Association between presbylarynx morphological severity and acoustic voice parameters

Presbilarinks morfolojik şiddeti ile ses akustiği parametreleri arasındaki ilişki

Abstract

Aim: Presbylarnx is an endoscopic reflection of age-related laryngeal changes, and the lack of a standard classification system results in uncertainty in diagnosis and treatment. This study aimed to investigate the relationship between the morphological classification of presbylarynx and the sociodemographic and anthropometric characteristics of patients, self-reported questionnaires, and objective acoustic voice analysis parameters.

Methods: In this prospective cross-sectional study, 172 participants aged 60 years and older underwent morphological evaluation of presbylaringeal changes using rigid videolaryngostroboscopy. In the evaluation, a three-tiered system was used to classify presbylarynx: Type 0 (normal), Type 1 (atrophy/bowing), and Type 2 (atrophy and glottic insufficiency). Analyses were performed of the sociodemographic characteristics of the patients, body mass index (BMI), Charlson Comorbidity Index (CCI), Turkish Voice Handicap Index-10 (T-VHI-10) scores, and acoustic parameters (fundamental frequency (F0), jitter (%), shimmer (%), harmonic-noise ratio (HNR), cepstral peak prominence smoothed (CPPS), and Acoustic Voice Quality Index (AVQI-3.0)).

Results: No statistically significant relationship was found between the morphological types of presbylarynx (Type 0, 1, 2) and age, gender, BMI, CCI, and T-VHI-10 scores ($p > 0.05$ for all comparisons). In the objective acoustic analysis, Type 2 morphology showed significantly higher Shimmer % (p=0.015), lower CPPS (p=0.013), and higher AVQI-3.0 (p=0.027) values compared to Type 1.

Conclusion: The results of this study show that the morphological severity of presbylarynx is strongly related to objective acoustic sound parameters, but not directly related to subjective sound perception or general anthropometric characteristics of the patients. This consistency between morphological and acoustic findings emphasizes the importance of supporting endoscopic examination with objective sound analysis in clinical evaluation. Future studies should be designed with larger samples and methods that directly measure muscle mass (e.g., DEXA, BIA) to elucidate the etiology of presbylarynx.

Keywords: Aging; body mass index; laryngeal diseases; vocal fold; voice

Öz

Amaç: Presbilarinks, yaşa bağlı larengeal değişimlerin endoskopik yansımasıdır ve standart bir sınıflandırma sisteminin olmaması tanı ve tedavide belirsizliğe yol açmaktadır. Bu çalışmanın amacı, presbilarinksin morfolojik sınıflandırması ile hastaların sosyodemografik ve antropometrik özellikleri, öz-bildirim anketleri ve objektif akustik ses analizi parametreleri arasındaki ilişkiyi araştırmaktı.

Yöntemler: Bu prospektif kesitsel çalışmada, 60 yaş ve üzeri 172 katılımcıya rijit videolaringostroboskopi kullanılarak presbilarinks değişikliklerinin morfolojik değerlendirmesi yapıldı. Değerlendirmede, presbilarinksi sınıflandırmak için üç kademeli bir sistem kullanıldı: Tip 0 (normal), Tip 1 (atrofi/bowing) ve Tip 2 (atrofi ve glottik yetersizlik). Hastaların sosyodemografik özellikleri, vücut kitle indeksi (VKİ), Charlson Komorbidite İndeksi (CCI), Türkçe Voice Handicap Index-10 (T-VHI-10) skorları ve akustik parametreler (temel frekans (F0), jitter (%), shimmer (%), harmonik-gürültü oranı (HNR), düzgünleştirilmiş kepstral tepe belirginliği (CPPS) ve Akustik Ses Kalitesi İndeksi (AVQI-3.0)) analiz edildi.

Bulgular: Presbilarinksin morfolojik tipleri (Tip 0, 1, 2) ile yaş, cinsiyet, VKİ, CCI ve T-VHI-10 skorları arasında istatistiksel olarak anlamlı bir ilişki bulunmadı (tüm karşılaştırmalar için $p > 0,05$). Objektif akustik analizde, Tip 2 morfoloji, Tip 1'e kıyasla istatistiksel olarak anlamlı düzeyde daha yüksek Shimmer % (p=0,015), daha düşük CPPS (p=0,013) ve daha yüksek AVQI-3.0 (p=0,027) değerleri gösterdi.

Sonuç: Bu çalışmanın sonuçları, presbilarinksin morfolojik şiddetinin objektif akustik ses parametreleriyle güçlü biçimde ilişkili olduğunu, ancak hastaların öznel ses algısı veya genel antropometrik özellikleriyle doğrudan ilişkili olmadığını göstermektedir. Morfolojik ve akustik bulgular arasındaki bu tutarlılık, klinik değerlendirmede endoskopik muayenenin objektif ses analiziyle desteklenmesinin önemini vurgular. Gelecekteki çalışmalar, presbilarinksin etiyolojisini aydınlatmak için daha büyük örneklemler ve kas kütlesini doğrudan ölçen yöntemlerle (ör. DEXA, BIA) tasarlanmalıdır.

Anahtar Sözcükler: Beden kitle indeksi; larinks hastalıkları; ses; vokal kıvrım; yaşlanma

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INTRODUCTION

Ageing is a process that affects all tissues in the human body, and consequently, structural and functional changes are observed in the vocal folds. The endoscopic reflection of this condition is defined as "presbylarynx." (1). Presbilarynx manifests with a wide range of pathologies, from microscopic changes such as thinning of the epithelium, loss of elasticity in the lamina propria, and irregularities in collagen fibres, to macroscopic findings such as vocal fold atrophy (tissue loss), bowing (curvature), and glottic closure insufficiency. (2–5). These structural changes often lead to a deterioration in voice quality, characterized by breathy voice production, and a clinical condition known as presbyphonia (4).

The fact that the diagnosis of presbylarynx relies heavily on endoscopic observation and that a standard classification system is not widely used leads to significant heterogeneity in clinical practice and research. The wide range of prevalence estimates, varying from 12% to 35%, reflects this diagnostic uncertainty (6). At the same time, this uncertainty complicates not only the reliability of epidemiological data but also treatment planning. To address this gap, Santos et al. developed a validated classification system that separates presbylarynx endoscopic findings into three morphological types (Type 0: no significant abnormalities; Type 1: atrophy/bowing; Type 2: significant glottic gap) (5,7). This system standardizes the classification of presbylarynx, enabling more objective evaluation and comparison.

The development and progression of presbylarynx is not limited to local aging processes alone, but may also be influenced by the individual's overall systemic condition. In this context, the patient's sociodemographic characteristics and anthropometric measurements reflecting body composition may play a potential role in the morphological appearance of presbypharynx. Body Mass Index (BMI), which is widely used in clinical practice, holds an important place among these measurements. While a low BMI may contribute to glottic insufficiency in association with a decrease in overall muscle mass (sarcopenia), a high BMI may alter voice production by affecting the respiratory support systems (8,9). However, although the literature partially addresses the effects of BMI on overall voice quality, it falls short of providing a detailed explanation of the relationship between specific morphological subtypes of presbylarynx and the patient's overall profile (anthropometric, sociodemographic, self-reported, and acoustic analysis data) (8).

This study aimed to investigate the relationship between the morphological classification of presbylarynx and the sociodemographic and anthropometric characteristics of patients, self-reported questionnaires, and acoustic sound analysis parameters.

MATERIAL AND METHODS

This prospective, observational, and cross-sectional study was approved by the Ethics Committee of Kutahya Health Sciences University (date: 12.10.2022, decision no: 2022/10-08) and was conducted in accordance with the principles of the Declaration of Helsinki. Evaluations were made of 214 consecutive patients who visited the Ear, Nose, and Throat (ENT) clinic of a tertiary-level healthcare centre between November 2022 and January 2025. The inclusion criteria for the study were defined as age ≥60 years, having sufficient cognitive capacity, and providing informed consent. Patients were excluded if they had any neurological disorders such as dementia, Parkinson's disease, and essential tremor, any autoimmune disorders, malignancies, a diagnosis of thyroid pathology, the presence of benign vocal cord lesions (nodules, polyps, etc.), sulcus vocalis, acute laryngitis, or vocal cord paralysis, or had undergone surgical intervention or radiotherapy in the thoracic or head-neck region. A total of 32 individuals who did not meet the inclusion criteria were excluded from the study.

All the study participants were evaluated by the same laryngologist (NT) and a comprehensive medical history was obtained using a standard protocol. Demographic (age, gender, education level), lifestyle (smoking, alcohol consumption, daily water consumption), and clinical data were recorded, and the severity of comorbidities was determined using the Charlson Comorbidity Index (CCI).

Anthropometric measurements

Anthropometric data included body weight (kg) and height (cm) measurements, all of which were performed using calibrated devices in accordance with institutional protocols. Height was measured with a stadiometer to an accuracy of 0.1 cm, and body weight was recorded using a digital scale to an accuracy of 0.1 kg. Body mass index (BMI, kg/m²) was calculated based on these measurements.

Presbylarynx evaluation

All the participants underwent 90° rigid videolaryngostroboscopy (EndoStrob, DX Xion 327, GmbH, Germany) for presbylarynx assessment, and images recorded with a Charge Coupled Device (CCD) camera were reviewed by two independent ENT specialists (OK, FZ) with more than 10 years of experience. Presbylarynx is an endoscopically defined morphological finding that can be observed in elderly individuals with or without voice complaints. Most studies in the literature have focused on presbyphonia and have only examined patients with voice complaints (1,7,10–12). However, this approach may lead to asymptomatic cases of presbylarynx being overlooked. Therefore, in this study, it was aimed to evaluate the morphological distribution of presbylarynx at the population level and its relationship with anthropometric characteristics (height, weight, BMI) from a broader perspective by including all individuals over the age of 60 years, regardless of voice complaints. This methodology enabled the identification of subclinical forms of presbylarynx, thereby facilitating the early detection of risk factors. The morphological classification of presbylarynx was based on the three types defined by Santos et al.: Type 0 (no significant morphological changes), Type 1 (presence of at least two endoscopic findings), and Type 2 (glottic insufficiency in addition to Type 1 findings) (7). Ten cases for which observers could not reach consensus were excluded from the study. The final analysis was performed on 172 participants.

All the participants were also administered the Turkish Voice Handicap Index-10 (T-VHI-10). The T-VHI-10 is a scale that assesses the level of subjective disability related to the voice and is scored on a scale of 0–40, with scores above 10 considered pathological (13).

Voice recording and acoustic analysis

The voice recordings were made in a quiet room with a maximum noise level of 25 dB, using Audacity (https://www.audacityteam.org/) software in 44,100 Hz single-channel "wave" format. The sounds were captured using an Audio-Technica AT2020 USB microphone (Audio-Technica Corporation, Tokyo, Japan) positioned at a 45° angle and approximately 15 cm away from the mouth. The participants completed two speech tasks in three repetitions: sustained phonation of the /a/ sound (VS) and reading of a 25-syllable Turkish passage "diyet" that was phonetically and phonologically balanced (CS). Acoustic analyses were performed using Praat v6.4.18 software. The parameters evaluated were fundamental frequency (F0), jitter (%), shimmer (%), harmonic-noise ratio (HNR dB), cepstral peak prominence smoothed (CPPS), and Acoustic Voice Quality Index 3.0 (AVQI-3.0).

Statistical analysis

Statistical analysis of the data was performed using the SPSS Statistics for Windows (Statistical Package for the Social Sciences package program version 26.0, IBM Corp., Armonk, N.Y., USA). Descriptive statistics were presented as numbers (n) and percentages (%) for categorical variables and as median (minimum-maximum) values for continuous variables, as they did not show normal distribution. The chi-square test was used to compare the relationship between categorical variables and presbylarynx morphological types. The Mann-Whitney U test was applied to compare continuous variables that did not show normal distribution between groups. In all analyses, the statistical significance level was set at $p < 0.05$.

RESULTS

The total 172 individuals participating in the study comprised 52.3% (n=90) males and 47.7% (n=82) females. When examining comorbidity burdens, it was observed that the most common Charlson Comorbidity Index (CCI) scores were 3 (29.1%) and 2 (23.8%). In terms of educational profile, the majority were primary school graduates (64.5%), while the proportion of university graduates was limited to 5.8%. In terms of lifestyle habits, smoking was prevalent at 27.9%, while alcohol consumption (1.7% active users) was quite low. In the assessment of daily water consumption, the most frequent group was those who consumed 5–7 glasses per day (36.0%). The morphological evaluation showed that the most common type of presbylarynx

Table 1. Distribution of demographic characteristics of the participants

Variable	n (%)
Gender	
Male	90 (52.3)
Female	82 (47.7)
Charlson comorbidity index	
1	25 (14.5)
2	41 (23.8)
3	50 (29.1)
4	33 (19.2)
5	18 (10.5)
6	3 (1.7)
7	2 (1.2)
Educational status	
Illiterate	23 (13.4)
Elementary school	111 (64.5)
Middle school	11 (6.4)
High School	17 (9.9)
University	10 (5.8)
Smoking	
No	124 (72.1)
Yes	48 (27.9)
Alcohol consumption	
No	166 (96.5)
Yes	3 (1.7)
Daily water consumption	
<2 cups	13 (7.6)
3-4 cups	49 (28.5)
5-7 cups	62 (36.0)
>8 cups	48 (27.9)
Presbylarynx morphology	
Type 0	58 (33.7)
Type 1	25 (14.5)
Type 2	89 (51.7)

n: Number, %: Percent

was Type 2 at 51.7%, followed by Type 0 (33.7%) and Type 1 (14.5%) (Table 1).

No statistically significant relationship was found between presbylarynx morphological types and gender (p=0.676), education level (p=0.841), smoking (p=0.635), alcohol consumption (p=0.215), or daily water consumption (p=0.419). Although Type 2 morphology was observed at a higher rate in those with an education level of high school or higher and those who consumed 5–7 glasses of water, these differences were not statistically significant. The detailed distribution of all the variables is shown in Table 2.

No statistically significant differences were found between the morphological types of presbylarynx (Type 0, Type 1, and Type 2) in terms of age, anthropometric measurements (height, weight, BMI), comorbidity status (Charlson Comorbidity Index), and participant-reported outcome measures (T-VHI-10)

Table 2. Relationships between presbylarynx morphological classification and sociodemographic characteristics of the participants

Type 0 (n (%))		**Presbylarynx morphology**			**p value***
		Type 1 (n (%))	**Type 2 (n (%))**		
Gender	Male	33 (36.7)	12 (13.3)	45 (50)	0.676
	Female	25 (30.5)	13 (15.9)	44 (53.7)	
Educational status	Illiterate	8 (34.8%)	3 (13.0%)	12 (52.2%)	0.841
	Elementary school	41 (36.9%)	16 (14.4%)	54 (48.6%)	
	Middle school	4 (36.4%)	1 (9.1%)	6 (54.5%)	
	High School	4 (23.5%)	3 (17.6%)	10 (58.8%)	
	University	1 (10.0%)	2 (20.0%)	7 (70.0%)	
Smoking	No	41 (33.1)	20 (16.1)	63 (50.8)	0.635
	Yes	17 (35.4)	5 (10.4)	26 (54.2)	
Alcohol consumption	No	58 (34.9)	25 (15.1)	83 (50)	0.215
	Yes	0 (0)	0 (0)	3 (100)	
Daily water consumption	<2 cups	6 (46.2)	3 (23.1)	4 (30.8)	0.419
	3-4 cups	19 (38.8)	4 (8.2)	26 (53.1)	
	5-7 cups	16 (25.8)	11 (17.7)	35 (56.5)	
	>8 cups	17 (35.4)	7 (14.6)	24 (50)	

*Chi-square test, n: Number, %: Percent

Table 3. Comparisons of age, anthropometric and self-reported parameters according to presbylarynx morphological types

	Presbylarynx morphology			**p value***	**p value***	**p value***
	Type 0 Med (min-max)	**Type 1 Med (min-max)**	**Type 2 Med (min-max)**	**(Type 0-Type1)**	**(Type 0-Type 2)**	**(Type1-Type 2)**
Age (years)	69 (60-84)	67 (60-80)	69 (60-84)	0.874	0.459	0.323
Charlson comorbidity index	3 (1-6)	3 (1-6)	3 (1-7)	0.205	0.306	0.477
Height (cm)	163.5 (133-182)	161 (141-180)	162 (17-180)	0.706	0.259	0.784
Weight (kg)	78.5 (54-117)	75 (45-166)	76 (49-103)	0.804	0.283	0.603
BMI (kg/m²)	28.7 (20.3-41)	29 (22-42.4)	29.4 (18.4-40)	0.532	0.522	0.905
T-VHI-10	0 (0-20)	0 (0-25)	0 (0-26)	0.629	0.119	0.130

* Mann Whitney U-test, BMI: Body mass index, T-VHI-10: Turkish Voice Handicap Index-10, Med: Median, Min: Minimum, Max: Maximum

Table 4. Comparisons of acoustic sound parameters according to presbylarynx morphological types

	Presbylarynx morphology			p value*	p value*	p value*
	Type 0 Med (min-max)	Type 1 Med (min-max)	Type 2 Med (min-max)	(Type 0- Type 1)	(Type 0- Type 2)	(Type1-Type 2)
F0 (Hertz)	156.5 (92-239)	155 (108.8-231.3)	156.5 (91-240)	0.522	0.608	0.755
Jitter (%)	0.3 (0.1-1.8)	0.3 (0.1-2.2)	0.4 (0.1-4.9)	0.447	0.077	0.565
Shimmer (%)	2.6 (0.8-14.7)	2.2 (1.1-9.2)	3 (1-14.6)	0.211	0.072	0.015
HNR (dB)	20.5 (6.4-26.6)	20.6 (8.6-27)	18.8 (3.3-28.3)	0.921	0.079	0.080
CPPS (dB)	14.2 (5.7-18.9)	15.4 (6.4-18.6)	13 (6-19.3)	0.156	0.146	0.013
AVQI-3.0	4.3 (0.6-7.4)	4.2 (2-7.1)	4.8 (1.1-7.9)	0.380	0.103	0.027

* Mann Whitney U-test, F0: fundamental frequency, HNR: harmonic-noise ratio, CPPS: cepstral peak prominence smoothed, AVQI-30: Acoustic Voice Quality Index 3.0, Med: Median, Min: Minimum, Max: Maximum, n: Number, %: Percent

(p > 0.05 for all comparisons). The median values for each group and detailed statistical results are presented in Table 3.

In pairwise comparisons between the morphological types of presbylarynx, significant differences were found in Shimmer % (Type 1–Type 2: p=0.015), CPPS (Type 1–Type 2: p=0.013), and AVQI-3.0 (Type 1–Type 2: p=0.027) values. No statistically significant differences were observed between the groups in terms of other acoustic parameters such as F0, Jitter %, and HNR (p > 0.05) (Table 4).

DISCUSSION AND CONCLUSION

The main finding of this study was the significant discrepancy between the objective acoustic parameters of presbylarynx and patients' perception of symptoms and basic anthropometric characteristics. Specifically, while Type 2 morphology, characterized by advanced atrophy, demonstrated significantly worse sound quality (higher Shimmer % and AVQI, lower CPPS) compared to Type 1, this objective deterioration was not reflected in patient-reported sound complaints (T-VHI-10). In addition, no significant differences were found between morphological groups in terms of age, gender, comorbidity, and lifestyle variables. These findings suggest that the morphological changes observed in presbylarynx may not always correspond to functional symptoms or specific patient profiles, and this should be considered in diagnostic and treatment algorithms.

In line with expectations, as the morphological severity of presbylarynx increased, objective acoustic deterioration in voice quality also became more pronounced. In particular, the significant differences observed in Shimmer %, CPPS, and AVQI-3.0 values between Type 1 and Type 2 morphologies support the clinical validity of the Santos classification et al. The increase in Shimmer % serves as an acoustic indicator of glottic insufficiency and is consistent with previous studies in the literature on age-related vocal fold atrophy and aerodynamic changes (14,15). Similarly, the increase in AVQI can be considered an objective acoustic outcome of age-related voice disorders in presbylarynx and is consistent with findings highlighting the relationship between muscle mass and vocal atrophy (16). However, the absence of significant differences in parameters such as fundamental frequency (F0) and Jitter is consistent with the findings of Takano et al. that glottic closure defects become more pronounced in older age, suggesting that these measurements may have limited sensitivity in advanced stages of laryngeal aging (15). All these findings reveal that the acoustic profile of presbylarynx reflects the complex interaction of structural, functional, and systemic ageing processes within the multifactorial etiology emphasized by Bhatt et al. (17).

Another important finding was that despite the significant deterioration in objective acoustic parameters, no statistical relationship was found between the morphological types defined endoscopically and the patients' self-reported voice complaints (T-VHI-10). This suggests that morphological classification may not always correspond to symptoms and that the clinical manifestation of presbylarynx may be influenced by factors such as individual adaptation, voice changes perceived as a "normal" part of ageing, and subjective expectations. In a prospective case-control study by Santos et al., significantly higher VHI-30 scores were found in individuals diagnosed with presbylarynx, suggesting that voice-related subjective discomfort may be prominent in this population (16). In the same study, the significantly lower muscle mass in the presbylarynx group pointed to a possible interaction between laryngeal ageing and systemic sarcopenia (16). However, in the current study, no significant relationship was found between morphological types and age, CCI, and BMI. This finding reflects the multifactorial nature of presbylarynx and a unique ageing process that cannot be explained solely by general body composition or comorbidity burden.

The study results also revealed that BMI is an inadequate indicator to assess muscle atrophy accompanying the presbylarynx. Although Santos et al. reported that muscle mass measured with bioimpedance analysis was significantly associated with presbylarynx, BMI is limited because it cannot distinguish between muscle and fat tissue (16). Especially in cases of sarcopenic obesity, significant muscle loss may go unnoticed even if BMI is normal or high. A study conducted by Kirchengast et al. using DEXA also showed that age-related muscle mass loss is mostly masked by an increase in adipose tissue and cannot be detected by conventional BMI measurements (18). Therefore, the fact that no significant relationship was found in the current study supports the inadequacy of BMI in assessing muscle atrophy underlying presbylarynx and the need to use methods that can directly measure muscle mass, such as bioimpedance analysis or DEXA, in order to establish this relationship in a healthy manner.

Moreover, the absence of a significant relationship of age, gender, educational level, smoking, alcohol consumption, and overall comorbidity burden with presbylarynx morphological types suggests that internal mechanisms such as genetic predisposition or individual anatomical differences may play a role in the development of presbylarynx rather than external factors. However, the report by Santos et al. that Type 2 morphology is more common in males differs somewhat from the current study findings (5). It was thought that this may be due to ethnic or demographic differences in the populations included in the studies. Furthermore, although the negative effects of harmful habits on voice health are acknowledged, as emphasized in the study by Angerstein, the current study findings suggest that these factors do not directly trigger specific morphological subtypes (19). Ultimately, our view that factors other than age, such as more specific biological and structural factors, may be involved in the development of presbylarynx is consistent with the systematic review by Bhatt et al., which highlights the multifactorial nature of laryngeal ageing (17).

This study had some limitations, primarily because of the cross-sectional design, causal relationships could not be established. In addition, the limited sample size in the Type 1 group reduced the statistical power of the analyses. The inadequacy of BMI in assessing biological variables such as sarcopenia, and the lack of control for potential confounding factors such as hormonal status, dietary habits, and voice usage profile can also be said to be other limitations. In light of these findings, there is a need for further studies with larger samples, longitudinal designs, and direct measurement of muscle mass to be able to clarify the etiology of presbylaryngitis and its relationship with systemic health.

Smoking leads to histopathological changes in the vocal folds, including chronic inflammation of the epithelium, reduced elasticity of the lamina propria, and impaired mucosal wave vibration. Alcohol consumption, on the other hand, may indirectly affect voice quality through dehydration and increased risk of gastroesophageal reflux. In the present study, the lack of a statistically significant association between smoking and alcohol use and the morphological types of presbylarynx suggests that these factors may exert their effects primarily at a functional level and in relation to individual voice-use behaviors, rather than directly influencing morphological severity.

The findings of this study indicate that while the morphological severity of presbylarynx is associated with objective acoustic voice parameters, it does not show a clear relationship with subjective voice perception or general anthropometric characteristics. These results suggest that laryngoscopic evaluation should be supported by acoustic analysis in clinical practice. Future studies with larger sample sizes and direct measurements of muscle mass are needed to better clarify the etiopathogenesis of presbylarynx.

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Conflict-of-interest and financial disclosure

The authors declare that they have no conflict of interest to disclose. The authors also declare that they did not receive any financial support for the study.

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