



# The Elderly Voice: Mechanisms, Disorders and Treatment Methods

Review

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## Abstract

The elderly population is increasing globally. In Turkey, the population aged 65+ is predicted to grow to more than 15% of the whole population by 2050. Just like the rest of the body, the voice also changes with age. Voice changes throughout life have been reported in up to 52.4% of aged individuals and may have a negative impact on their quality of life. Voice is affected by various factors, including age, disease, hormones, medications, and physiological, psychological, and social conditions. A multidisciplinary approach is therefore needed to achieve the best voice outcomes. In this review, we summarize the mechanisms involved in voice changes in the elderly together with the applicable diagnostic and treatment methods.

**Keywords:** Voice, elderly, presbyphonia, phonosurgery, voice disorders, voice therapy

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## Introduction

In 2020, the elderly population accounted for 18.35% of the total population in high-income countries, but this rate is increasing annually and estimated to reach 24.66% by 2050 (1). The rate of the population aged over 65 years in Turkey was 5.7% in 2000, 7.2% in 2010, and 9.5% in 2020, and is anticipated to exceed 15% by 2050 (1-3).

The human larynx and vocal cords show some changes over time due to various factors, such as age, diseases, hormones,

and medications (4). Majority of the elderly individuals have multiple medical conditions and need to use a range of medications. This population also presents with decreased sex hormone levels. It is therefore inevitable that they experience changes in their voice. Previous studies have shown that the prevalence of dysphonia in the elderly is 4.8–29.1% and rises to 52.4% throughout life (5). The most common voice complaints in the elderly include hoarseness, vocal fatigue, cough, breathy or rough voice, decreased volume and projection (6). Although

dysphonia has a negative impact on the quality of life of the elderly, almost one-fourth of this population consider it to be part of the normal course of aging (7-9). Similarly, in a recent study, Lindström et al. (10) found that although patients thought that the voice was important for them and were aware of the changes in their voices, they did not seek for healthcare professional as they considered it to be a normal part of aging. Voice changes due to aging had a negative effect on their communication skills and social life, particularly in those elderly who did not seek treatment. Nevertheless, the frequently encountered coexistence of voice disorders and hearing impairment may cause depression, anxiety, and social isolation (8). Accordingly, if left untreated, the quality of life can also be affected in many elderly individuals.

Given that this underestimated issue affects at least 10% of the population, we aimed to review the mechanisms, the diagnostic and treatment methods of voice changes in this population.

### The Mechanisms of Voice Changes

Aging causes many changes in the body, and these may have physiological, psychological, and social impacts. The voice is affected by changes in the laryngeal structures as well as the respiratory, resonator, secretory, and velopharyngeal functions and the individual's emotional status (11). Presbylarynx is defined as age-related changes in the larynx, such as epithelial, thyroarytenoid muscle and elastic fiber atrophy resulting in incomplete glottal closure, vocal cord bowing and prominent vocal process (12). Turk and Hogg (13) showed how calcification and ossification of the laryngeal cartilage framework could differ among individuals as they age. Liu et al. (14) found that the antero-posterior dimensions of the cricoid cartilage change with age and gender. However, such changes are not limited to the laryngeal cartilage framework. Previous studies reported ankylosis, narrowing, and degeneration, including thinning and irregularities of the articular surfaces and disorganization of the collagen matrix of the cricoarytenoid joint, and concluded that the mobility capacity and smoothness of the vocal cords could be affected by age (11, 15, 16). Furthermore, decreases occur in the number of the myelinated fibers of the laryngeal nerves, the blood supply, and the size and number of motor units (11, 17, 18). The laryngeal muscles therefore atrophy with age. Rodeño et al. (19) found an increase in the type 1 and a decrease in the type 2 fibers of the thyroarytenoid muscles and further detected a decrease in the type 1 and an increase in the type 2 fibers of the posterior cricoarytenoid muscle. Nevertheless, the vocal cords of the elderly also demonstrate some histological differences when compared with those of younger individuals. The vocal cords include five histological layers: the epithelium, the superficial, intermediate, and deep lamina propria, and the thyroarytenoid muscle. An increase in epithelial thickness, yellowing with a loosening

of the underlying lamina propria attachment, and reduced epithelial cell density have been reported (20). Hirano et al. (21) found that the vocal cord shortened in males and the mucosa thickened in females as they age. The authors also detected edema in the superficial layer of the lamina propria in both sexes, a deterioration and atrophying of the elastic fibers, thinning of the intermediate layer, and thickening in the deep layer in males. All these changes may therefore contribute to the development of presbylarynx, bowing and contour irregularities in the vocal cord mucosa. Atrophy, degeneration, and a decrease in the density, distribution, and number of the salivary glands of the larynx may cause both irregularities during vibration and laryngeal sicca syndrome (11, 22).

Ageing produces many changes in the respiratory function, such as decreases in muscle strength, lung function and elasticity, exercise capacity, and chest wall compliance and increases in the alveolar dead space and air space sizes (23). Adequate pulmonary function is needed for a sustained and effective voice. A sustained and effective voice is needed for adequate pulmonary function. It is therefore possible for the elderly to experience shortness of breath, coughing or increased mucus production, and a breathy and raspy voice irrespective of whether or not they have a pulmonary disease (24).

Voice is further affected by the hormonal status of individuals as vocal cords contain progesterone, androgen, and estrogen receptors (4). Previous studies have shown that voice changes occur during the menstrual cycle, menopause, and even precocious puberty (25). Vocal fatigue, lowered vocal intensity, and loss of high tones and voice quality are apparent in menopausal individuals as part of menopausal vocal syndrome (26). However, Gugatschka et al. (27) found that estrogen, but not androgen, levels had a significant correlation with voice parameters in males. They further determined that elderly people with low levels of estrogen had a low voice-related quality of life.

Voice can also be affected by many systemic and/or local factors, including thyroid disease, obesity, hypertension, cancer, coronary artery disease, diet, cerebrovascular disease, stroke, rheumatological diseases, neurological (i.e., Parkinson's disease, essential tremor, Alzheimer's disease) or psychological conditions (i.e., depression), intellectual capacity, dentition, and hearing loss (8, 28).

Meenan et al. (24) suggested that an evaluation of pulmonary function should be included in voice assessments. Correspondingly, Woo et al. (29) showed that pulmonary disease and hypertension were the most common accompanying diseases among the elderly with voice complaints. Furthermore, 53.6% of these patients had a systemic disease, and more than one-third had been prescribed one or more medications. Santos et al. (28)

identified presbylarynx in 41% of their patients with chronic medical illnesses; among whom type 2 diabetes mellitus, pulmonary disease, or psychiatric conditions were more common alongside presbylarynx. The authors concluded that presbylarynx could be an indicator of the health status of the elderly.

Martínez-Nicolás et al. (30) conducted a systematic review, and using voice analysis determined with an accuracy of over 80% that mild cognitive impairment and Alzheimer's disease could be present in individuals with decreased and wider variability in fundamental frequency ( $F_0$ ), shimmer, and noise-to-harmonic ratio (NHR). The relationship between Parkinson's disease and voice changes is well established. A rough, weak/asthenic, breathy voice, hypophonia or monoloudness, higher pitch levels, and monopitch, which are reflected in voice analyses as decreased harmonics-to-noise ratio and increased  $F_0$ , jitter, and shimmer, are typical characteristics of the voice changes in patients with Parkinson's disease (31).

Edema, hyperemia, swelling in the larynx mucosa, and/or cricoarytenoid joint involvement, and/or vocal cord nodules are discernible in patients with rheumatoid arthritis or other rheumatological diseases. Different phases of rheumatoid arthritis cause some voice changes, such as higher jitter and NHR, during the remission phase (32). Meanwhile, diseases of the thyroid gland can cause shortness of breath when speaking and roughness of the voice due to changes in the lamina propria (33).

### Diagnosis

Some voice changes, such as reduced volume and projection, easy fatigability, tremor, a higher pitch in men and a lower pitch in women, a rough or breathy voice, a decreased maximum phonation time, dysphagia, and hoarseness are observed in the elderly population (6, 7, 34). A detailed medical history should be taken before any voice examination to determine the presence of these diseases or conditions,

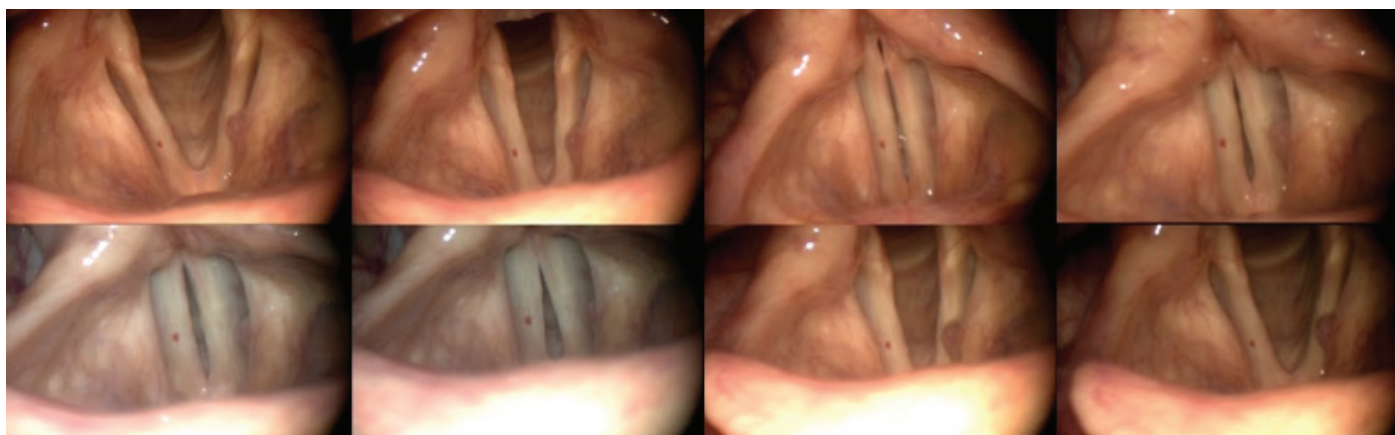
trauma, surgery, intubation, infection, medications, tobacco and/or alcohol consumption, and signs of laryngopharyngeal reflux. Patients should be examined physically, followed by videostroboscopy, and an acoustic voice analysis should be performed. Determining hearing loss is also crucial to increase speech intelligibility and quality of life in the elderly (6, 7, 11).

### Videostroboscopy

Videostroboscopy is an essential tool used in the examination of moving vocal cords. It allows high-speed vocal cord vibrations to be detected with the naked eye by slowing down the vibrations using flashing lights during the glottic cycle and provides the opportunity to assess vibration absence or asymmetry and laryngeal closure abnormalities (35). Nevertheless, videostroboscopy requires the cooperation of the patient, and prolonged phonation is needed to utilize the "slow-motion" effect and perform an optimal evaluation. It may therefore not be suitable for all individuals, particularly patients with neuropsychiatric disorders. Glottal incompetence, vocal cord atrophy, the prominence of the vocal process of the arytenoid cartilage, bowing, edema, reduced amplitude, and the periodicity of mucosal waves may be observed during evaluations of presbylarynx using videostroboscopy (Figure 1) (11). In addition, previous studies have shown that presbylarynx is generally accompanied by one or more voice disorders, including laryngopharyngeal reflux, vocal cord paralysis/paresis, muscle tension dysphonia, a benign (Figure 2), premalignant, or malignant vocal mass (Figure 3), tremor, and laryngitis (6, 34, 36).

### Acoustic Voice Analysis

Acoustic voice analysis, which provides objective measurements of speech, is a software-based assessment tool. Descriptions of the outcome variables of voice analysis programs have been clearly defined in numerous studies. To summarize,  $F_0$  demonstrates the number of times a sound wave occurs within a short time period. Short-term perturbation in  $F_0$  is shown by jitter.



**Figure 1.** One glottic cycle during examination using videostroboscopy that shows vocal cord atrophy, prominence of vocal process and glottic insufficiency

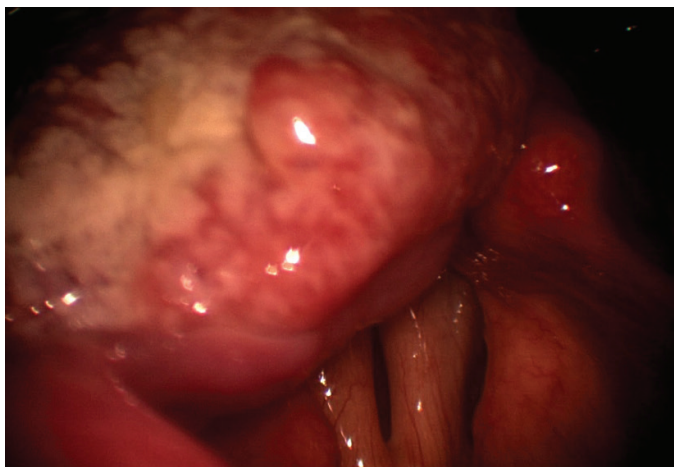


Shimmer reflects the amplitude variation of a voice. NHR is the ratio between the periodic or harmonic components and the non-periodic or non-harmonic components of a voice. Notwithstanding, it is important to note that the values of the outcome variables may differ depending on the software used (37).

Voice parameters not only change with age, but also differ based on gender (8, 11). The results of voice analyses in previous studies have demonstrated a higher  $F_0$  in males and lower  $F_0$  in females, as well as higher variability in intensity and  $F_0$ , increased jitter (perturbation), shimmer (perceptual qualities of harshness and roughness), and NHR, and decreased maximum intensity levels and maximum phonation time in both sexes in the elderly compared to younger subjects (6, 8, 11, 38). On the other hand, the Grade, Roughness, Breathiness, Asthenia, Strain (GRBAS)



**Figure 2.** Right-sided hemorrhagic polyp and glottic insufficiency in a 65-year-old male patient



**Figure 3.** Right-sided supraglottic laryngeal carcinoma in a 67-year-old female patient

scale, the Roughness, Breathiness, Hoarseness scale, and the Consensus Auditory-Perceptual Evaluation of Voice are widely used tests to assess perceptual voice (39). More specifically, Etter et al. (40) described the Aging Voice Index (AVI) as including the following six items: the ability to be understood by others, a feeling of being inhibited by one's voice, the energy and effort required to make a sound, dissatisfaction with the sound of one's voice, the emotional impact of a lack of voice quality, and the inhibiting effect of one's voice on activities one enjoys. The authors found that the mean AVI scores were 6.05 and 37.82 in normal larynx and presbylarynx, respectively.

### Voice Disorders

Although presbylarynx itself causes voice changes, it is generally accompanied by one or more organic and/or functional voice disorders. Gregory et al. (6) reported that laryngopharyngeal reflux (91%) to be the most common condition present with presbylarynx, followed by muscle tension dysphonia (73%), paresis (72%), vocal cord mass (31%), varicosity/ectasia (19%), glottic insufficiency (19%), Reinke's edema (14%), tremor (13%), vocal cord stiffness (12%), scarring/fibrosis (11%), leukoplakia (3%), and cancer (2%). Spasmodic dysphonia, hemorrhage, pseudosulcus vocalis, fluctuating neuro-asymmetry, neurogenic dysphonia, anterior glottic web, sulcus vocalis, sulcus vergeture, and candida were the other conditions (29%). While the incidence of presbylarynx was only 11.6% in the series of the elderly with voice complaints by Mahmoud et al. (36), benign vocal fold lesions (34%) was the most common voice disease in the elderly in the study by Çiyiltepe and Şenkal (34). It may be concluded that although the incidence and frequency of age-related voice disorders vary, the reasons are similar.

### Treatment Methods

Although there are many treatment options, including medical, surgical, and voice therapy, the management of voice disorders mainly consist of one or more combinations of these. Moreover, given their complexity, a multidisciplinary approach is crucial to achieve an optimal improvement in voice quality.

### Medical

Medical therapy should include the treatment of any underlying medical diseases and be evaluated by the relevant department. Regardless of such diseases, given that physical age has a notable effect on voice, physical exercise and proper nutrition should be recommended to maintain muscle function, increase lung capacity, and reduce cardiovascular risk (8, 11). Treatment of a loss of dentition and hearing loss is also crucial to enhance life quality.

Laryngopharyngeal reflux, infectious laryngitis, and oral care are some of the reasons medical therapy might be needed (6, 8). Moreover, hormonal replacement therapy may be an option in patients with voice changes resulting from menopause (4). Karbiener et al. (41) used chronic electrostimulation of the recurrent laryngeal nerve as a novel technique to reverse age-related muscle atrophy in an animal model and found a statistically significant difference between the stimulated and non-stimulated sides of the mean muscle fiber diameters ( $p < 0.001$ ). Gugatschka et al. (42) reported a statistically significant improvement in voice-related quality of life and subjective voice perception in patients treated with electrostimulation of the recurrent laryngeal nerve, but an improvement was not apparent in objective voice assessments. Although this procedure is promising, the long-term effects are still unknown.

### Voice Therapy

Voice therapy is a widely used and effective method for the treatment of benign vocal cord pathologies. According to a survey conducted with laryngologists, most of them preferred voice therapy as a first-line treatment of presbyphonia (12). Various studies have demonstrated the effectiveness of voice therapy in the elderly (43). For example, Bick et al. (44) reported a significant improvement in the results of voice analyses and voice-related quality of life in the elderly with vocal cord atrophy who underwent voice therapy. Kaneko et al. (45) showed voice therapy to be an effective treatment for improving vocal function and thyroarytenoid muscle activity confirmed with laryngeal electromyography in patients with aged vocal cord atrophy. Interestingly, Lin et al. (46) showed that both tele-practice and face-to-face voice therapy led to statistically significant improvements in voice outcomes, including Voice Handicap Index-10 outcomes, and no significant difference was evident between the methods. Tele-practice may be an alternative for patients who cannot participate in face-to-face voice therapy.

### Surgery

Laryngeal surgery is mainly considered in patients with malignancy or those who have not benefitted from voice therapy, and have a benign vocal mass or glottic insufficiency due to presbylarynx or paralysis (47). It is crucial to understand when such procedural intervention is needed as a first-line treatment. Sund et al. (12) found in their survey among laryngologists that severe glottal insufficiency (87%), high occupational/social voice demands (76%), voice not stimuable for change (73%), difficulty attending voice therapy (70%), severe dysphonia (65%), and dysphagia (61%) were the causes of choosing a procedural intervention as a first-line treatment. Injection laryngoplasty using calcium hydroxyapatite or hyaluronic acid can be performed as an office procedure; however, repeated injections may be required due to absorption. Vocal fold injection augmentation

by autologous adipose tissue may be preferably performed under general anesthesia in the operating room. Kwon et al. (48) reported that 12 months after injection laryngoplasty with calcium hydroxyapatite, patients showed improvement in both subjective and objective voice measurements. González-Herranz et al. (49) found that elderly patients treated with autologous adipose tissue for presbyphonia had improvement in Voice Handicap Index-10 outcomes, maximum phonation time, and GRBAS scale during a mean 22.89-month follow-up. Another method, as a durable treatment option, for glottic incompetence is type I (medialization) thyroplasty which needs to be performed in an operating theater under local anesthesia in patients with larger glottic gap or those who did not sufficiently benefit from voice therapy or injection laryngoplasty (8, 47).

Allensworth et al. (50) demonstrated the effectiveness and safety of bilateral type I thyroplasty in patients with presbylarynx. Further, Sund et al. (12) reported that most of the laryngologists (81%) preferred injection laryngoplasty [calcium hydroxyapatite (15%) and lipoinjection (11%)] before a permanent treatment method [bilateral type 1 thyroplasty (71%)]. Botulinum toxin injection has been established as an effective treatment method for spasmodic dysphonia (6), while vocal cord polyp, sulcus vocalis, Reinke's edema, and vocal cord scar could be treated with laryngeal phonosurgery to protect the vibratory properties of the vocal cords.

### Conclusion

Voice changes in the elderly involve complex mechanisms and require a multidisciplinary approach from the early stages of diagnoses through to the final phases of treatment. Recognition of voice problems, which are thought to be normal part of aging, by physicians and the elderly population, and referring them to a laryngologist and a speech-language pathologist are crucial steps in increasing voice outcomes. While voice therapy is the first method of choice, expectations of the patients, laryngoscopic findings, coexistence of dysphonia and dysphagia may indicate a need for surgical intervention.

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### Authorship Contributions

Concept: S.B., L.Y., Design: S.B., H.B., Data Collection and/or Processing: S.B., H.B., Z.Ç.B., Literature Search: S.B., L.Y., H.B., Z.Ç.B., Writing: S.B., L.Y.

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**Main Points**

- Just like the organs in the human body, also voice changes with age. The prevalence of dysphonia in the elderly is up to 52.4% throughout life.
- Although dysphonia has a negative impact on the life quality of the elderly, almost one-fourth of this population consider it to be part of the normal course of aging.
- Some voice changes, such as reduced volume and projection, easy fatigability, tremor, a higher pitch in men, a lower pitch in women, a rough or breathy voice, a decreased maximum phonation time, dysphagia, and hoarseness are observed in the elderly population.
- Glottal incompetence, vocal cord atrophy, prominence of the vocal process of the arytenoid cartilage, bowing, edema, reduced amplitude, and periodicity of mucosal waves may be observed during evaluations of presbylarynx using videostroboscopy.
- While there are many treatment options, including medical, surgery, and voice therapy, the management of voice disorders mainly consists of one or more combinations of these and requires a multidisciplinary approach from the early stages of diagnosis through to the final phases of treatment.

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