**An Epidemiological Analysis of Vocal Fold Atrophy at a Japanese Centre**

Short running title: Vocal Fold Atrophy Epidemiology

**Data availability statement**:

The data that support the findings of this study are available from the corresponding author, [TH], upon reasonable request.

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**Ethics approval statement**: This study was conducted in accordance with the principles of the Declaration of Helsinki and. Prior to commencement, the study was reviewed and approved by the Ethics Committee of our institution (including approval numbers).

**Patient consent statement**: Informed consent was obtained from research participants in an opt-out manner.

**Permission to reproduce material from other sources**: Not applicable.

**Clinical trial registration**: Not applicable.

**Author Contributions: TH** designed the main conceptual ideas and collected the data. **YW** aided in interpreting the results on the manuscript. Both authors discussed the results and commented on the manuscript.

**Abstract**

**Objective**: To update the epidemiological understanding of vocal fold atrophy (VFA), a condition with increasing morbidity in an ageing global population by assessing prevalence and phonographic characteristics by age, gender, and occupation.

**Design**: Retrospective chart review

**Setting**: Single centre

**Participants**: The study analysed medical records of patients diagnosed with VFA for the first time from January 2020 to December 2022.

**Main Outcome Measures:** Parameters such as age, sex, maximum phonation time (MPT), Voice Handicap Index (VHI), occupation, and voice disease complications were extracted and analysed.

**Results**: The study included 610 patients (319 women and 291 men), with ages ranging from 17 to 96 years (median, 64; mean, 61.14). The majority of patients were in their 70s, with a higher prevalence of women than men overall but more men in their 60s and an equal gender distribution among patients in 70s. Among participants aged 60 and above, 185 were women and 189 were men. On the other hand, some patients were diagnosed with atrophy at a young age. Most participants were unemployed, and the most common complication was functional dysphonia. A moderately negative correlation was found between VHI and MPT in unemployed men. Other analyses showed no or weak correlations between age, sex, occupation, and complications.

**Conclusion**: VFA is not exclusively a disease of older men. The study suggests that early diagnosis and appropriate use of simple tests, such as MPT, could potentially extend healthy life expectancy in unemployed men diagnosed with this condition.

**Keywords**: vocal fold atrophy, Voice Handicap Index, maximum phonation time

**Key Points**:

* This study aimed to update the epidemiological understanding of vocal fold atrophy
* We found that even young people can suffer from vocal fold atrophy
* Vocal fold atrophy may not differ by sex if young people are included in the sample
* Maximum phonation time and the Voice Handicap Index are correlated in unemployed men
* Early diagnosis and appropriate use of simple tests, could potentially extend healthy life expectancy in unemployed men with vocal fold atrophy

**INTRODUCTION**

The population of the world, including that of our country, is ageing [1]. Therefore, vocal fold atrophy (VFA), the most common voice disorder, the morbidity of which increases with age, has become a global concern. Reports exist, including from our country, on basic histological studies [2-5], diagnostic methods [6], and treatment methods, such as voice therapy [7] and injection therapy [8]. However, in our country, this disease is not as well-known as head and neck cancer, and it is unclear whether even otolaryngologists who examine the vocal fold are fully aware of the disease. This low awareness may be one of the reasons for the limited research on this disease despite the expected increase in affected individuals with population ageing. Consequently, appropriate evaluation and management of the disease have not yet been achieved [9]. In that context, Takano et al. [10] clinically analysed the relationship between age, maximum phonation time (MPT), and mean flow rate (MFR) in 72 patients with VFA. However, this paper was published in 2010, over 10 years earlier. As the population in our country is experiencing an ageing demographic shift, the epidemiology of VFA has likely evolved accordingly. Additionally, in those previous studies [9,10], the sample size was inadequate and Voice Handicap Index (VHI), the indicator considered most important for voice evaluation, was not assessed. Against this background, we noted that epidemiological information on recent patients with VFA in our country is not yet available.

Thus, herein, we extracted medical record information, such as age, MPT, VHI, occupation, and complications of patients diagnosed with VFA for the first time in our institution and investigated the relationship among them.

**MATERIALS AND METHODS**

In total, 610 patients (319 women and 291 men) visited our centre between January 2020 and December 2022. The vocal folds were examined by a physician specialising in voice at the Department of Otolaryngology. During the study period, diagnostic criteria for VFA had not been developed. Therefore, the physician diagnosed VFA by laryngoscopy and stroboscopy based on the glottal gap in the closed phase and a comprehensive judgement of voice and other data. We did not diagnose VFA if the bilateral vocal process were not in contact in cases where bilateral vocal fold protrusions can be observed during vocalisation. We excluded patients diagnosed with VFA in the past, including patients who required repeated consultation and patients treated with voice therapy (VT) or other therapeutic interventions without voice examination (e.g., MPT, VHI) at the first visit, as the effectiveness of VT and other treatments was considered to create a bias. Moreover, we excluded patients who had lost voice data at the first visit and those with VFA due to vocal fold paralysis (such as bilateral vocal fold paralysis, unilateral complete paralysis, incomplete paralysis). Herein, a complication was defined as a voice disorder present in a patient diagnosed with VFA. If two voice disorder complications were present (e.g., a patient with VFA had both vocal fold polyps and functional dysphonia), they were listed as duplicates.

Items extracted from the medical records included age, sex, MPT, VHI, occupation, and voice disease complications at the first diagnosis. Data were analysed using R version 4.3.2. Correlations of MPT and VHI with the other variables were investigated. Correlations between parameters were categorised as follows: | r | = 0.7 to 1 indicated a fairly strong correlation; | r | = 0.4–0.7, a moderate correlation; | r | = 0.2–0.4, a weak correlation; and | r | = 0 to 0.2, almost no correlation.

This study was conducted in accordance with the principles of the Declaration of Helsinki and was designed as an opt-out study for research participants. Prior to commencement, the study was reviewed and approved by the Ethics Committee of our institution (including approval numbers).

**RESULTS**

**Epidemiological results**

The epidemiological findings are summarised in Table 1. A total of 610 patients (319 women and 291 men) were included. The patients’ ages ranged from 17 to 96 years (median, 64 years; mean, 61.14 years), with most men and women being in their 70s. Approximately 25% of the patients were aged below 50 years, and some patients in their teens and 20s were diagnosed with VFA. There were more women than men overall, more men in their 60s, and approximately equal numbers of men and women in their 70s. Among those 60 years and older, there were 185 women and 189 men, with more men.

Functional dysphonia was the most common complication, followed by gastroesophageal reflux disease (GERD). GERD is a gastrointestinal disorder. However, as GERD is often associated with voice disorders, we classified it as a complication of voice disorders. Other voice and vocal fold complications included dysphagia, microvascular lesions, and voice tremors. There were 27 duplicate cases (e.g., functional dysphonia and GERD).

Most patients were unemployed, whereas most employed patients were company clerks. The second most common occupational group was professional vocal performers (VPs). VPs included elite VPs, i.e., singers, actors, or others who use their voices as professionals; amateur singers; and music students. Our institution is characterised by a large number of voice users visiting. The desk workers among patients included lyricists, writers, painters, programmers, and real estate managers. As their amount of voice use was unknown, they were considered separate from company clerks. Fifteen patients had undisclosed occupations. Other participants included transportation workers, hairdressers, and cleaners.

**Relationship between age, VHI, and MPT**

A negative correlation existed between age and MPT (Fig. 1A; R = -0.14), age and VHI (Fig. 1B; R = -0.13), and MPT and VHI (Fig. 1C; R = -0.21) for all patients, including 319 women and 291 men.

Figure 2 shows the relationship between age and MPT (Fig. 2A; R = 0.03), age and VHI (Fig. 2B; R = -0.12), and MPT and VHI (Fig. 2C; R = -0.26) in the 110 unemployed individuals (women: 59; men: 51). The relationship between MPT and VHI in the unemployed women (R = -0.14) and men (R = -0.42) are shown in Fig. 3. No significant correlation was found in women. However, a moderate negative correlation between MPT and VHI was observed in unemployed men.

The correlation between age and MPT (Fig. 4A), age and VHI (Fig. 4B), and MPT and VHI (Fig. 4C) for the 96 company clerks (women: 39; men: 57) is shown in Fig. 4. The correlation coefficients were R = 0.01, R = -0.28, and R = -0.23, respectively.

**DISCUSSION**

**Epidemiological results**

In terms of age, the largest number of patients in our study, both men and women, were in their 70s. However, approximately 25% of the patients were under the age of 50 years, and notably, some patients in their teens and 20s were diagnosed with VFA. As indicated by studies [9,10,11,12], most reports highlight VFA in individuals typically in their 60s to 70s. Sugito et al. [9] reported that VFA gradually commences when people reach their 30s. We agree with this suggestion. There is no dispute that VFA is more common in older people due to the effects of ageing. Herein, some patients younger than those mentioned in Table 1 were diagnosed with VFA. Surprisingly, age did not significantly impact two measures, MPT and VHI, suggesting that VFA can affect people at a young age. Although not many, we have real clinical experience with cases where vocal fold ageing does not correlate with actual age ageing. Given the lack of a severity classification for VFA, it remains difficult to determine therapeutic interventions. However, failure to accurately diagnose VFA in young patients can delay therapeutic intervention and deprive the patient of opportunities for voice improvement. Voice physicians must recognise the presence of VFA in young patients and consider less invasive therapeutic interventions, such as VT.

In terms of sex, there were more women in this study. VFA is less common in women than in men. [9,10,11,12] Pontes et al. [13] reported that age causes VFA in men but oedema in women. Honjo et al. [14] reported that vocal fold oedema in women is thought to be influenced by sex hormones. Therefore, women may be less likely to experience emphysematous hoarseness than men, even with VFA, because vocal fold oedema fills the glottal gap in VFA.

In terms of occupation, most of our patients were unemployed, a situation typically associated with less frequent voice use. Most employed patients were company clerks, whose usual work involved preparing documents and so on, typically requiring infrequent use of the voice.

In terms of complications, functional dysphonia was common. Koufman and Blalock [15] categorised laryngeal findings of functional dysphonia into four types (type I: glottal gap during vocalisation, type II: proximity between bilateral false vocal folds due to compensatory vocalisation; type III: moderate proximity between arytenoids and the petiole of the epiglottis; and type IV: very close proximity with barely observable vocal folds), all of which were encountered in the present study.

**Relationship between Age, MPT, and VHI by occupation**

Takano et al. [10] reported that age and MPT were negatively correlated. We also believed that MPT would decrease with age because VFA is associated with age-related changes in the vocal folds. However, we found no significant correlation between age and MPT. Our institution is a specialised in voice; therefore, patients from various occupations visit our institution. Hence, the connection between VHI, MPT, and age might have been less clear due to the inclusion of many VPs, who used their voices more often. Therefore, we investigated the relationship between age and VHI, age and MPT, and MPT and VHI in subgroup analyses by occupation and sex (Table 2; Figs. 2–4). We found only a moderately negative relationship between MPT and VHI in unemployed men. Conversely, no or weak correlations were found for other occupations or sex-based analyses. This finding may provide an important basis for developing a severity classification of this disease. The MPT, an objective item, evaluates the duration of monovowel /a/ after maximal inhalation. Thus, it can determine one aspect of monovowel sounds; however, it is difficult to assess the symptoms of the disease, i.e., patient satisfaction. In VFA, MPT may be one of the most important but not the most important indicators. Therefore, it may be better to consider not only MPT in severity classification, but also MFR, bowing index, and other indices that reflect the glottal gap.

Next, to examine the moderately negative relationship between MPT and VHI in unemployed men, we report below on the characteristics of retired men in our country. Retirement is a major turning point in the later stages of life [16-18]. In our country, 94.4% of companies have a mandatory retirement age of 60–65 years [19], and large-scale observational studies on retirement have shown that retirement generally benefits mental health [20], with positive effects on the body and mind [21]. However, in our country, pre-retirement men have poor social interactions because of their involvement in work, and they find it difficult to participate in social interactions once they retire. The issue is that reduced social interaction and activity increase mortality [22,23]. Various causes of reduced social interaction and activity increase mortality, including locomotive syndrome. We believe that difficulty producing voice due to VFA is also one of the causes. We believe that the reduced use of the voice due to VFA may indirectly increase mortality because it further contributes to reduced social interaction and activity. Moreover, [Angerstein](https://pubmed.ncbi.nlm.nih.gov/?sort=pubdate&term=Angerstein+W&cauthor_id=30406619) suggested that presbyphonia increases the risk of aspiration [24], and directly VFA may increase mortality from aspiration pneumonia. Additionally, in terms of sex, Marrie et al. reported that pneumonia in older nursing home residents was more common in men [25]. Consequently, reduced opportunities to use one's own voice, particularly among men, may directly and indirectly lead to increased mortality. Thus, in our super-ageing society, we believe that VFA in unemployed men is a disease that should not be left untreated.

The MPT is a simple test to determine how long a person can sustain voice use in monovowel sounds. Although it is impossible to accurately assess patient satisfaction, a moderately negative relationship exists between MPT and VHI in unemployed men. We suggest that if the MPT is low in an unemployed male, he may not be satisfied with his voice and should be referred to a specialist for suspected VFA. Early therapeutic interventions such as VT [7] and intracordal injection [8]can prolong healthy life expectancy.

Conversely, there was no relationship among age, MPT, and VHI in women. We believe that social interaction and activity, which are more common among women in our country, could also be a significant factor in sex differences in VFA.

**LIMITATION**

Given that this was a retrospective study based on an analysis of medical records, it did have certain limitations. First, the diagnostic criteria used to determine VFA were not established during this research period for this paper, and it is difficult to differentiate this condition from type 1 functional dysphonia or sulcus in young patients. Even with normal vocal folds, a glottal gap may be observed in the closed phase during high-pitched tones. This may have led to an increase in the diagnosis of VFA in women and young people herein. In addition, the VFA diagnosis had been made by different physicians specialising in voice disorders at the Department of Otolaryngology, and physicians with different lengths of experiences made individual diagnosis based on disease history, cause of onset, mean flow fate and other acoustic data. Therefore, the criteria for diagnosis could vary from physician to physician. Second, given many patients who visit our institution are elite VPs whose careers are based use their vocal contributions, such as singers and actors, we conducted a subgroup analysis according to occupation. Nevertheless, there may still have been some extent of selection bias. Furthermore, today, there are many occupations. Given that there was no significant correlation between MPT and age, the analysis was stratified by occupation; however, the results may differ depending on how the occupations are classified. Finally, although we have described the characteristics of men who retired at the age of 65 years, a small number of men among the unemployed were younger than 65 years in age and had yet to reach the age of retirement.

**CONCLUSION**

We found that (1) even young people can suffer from VFA, (2) VFA may not differ by sex if young people are included, and (3) MPT and VHI are correlated in unemployed men. We do not believe that VFA should be considered a disease that affects only men or older people. As the population ages, the morbidity of VFA and aspiration pneumonia is expected to increase in our country and worldwide. It may be possible to extend the healthy life expectancy of unemployed men diagnosed with VFA if simple tests, such as the MPT, are used appropriately.

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**TABLES**

**Table 1**. Patient background characteristics

|  |  |  |  |
| --- | --- | --- | --- |
|  | No. | Female | Male |
| Total | 610 | 319 | 291 |
| Age (years) |  |  |  |
| ≤ 19 | 2 | 1 | 1 |
| 20–29 | 29 | 20 | 9 |
| 30–39 | 49 | 24 | 25 |
| 40–49 | 67 | 39 | 28 |
| 50–59 | 89 | 50 | 39 |
| 60–69- | 138 | 59 | 79 |
| 70–79 | 171 | 87 | 84 |
| 80–89 | 62 | 38 | 24 |
| ≥ 90 | 3 | 1 | 2 |
| Complications |  |  |  |
| None | 431 | 229 | 202 |
| Functional dysphonia | 53 | 29 | 24 |
| GERD\* | 29 | 17 | 12 |
| Sulcus | 22 | 4 | 17 |
| Chorditis | 19 | 10 | 9 |
| Others | 29 | 18 | 11 |
| Duplication | 27 | 11 | 16 |
| Occupation |  |  |  |
| Unemployed | 110 | 59 | 51 |
| Company clerk | 96 | 39 | 57 |
| VP\*\* | 78 | 49 | 29 |
| Homemaker | 63 | 63 | 0 |
| Management | 58 | 12 | 46 |
| Teacher | 44 | 24 | 20 |
| Desk workers | 26 | 6 | 20 |
| Announcer | 19 | 11 | 8 |
| Medical profession | 17 | 8 | 9 |
| Service industry | 17 | 7 | 10 |
| Unidentified | 15 | 7 | 8 |
| Receptionist | 15 | 10 | 5 |
| Entertainment | 11 | 3 | 8 |
| Part-time job | 6 | 5 | 1 |
| Student | 6 | 4 | 2 |
| Shinto priest | 5 | 2 | 3 |
| Consultancy | 4 | 0 | 4 |
| Others | 20 | 10 | 10 |

\*GERD, gastroesophageal reflux disease

\*\*VP, voice performer

**Table 2**. Analysis of correlations among age, MPT, and VHI by occupation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Occupation |  | Total | Female | Male |
| All |  | 610 | 319 | 291 |
|  | MPT-Age | -0.14 | -0.11 | -0.19 |
|  | VHI-Age | -0.13 | -0.14 | -0.13 |
|  | MPT-VHI | -0.21 | -0.21 | -0.23 |
| Unemployed |  | 110 | 59 | 51 |
|  | MPT-Age | 0.03 | 0.01 | -0.01 |
|  | VHI-Age | -0.12 | -0.11 | -0.1 |
|  | MPT-VHI | -0.26 | -0.14 | -0.42 |
| Company clerk |  | 96 | 39 | 57 |
|  | MPT-Age | 0.01 | -0.08 | 0.04 |
|  | VHI-Age | -0.28 | -0.38 | -0.22 |
|  | MPT-VHI | -0.23 | -0.28 | -0.21 |
| VP\* |  | 78 | 49 | 29 |
|  | MPT-Age | -0.18 | -0.03 | -0.39 |
|  | VHI-Age | -0.06 | 0.05 | 0.096 |
|  | MPT-VHI | -0.19 | -0.29 | -0.05 |
| Homemaker |  | 63 |  |  |
|  | MPT-Age | -0.02 |  |  |
|  | VHI-Age | 0.04 |  |  |
|  | MPT-VHI | -0.12 |  |  |
| Complications |  | 431 | 229 | 202 |
|  | MPT-Age | -0.13 | -0.14 | -0.16 |
|  | VHI-Age | -0.06 | -0.07 | -0.06 |
|  | MPT-VHI | -0.22 | -0.18 | -0.26 |
| Age > 50 years |  | 462 | 234 | 228 |
|  | MPT-Age | -0.13 | -0.12 | -0.14 |
|  | VHI-Age | -0.09 | -0.06 | -0.12 |
|  | MPT-VHI | -0.23 | -0.18 | -0.29 |

MPT, maximum phonation time; VHI, Voice Handicap Index

**FIGURE LEGENDS**

**Figure 1:** The relationship between A: Age and MPT, B: Age and VHI, and C: MPT and VHI in all patients (total: 610; women: 319; men: 291). The correlation coefficients were R = -0.14, R = -0.13, and R = -0.21. MPT, maximum phonation time; VHI, Voice Handicap Index

**Figure 2:** The relationship between A: age and MPT, B: age and VHI, and C: MPT and VHI in unemployed patients (women: 59; men: 51). The correlation coefficients were R = 0.03, R = -0.12, and R = -0.26, respectively. MPT, maximum phonation time; VHI, Voice Handicap Index

**Figure 3:** The relationship between MPT and VHI in unemployed A: women and B: men. The correlation coefficients were R = -0.14 for women and R = -0.42 for men. No correlation was found in women; however, a moderate negative correlation was observed in men. MPT, maximum phonation time; VHI, Voice Handicap Index

**Figure 4:** The relationship between A: Age and MPT; B: Age and VHI; and C: MPT and VHI in company clerks (total: 96; women: 39; men: 57). The correlation coefficients were R=0.01, R=-0.28, and R=-0.23, respectively. MPT, maximum phonation time; VHI, Voice Handicap Index