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ORIGINAL ARTICLE

The Effect of Medical Treatment on Voice Quality in Allergic Rhinitis

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Abstract To evaluate the change in the voice quality of patients with allergic rhinitis (AR) after medical treatment. The study enrolled 69 subjects: 39 with high serum-specific IgE levels to inhalant allergens as the study group and 30 healthy individuals as controls. All patients were evaluated using the total nasal symptom score (TNSS) and voice handicap index-10 (VHI-10) and then underwent an acoustic voice analysis. After 1 month of treatment with mometasone furoate nasal spray (two 50-μg puffs in each nostril once daily) and desloratadine (5-mg tablet once daily), the patients repeated the surveys and acoustic voice analysis. The results before and after treatment were compared. The TNSS and VHI-10 scores decreased significantly after treatment ($p < 0.01$). After treatment, the acoustic analysis parameters improved significantly and were similar to the control group, and the maximum phonation time increased significantly ($p < 0.05$). The voice quality of patients with AR is improved with medical treatment.

Keywords Allergic rhinitis · Total nasal symptom score · Voice handicap index · Acoustic voice analysis

Introduction

Allergic rhinitis (AR) is a chronic inflammatory illness that causes upper airway symptoms such as nasal congestion, rhinorrhoea, and nasal itching [5, 6, 7, 8, 13]. Depending on allergen sensitivity, AR may be seasonal or perennial. Patients with AR have episodic or persistent irritation of the upper airways, which may lead to chronic rhinitis and laryngitis [2]. Signs of laryngeal irritation, such as oedema or erythema over the arytenoids, may be absent. Any mucus, if present, is usually thick and sticky. This mucus can dampen the vocal fold mucosal vibrations [2]. Consequently, oedema and excessive mucus on the vocal folds negatively influence voice quality [3]. Additionally, patients cough and clear their throats more frequently [1], which stresses the vocal folds, causing oedema and inflammation of the vocal folds and affecting voice quality.

Patients with seasonal AR usually have symptoms such as rhinorrhoea, nasal congestion, or obstruction. These symptoms can be decreased with medications, or patients may have symptom-free periods. The nasal cavity and its contents incontrovertibly affect the human voice. The structure of the upper airway and nasal cavity affect the resonance of the voice. Diseases like acute rhinitis or sinusitis, nasal septal deviation, allergic rhinitis, and nasal polyposis narrow the nasal passage, thereby changing the resonance of the voice. This is called hyponasality and can be observed both subjectively and objectively.

Although allergic rhinitis is common, few reports have addressed the voice-related quality of life in AR patients. Simberg et al. [14] found that college students with AR had symptoms such as throat clearing, hoarseness, voice fatigue, voice breaks, the sensation of pain or a lump in the throat, or difficulty being heard. Another study used the voice handicap index (VHI) to observe voice problems in patients with AR, who scored significantly higher on the functional and physical domains of the VHI and the total VHI score compared with control subjects [12]. Doğan et al. used acoustic analysis to investigate voice quality in

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asthmatic patients and found an impairment of voice quality [11].

In addition to subjective voice assessments such as the voice-related quality of life and VHI, the voice can be evaluated objectively with acoustic analysis. Although the impact of AR on voice quality has been documented with acoustic analysis, the relationship between voice quality and AR treatment has not been assessed. Therefore, this study examined objective and subjective voice parameters in AR patients and compared the pre- and post-treatment values in patients and healthy controls.

Materials and Method

This prospective clinical study was conducted in the Taksim Training and Research Hospital, Department of Otolaryngology. The subjects were 12–65 years old. To diagnosis AR, the patients were required to have AR symptoms such as nasal obstruction, itching, sneezing, and rhinorrhoea and a physical examination that revealed a pale nasal mucosa and hypertrophy of the inferior turbinates. These patients underwent blood tests for serum IgE levels for airway pathogens and mites (Siemens DPC Immulite). Patients with elevated IgE levels were included in the study.

Exclusion criteria included known asthma, laryngeal intubation within the past 3 months, medical treatment for upper airway disease in the last month, AR medication use, nasal or laryngeal surgery, vocal fold mucosal pathology (e.g., nodules, polyps, or sulcus), smoking, and laryngopharyngeal reflux.

The control group consisted of healthy individuals of similar ages with no AR symptoms or voice problems.

All patients gave informed consent, and the study was approved by the institution ethics committee.

Patient Selection

The patients completed the total nasal symptom score (TNSS) survey, which assesses four AR symptoms: nasal obstruction, itching, rhinorrhoea, and sneezing [15, 18]. The patients are asked to score each symptom from "0" to "3" based on symptom severity, where "0" meant no symptom and "3" meant very severe symptoms [15, 18]. Patients with a TNSS score $\geq$6 were enrolled. Then, the serum-specific IgE levels for common airway pathogens were measured and patients with IgE levels higher than that in the normal population were enrolled. All subjects then underwent laryngovideostroboscopic analysis for vocal fold mucosal pathologies, such as laryngeal oedema, secretions, nodules, polyps, or masses. Patients who completed these steps underwent the subjective and objective voice analysis.

Subjective Voice Analysis

The patients were asked to complete the VHI-10 survey about their voice complaints [1, 10, 16]. This index includes 10 items assessing the impact of voice disorders on daily life. The scores range from 0 to 4 according to the frequency of the problem (0 = never, 1 = almost never, 2 = sometimes, 3 = almost always, and 4 = always). The validated Turkish version of the original VHI-10 was used [16].

Objective Voice Analysis

For the objective voice evaluation, all patients underwent acoustic voice analysis. Using a MAI/CM-903 microphone and Tiger preamplifier, the patients were asked to say/a/for 5 s. The recorded voice was assessed using the Tiger DRS Dr. Speech Vocal Assessment (ver. 4.50). This analysis determines the fundamental frequency (F_0), jitter, shimmer, signal-to-noise ratio (SNR), harmonics-to-noise ratio (HNR), and normalised noise energy (NNE). Then, the patients were asked to take a deep breath and make an/a/ sound during exhalation until the end of their breath. This measurement was repeated three times for all patients, and the best result was counted. This manoeuvre measures the maximum phonation time (MPT). As the MPT is expected to be longer in professional voice users than in non-professionals, to avoid any unbalanced increase in MPT, control subjects were recruited from non-professional voice users.

For treatment, all patients were prescribed a nasal steroid spray (mometasone furoate nasal spray, two 50-μg puffs in each nostril once daily) and antihistamine (desloratadine, 5-mg tablet once daily), as recommended by current medical guidelines [5, 7, 17]. After 1 month of treatment, the patients were re-examined, and the surveys and acoustic analysis repeated.

The TNSS and VHI-10 scores of the patients were determined before and after the treatment, and acoustic analyses were performed for both patients and control subjects. The data were compared using the Statistical Package for the Social Sciences (SPSS) for Windows ver. 10.0. The level significance was $p < 0.05$.

Results

Thirty-nine patients completed the study (23 (59 %) females, 16 (41 %) males; average age 32.53 ± 12.53 (range 15–64) years). All of these patients completed the surveys and acoustic measurements before and after treatment. The control group consisted of 30 healthy individuals (14 females, 16 male; average age 35.03 ± 9.09 (range

Table 1 The TNSS and VHI-10 scores

	TNSS (mean ± SD)	VHI-10 (mean ± SD)
Before treatment	8.97436 ± 1.85653	24.82051 ± 7.59457
After treatment	3.10256 ± 1.60255	14.76923 ± 3.87612
Difference	5.8718 ± 1.94908	10.0513 ± 6.04783
p value*	$p < 0.01$*	$p < 0.01$*

* Statistical analysis was performed using a one-sample test to examine the difference between before and after treatment. A p value < 0.01 was considered significant

22–56) years). All of the study subjects completed the surveys and acoustic analysis.

Subjective Analysis

The mean scores on the TNSS and VHI-10 in the patients were significantly lower after treatment ($p < 0.01$) (Table 1).

Objective Vocal Analysis (Acoustic Analysis)

The data consisted of the F_0, jitter, shimmer, NNE, HNR, and MPT results recorded before and after treatment in the patients and once in the control group. The F_0 did not differ statistically between the groups ($p = 0.43$), but treatment significantly improved the other acoustic parameters (jitter, shimmer, NNE, HNR, and MPT, all $p < 0.05$), and the values approached those for the control group (jitter $p = 0.682$, shimmer $p = 0.94$, NNE $p = 0.79$, HNR $p = 0.69$, and MPT $p = 0.45$) (Table 2 ; Fig. 1).

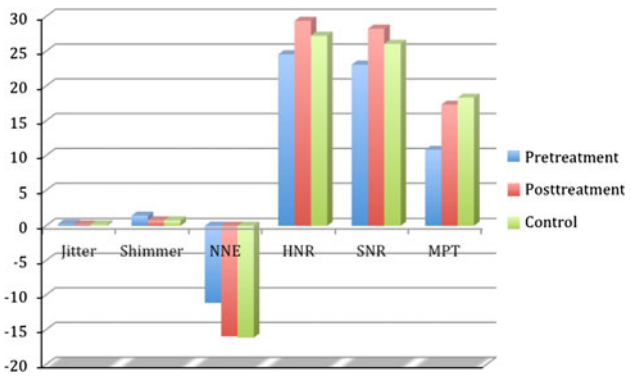

Fig. 1 Graphical demonstration of changes between groups

Discussion

Allergic rhinitis is a symptomatic illness of the nose caused by an inflammatory IgE-dependent reaction of the airways after encountering allergens [5, 17]. Its pathogenesis and physiology are well known. Symptoms can be mild or severe, and the disease can be seasonal or perennial. Worldwide, this disease affects more than 600 million people of all races, ages, and sexes. It affects their social lives, sleep, education, and business lives, seriously affecting their quality of life and productivity [5, 17].

The voice is one of the most important human features, enabling communication with others and individual expression. The voice is a complex physiological process that requires interaction among the respiratory, laryngeal, and resonator systems. All parts of the body can affect the voice directly or indirectly. The pathophysiology of AR is well known, but its effects on the larynx are not well studied. Local or systemic inflammation can trigger some reactions that affect all of the respiratory mucosa [19].

The larynx is the connection between the upper and lower airways. Therefore, it is affected by secretions coming from both. The direct effect of inflammation on the airways is increased mucus secretion, laryngeal oedema in the interarytenoid or vocal process area, cough, and dysphonia [19]. Corey et al. [4] divided allergic laryngitis into acute (anaphylactic) and chronic types.

To examine the acute impact of allergy on the larynx, Reidy et al. [9] studied nine patients who were sensitive to the well known allergen house-dust mites (*Dermatophagoides pteronyssinus*) using skin-prick tests. Allergens were introduced into each patient's larynx via nebulisation. A laryngeal examination and acoustic voice analysis were performed before and 30 min after this. They observed increased mucus secretion and inflammation, but the acoustical measures did not change significantly. They concluded that they could not demonstrate any physical or functional abnormality of the larynx, but they suggested future experiments that changed the method of allergen introduction or increased the duration of allergen impact to analyse the long-term response [9].

Patients with allergies sometimes complain of voice changes during the pollen season. Millqvist et al. [12] examined 30 patients with birch pollen allergy and 30 healthy individuals. The participants were examined twice:

Table 2 Means of the acoustical analysis values pre- and post-treatment and in the controls

	F_0	Jitter	Shimmer	NNE	HNR	SNR	MPT
Pre-treatment	186.7508	0.2946	1.4587	−11.1497	24.5697	23.0864	10.8233
Post-treatment	184.821	0.1882	0.7859	−15.9259	29.401	28.2613	17.3279
Controls	179.4467	0.1953	0.7743	−16.12	27.2507	26.0767	18.3437

once in the pollen season (mid-May) and once in October. All patients completed a questionnaire on their upper and lower airway symptoms and the VHI to evaluate voice dysfunction. Additionally, their voices were recorded, and a voice therapist listened to the recordings to identify any vocal abnormality. They found that all of the patients had vocal problems during the pollen season. They proposed that allergy patients might seek help for voice problems in spring [12].

In Finland, Simberg et al. [14] examined 49 patients with allergy and 54 healthy subjects. All participants completed an 80-item questionnaire asking about AR, vocal problems, and their hobbies and habits. The main part of the questionnaire consisted of seven questions about AR and voice. These seven questions asked about the presence of throat clearing or coughing, hoarseness, a strained or tired voice, voice breaks, a sensation of pain or a lump in the throat, difficulty being heard, and a loss of voice. The patient group reported more frequent vocal problems than the control group, except for hoarseness. Simberg et al. [14] reported that immunotherapy decreased the patients' problems.

These two studies form the basis of our research. Although they both used questionnaires, as we did, they lacked an objective measure of voice quality. This is the main difference between our research and similar studies. We performed objective and subjective assessments before and after treatment and compared the changes with a control group that consisted of healthy individuals.

Statistically, the TNSS scores after treatment decreased significantly in all patients. Therefore, our results clearly show that patients' nasal symptoms decreased with medical treatment, as we expected. We concluded that our patients' AR symptoms decreased with treatment, implying that the swelling and oedema in the upper airways and nasal secretions were decreased. Our main study objective starts from this point. Does the decrease in AR symptoms affect the voice positively or negatively?

We used the VHI-10 for a subjective voice analysis. The results showed a significant decrease in vocal symptoms after treatment. This implied that the treatment of AR decreased nasal secretions, postnasal drip, and coughing, reducing the trauma to the vocal folds and resolving any irritation and oedema. We concluded that as the tension on the vocal cords decreased, the patients needed less effort for conversation. The objective analysis involved acoustical analysis. This procedure changes the vocal energy into numerical values, which then enable statistical analysis. Compared with similar studies, ours differed in the use of acoustic analysis parameters before and after treatment, in the pollen season, to examine the objective effects of medical treatment. Based on the acoustic analysis, we concluded that AR impairs voice quality. The pre-treatment values of the patients improved significantly and became similar to those of the controls.

The maximum phonation time (MPT) is used to measure vocal performance. The expiration volume provides the aerodynamic energy used for phonation, and a decline in aerodynamic energy leads to shortening of the MPT. We found that the MPT was shortened in AR patients compared with the controls. AR seems to cause a decrease in the power supply for the voice, and the treatment of AR increased the MPT, which become similar to the value for the control subjects. This implies that with treatment, patients have less upper airway resistance and a better reservoir for inhaling. Treatment leads to a better, more powerful voice and hence a longer MPT.

Conclusion

Allergic rhinitis can cause vocal problems when its symptoms are increased. This can lead to serious problems, especially for vocal professionals. Our research revealed that combination therapy with a nasal steroid and an oral antihistamine decreases both AR symptoms and vocal problems.

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