 | 66.91±9.30 | 66.65±9.63 |
| Education years (X±SD) | | 4.600±3.066 | 7.136±3.992 | 6.108±3.814 |
| Smoking status (n) | Never smoked | 10 | 6 | 16 |
| | Smoked or smokes | 5 | 16 | 21 |
| Alcohol use (n) | Never used | 15 | 13 | 28 |
| | Has used or is using | 0 | 9 | 9 |
| Presence of a previous history of stroke (n) | Yes | 6 | 6 | 12 |
| | No | 9 | 16 | 25 |
| Hypertension (n) | Yes | 11 | 15 | 26 |
| | No | 4 | 7 | 11 |
| Diabetes mellitus (n) | Yes | 6 | 10 | 16 |
| | No | 9 | 12 | 21 |

SD: Standard deviation.

**TABLE 3:** Results of aerodynamic and subjective voice assessments.

| | | Female (n=15) | Male (n=22) | All participants (n=37) |
|---|---|---|---|---|
| VHI-10 (median) | Acute phase | 2.214±3.786 (0.00) | 4.364±6.261 (0.50) | 3.528±5.475 |
| | Subacute phase | 1.643±3.028 (0.00) | 1.500±3.419 (0.00) | 1.556±3.229 |
| | t/z, p value | -1.198, p=0.252 | **-2.807, p=0.011*** | **-2.940, p=0.005*** |
| V-RQOL (median) | Acute phase | 12.714±4.531 (11.00) | 15.045±7.594 (12.00) | 14.139±6.599 |
| | Subacute phase | 12.143±3.634 (10.00) | 13.364±6.558 (10.00) | 12.889±5.574 |
| | t/z, p value | -0.678, p=0.510 | -1.882, p=0.074 | -1.967, p=0.057 |
| MPT (median) | Acute phase | 5.974±2.989 (5.77) | 6.463±3.948 (5.10) | 6.279±3.544 |
| | Subacute phase | 6.948±5.561 (6.08) | 7.82±4.448 (7.585) | 7.461±4.875 |
| | t/z, p value | 0.715, p=0.487 | 0.999, p=0.330 | 1.245, p=0.222 |
| s/z (median) | Acute phase | 0.943±0.28 (0.95) | 0.939±0.219 (0.967) | 0.94±0.24 |
| | Subacute phase | 0.877±0.251 (0.858) | 0.974±0.403 (0.947) | 0.935±0.347 |
| | t/z, p value | -0.524, p=0.612 | 0.338, p=0.74 | -0.072, p=0.943 |

SD: Standard deviation; VHI-10: Voice Handicap Index-10; V-RQOL: Voice-Related Quality of Life; MPT: Maximum phonation time; *: Considered statistically significant for $p < 0.05$.

## DISCUSSION

In various professions, it is very important to have a healthy voice. Furthermore, voice disorders can significantly affect a patient's quality of life, jeopardizing their physical, emotional, and functional abilities. The primary aim of our study was to analyze the objective and subjective changes related to voice in the subacute period compared to the acute period. In accordance with this aim, for the first time in the literature, acoustic, aerodynamic, and subjective voice characteristics were evaluated in stroke patients in both acute and subacute periods.

**TABLE 4:** Results of acoustic voice analysis.

| | | Female (n=15) (X̄±SD) (median) | Male (n=22) (X̄±SD) (median) | All participants (n=37) (X̄±SD) (median) |
|---|---|---|---|---|
| F0 | Acute phase | 195.846±44.323 (205.673) | 145.611±40.44 (129.772) | 166.677±48.451 (167.349) |
| | Subacute phase | 214.666±51.881 (223.101) | 157.216±40.969 (157.856) | 181.308±53.463 (180.172) |
| | t/z, p value | **2.546, p=0.026*** | **2.411, 0.016*** | **3.039, p=0.005*** |
| Jitter (local) | Acute phase | 0.254±0.158 (0.194) | 1.230±2.262 (0.349) | 0.821±1.774 (0.292) |
| | Subacute phase | 0.213±0.148 (0.174) | 0.738±1.065 (0.324) | 0.518±0.849 (0.235) |
| | t/z, p value | -0.936, p=0.368 | -0.902, p=0.380 | -0.959, p=0.345 |
| Jitter (rap) | Acute phase | 0.131±0.097 (0.092) | 0.619±1.459 (0.149) | 0.414±1.127 (0.130) |
| | Subacute phase | 0.108±0.088 (0.072) | 0.359±0.593 (0.167) | 0.254±0.467 (0.130) |
| | t/z, p value | -0.884, p=0.394 | -0.759, p=0.458 | -0.812, p=0.423 |
| Shimmer (local) | Acute phase | 4.164±2.651 (3.793) | 5.245±4.658 (4.236) | 4.792±3.924 (3.932) |
| | Subacute phase | 5.020±3.004 (3.784) | 6.693±4.506 (4.998) | 5.991±3.979 (4.287) |
| | t/z, p value | 1.775, p=0.101 | 0.912, p=0.374 | 1.285, p=0.209 |
| Shimmer (dB) | Acute phase | 0.383±0.258 (0.348) | 0.482±0.442 (0.368) | 0.440±0.374 (0.348) |
| | Subacute phase | 0.476±0.303 (0.328) | 0.606±0.384 (0.429) | 0.552±0.353 (0.410) |
| | t/z, p value | 2.027, p=0.065 | 0.866, p=0.399 | 1.316, p=0.198 |
| HNR | Acute phase | 23.353±5.558 (23.102) | 19.854±6.705 (20.758) | 21.322±6.397 (21.908) |
| | Subacute phase | 21.152±4.242 (22.029) | 17.545±5.108 (17.259) | 19.058±5.026 (20.535) |
| | t/z, p value | -1.787, p=0.099 | -1.130, p=0.274 | -1.775, p=0.086 |

SD: Standard deviation; F0: Fundamental frequency; HNR: Harmonic to noise ratio; *: Considered statistically significant for $p < 0.05$.

Speech production and phonation are complex, rapid motor behaviors involving the precise coordination of numerous laryngeal, orofacial, and respiratory muscles. The simplest task to isolate the respiratory phonation system for speech is vowel lengthening. Therefore, continuous vowel phonation is widely used to assess the function of the respiratory-phonatory speech subsystem, both in clinical assessment and in voice dysfunction research. MPT was calculated as low as 6-7 in both men and women. These results showed that the MPT of individuals with CVA was inconsistent with their age. A healthy adult is expected to be able to produce the phonation for approximately 20-26 seconds in men and 18-24 seconds in healthy women.[28,29] According to some sources, normal MPT values for healthy adults are expected to be between 14 and 25 seconds. Values less than 10 are considered abnormal. The average age of all participants in our study was 66 years, and Pessin et al., who had the closest average age to our study, found MPTs of 12.4 s in the group aged 60-75 years, and Mezzedimi et al. found 9.48 s and 8.54 s in elderly men and women, respectively.[30,31] According to these studies, our MPT findings were low in

both acute and post-acute periods. MPT reflects the ability to control the aerodynamic forces in the airflow from the lungs and the myoelastic forces caused by the closure of the vocal folds during phonation. One of the reasons for the findings may be the decrease in the vital volume of the individual with the weakening of the respiratory and laryngeal muscles in stroke patients and the inability to use the breath effectively. Hospitalization and the intensive care process may affect respiratory functions.[32,33] Normally, an increase is expected with the recovery process. In our study, although maximal phonation time increased in all individuals, this increase was not significant and was still low compared to normal peers. Respiration is the basic component of voice production and speech. Affected respiration will directly affect the voice. Our results showed that respiratory functions should be evaluated in detail during the acute period in individuals with CVA.

One of the aerodynamic evaluation methods is the s/z ratio. It indicates whether the vocal folds are closed properly. When there is any pathology in the vocal folds, the production of /z/ will be affected, and as a result, the s/z ratio will increase. The s/z ratio allows the evaluation of glottic closure. Its normal value is 1.2 or lower.[34] Pessin et al. found an s/z ratio of 0.83 in the 60-75 age group. Our s/z findings, both in all stroke patients and in male and female stroke groups, are consistent with other studies.[31,34]

In our study, in the acute period, women had F0 195.8, Jitter 0.3, Shimmer 4.2, and HNR 23.4; men had F0 145.6, Jitter 1.2, Shimmer 5.2, and HNR 19.9. Wang et al., who performed acoustic voice evaluation in individuals with stroke, found all parameters above the threshold except HNR in elderly men, and they stated that this could be due to large standard deviations in many measurements.[35] In our study, similar to this study, the Jitter value of men exceeded the normal limits in the acute period. Jitter is a parameter related to frequency irregularity. Jitter evaluates very short-term irregularities in the pitch period of the voice. The normal value is expected to be below 1%.[36,37] However, in our study, the Jitter % and Jitter rap values in the acute and subacute periods were within the normal limits in women, and the Jitter % in the sub-acute period reached the normal limits in men. This may be due to the effect of spontaneous healing on the perturbation of the vocal folds.

HNR is the numerical equivalent of extra-audible noise in the voice. This noise may be due to inadequate closure of the vocal folds or irregular vibration. Where voice quality is affected, the noise harmonic ratio is a parameter related to the physiological state of voice production.[38] High values indicate a low noise figure. HNR values were within normal limits in both acute and subacute periods. This finding of our study is similar to that of Wang et al. However, the decrease was significant in the subacute period compared to the acute period. This may have been due to the last evaluated environment.

Shimmer, which is one of the amplitude perturbation parameters, shows the amplitude differences between successive periods. It is expected to be less than 3%.[36,37] However, in our study, the Shimmer values of both men and women in both acute and subacute periods were above normal limits, similar to found by Wang et al. This reflects the irregularity of glottic closure and indicates that individuals with strokes have difficulty adjusting the stability of loudness. In addition, the statistically significant increase in the subacute period indicates that the irregularity of glottic closure after stroke increased instead of improving. This situation is also shown in respiratory control. Our finding of low MPT also supported this idea.

In our study, according to the data of Oguz et al. using Praat for women, the F0 value of normative women was found to be low in both acute and subacute periods. This shows that inmednin decreases the number of vibrations in the vocal folds. This may be due to vocal fold abductor or abductor muscle weaknesses. The F0 value of men was within normal limits in both acute and subacute periods, according to Oguz et al.[39] However, statistically significantly, the F0 value increased and reached normal limits in women in the subacute period. In addition, the F0 value of males and all individuals increased statistically significantly in the subacute period compared to the acute period.

Urban et al. reported a descriptive analysis of 22 individuals with hemispheric or brainstem stroke and tentatively concluded that voice impairment after unilateral hemispheric stroke is associated with abnormal frequency perturbation parameters, amplitude parameters, and increased F0 variability.[9] However, in our study, F0, Jitter, and HNR values were within normal limits. These inter-study differences may be due to differences in the location and size of the lesion between studies, the complexity and variability of speech impairment caused by stroke, and the use of different speech assessment methods in various studies.[9,35]

Objective methods appear to be insufficient to address quality of life issues and emphasize the importance of implementing the VHI in stroke patients. Results from Hwang et al. showed that patients with voice problems after stroke had a significant decrease in quality of life even after controlling for other confounding factors such as neurological deficits and dysphagia.[16] In our study, the 10-question version of the VHI, one of the subjective methods, was used. At the beginning, VHI-10 decreased statistically significantly from 4.4 to 1.5 in men. It also decreased in women, but the decrease was not significant. In fact, the average of the subacute period became lower in men than in women. This was an important finding: the voice complaints of men decreased significantly in the 1-month period despite their smoking history. This may have resulted from the fact that men had a lower number of strokes in their history than women. Because the regeneration rate varies according to the number of strokes and the number of days spent after a stroke. When VHI-10 was considered for all individuals, it decreased statistically from 3.528±5.475 to 1.556±3.229, which showed that the voice complaints of all individuals with CVA decreased in general. However, this was especially true for male individuals.

The main limitation of our study is that no instrumental laryngeal imaging method was used. Instrumental laryngeal imaging methods such as videostroboscopy or a flexible endoscope could have been used to examine the pathological conditions of the laryngeal structures, especially the vocal folds, and their changes until the subacute period.

## CONCLUSION

In this study, to the best of our knowledge, the voice of stroke patients in the acute phase was evaluated by both subjective and objective methods, and voice changes in the subacute phase compared to the acute phase were analyzed for the first time. In general, it was determined that the MPT of stroke patients was limited and the Shimmer values of acoustic parameters were above normal limits. In the sub-acute period, it was observed that phonation times were still low and Shimmer values tended to increase. Therefore, acoustic, aerodynamic, and special voice evaluations, especially MPTs, should be performed in stroke patients during the acute period.

***Acknowledgements***

*We would like to thank Sebiha ABZAK and Aynur ŞENOCAK for her help with data collection.*

***Source of Finance***

*During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.*

***Conflict of Interest***

*No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.*

***Authorship Contributions***

***Idea/Concept:*** *Mümüne Merve Parlak, Güleser Saylam, Özlem Bizpınar Munis, Sibel Alicura Tokgöz;* ***Design:*** *Mümüne Merve Parlak, Güleser Saylam, Özlem Bizpınar Munis;* ***Control/Supervision:*** *Güleser Saylam, Sibel Alicura Tokgöz;* ***Data Collection and/or Processing:*** *Mümüne Merve Parlak, Özlem Bizpınar Munis;* ***Analysis and/or Interpretation:*** *Mümüne Merve Parlak, Özlem Bizpınar Munis;* ***Writing the Article:*** *Mümüne Merve Parlak, Güleser Saylam, Özlem Bizpınar Munis;* ***Critical Review:*** *Güleser Saylam, Sibel Alicura Tokgöz.*

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