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Main Article

Effects of antituberculosis treatment on self assessment, perceptual analysis and acoustic analysis of voice quality in laryngeal tuberculosis patients

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Abstract

Objectives: To evaluate the effects of antituberculosis treatment on the voice quality of laryngeal tuberculosis patients, measured by patient self-assessment, perceptual analysis and acoustic analysis.

Materials and methods: A total of 14 laryngeal tuberculosis patients were enrolled. Laryngeal tuberculosis was established either by biopsy and histopathological examination or by rapid regression of the laryngeal lesions after antituberculosis medication. Before and after treatment, all patients were evaluated perceptually (on a scale of zero to three), and 12 assessed their own voices using the voice handicap index-10 scale. Acoustic analysis was performed to allow objective evaluation.

Results: Patients' ages ranged from 21 to 72 years (mean, 41). The male to female ratio was 12:2. Eight patients (57 per cent) had tuberculous involvement of the epiglottis, four (28 per cent) had involvement of the aryepiglottic fold and eight (57 per cent) had involvement of the false vocal folds. The glottis was the less commonly involved part of the larynx, including true vocal folds (28 per cent, $n = 4$) and posterior commissure (14 per cent, $n = 2$). Perceptual evaluation, on a scale of zero to three, gave the patients a median score of six; after commencement of treatment, the median score decreased to two. The mean voice handicap index-10 score decreased from 24 to 12 after treatment. An obvious improvement in acoustic analytical parameters was also found following treatment.

Conclusions: Antituberculosis treatment clearly improved the voice outcomes of laryngeal tuberculosis patients, according to self-assessment, perceptual analysis and acoustic analysis.

Key words: Larynx; Tuberculosis; Voice; Antitubercular Agents

Introduction

Despite a dramatic decrease in incidence, laryngeal tuberculosis is still the most frequent granulomatous disease of the larynx.[1] In the past, it commonly developed as a sequel of severe pulmonary tuberculosis, in which the ulcero-infiltrative lesions predominantly affected the posterior portion of the true vocal folds, the arytenoid cartilages and the interarytenoid space. However, the disease has changed its behaviour with regard to average age of onset, site and type of lesion. Macroscopically, it is now likely to appear as diffuse oedema or as a pseudotumour located in any zone.[2–4]

Although the features of laryngeal tuberculosis have been reported in detail in the English literature, the effects of antituberculosis treatment on the voice have not thus far been assessed. We aimed to objectively and subjectively evaluate voice quality following treatment. We also aimed to determine the relationship between the site of laryngeal involvement and the degree of vocal impairment, as well as the degree of vocal improvement following treatment.

Materials and methods

A total of 19 laryngeal tuberculosis patients were evaluated prospectively. The diagnostic criteria were: histopathological examination of the biopsy specimen; presence of acid-fast bacilli in the sputum; and regression of the lesions following antituberculosis treatment. Fourteen patients were diagnosed in the Taksim Education and Research Hospital otolaryngology department and five patients in the otolaryngology department of the Gaziosmanpasa University medical faculty. Pulmonary status at the time of diagnosis was assessed via chest radiography, sputum culture and microbiological analysis with acid-fast bacilli staining. Fourteen patients had active pulmonary tuberculosis, three had a history of pulmonary tuberculosis which was diagnosed as currently

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inactive, and two had normal chest radiographs without any evidence of active lung lesions. Five of the 19 patients were lost to follow up after the beginning of treatment, and were therefore excluded from the study. The first voice analysis was made when the patients were diagnosed with laryngeal tuberculosis and at the same time antituberculosis treatment was started. The second voice analysis was made when the larynx endoscopicaly returned to a near-normal appearance over a period of six weeks to nine months (average, 18 weeks).

Ten patients underwent voice recording at the voice laboratory of the Taksim Education and Research Hospital, within a sound-treated room. A MAI/CM - 903 microphone (Mento, Bucuresti, Romania) with pre-amplifier was placed 5 cm from the mouth. A standard reading text (the first paragraph of the diyet passage) was used, and the patients were asked to read the text at a comfortable pitch and loudness. Videolaryngostroboscopic examination was conducted using a Xion (Munich, Germany) 90º, rigid stroboscope.

The remaining four patients were evaluated at the voice laboratory of the otolaryngology department of the Gaziosmanpasa University medical faculty, within a sound-treated room. SN 4388 microphone (Snopy, Istanbul, Turkey) with pre-amplifier was placed at a distance of 5 cm from the mouth. The patients were asked to read the same text, at a comfortable pitch and loudness. Videolaryngostroboscopic examination was performed using a flexible fibre-optic laryngostroboscope (Xion nasopharyngoscope). The basic parameters evaluated in the both of the settings were: glottic closure, regularity, amplitude, symmetry, mucosal wave, presence of non-vibratory portion and periodicity.[5]

At both hospitals, the recordings were perceptually evaluated using a scale of zero to three. This evaluation assessed subjective voice properties such as hoarseness, harshness, strain or strangle, breathiness, and loudness. These properties were scored from zero to three (zero = normal, one = mild voice disorder, two = moderate disorder, three = severe disorder). Voice recordings were scored by a panel, comprising authors KY, MT and EG at the Taksim Education and Research Hospital, and authors KY, MG and FT at the Gaziosmanpasa University medical faculty. For each assessment, a consensus result (from at least three listeners) was recorded in order to minimise inter-observer variability.

Twelve of the 14 patients assessed their own voices, using the voice handicap index-10 assessment tool, before and after commencement of treatment.[6] This index included 10 items investigating the impact of voice disorder on daily life. The scores ranged from zero to four, reflecting the frequency of the problem (zero = never, one = almost never, two =sometimes, three = almost always, four = always).

Acoustic assessment took place at both hospitals, at the time of diagnosis and following treatment. Patients were recorded whilst phonating an /a/ vowel at a comfortable pitch and loudness. The digitally recorded data were then transferred to an IBM personal computer at a sampling rate of 44.1 kHz. Acoustic analysis was performed (including fundamental frequency, intensity, perturbation measurements (jitter and shimmer) and harmonic to noise ratio) by means of vocal assessment (Tiger DRS, Inc. Dr. Speech Vocal assessment Version 4,50) (Dr Speech Vocal Assessment version 4.50; Tiger DRS, Inc. Seattle, WA) at the voice laboratory of the Taksim Education and Research Hospital.

Statistical analysis was performed on all data sets using descriptive methods (median, minimum and maximum). Because the sample size was small, all of the variables used in the study were evaluated via non-parametric, two-related, sample t testing. Statistical significance was assumed at $p < 0.05$.

Results and analysis

The patients' ages ranged from 28 to 71 years, with a median age of 46 years. The male to female ratio was 12:2. The most frequent main complaint was hoarseness (85 per cent, $n = 12$), followed by odynophagia (57 per cent, $n = 8$) and dysphagia (14 per cent, $n = 2$). Endoscopic findings (Table I) were categorised by lesion side and site (i.e. epiglottis, aryepiglottic folds, false vocal folds, true vocal folds and posterior commissure). Eight patients (57 per cent) had involvement of the epiglottis, four (28 per cent) had involvement of the aryepiglottic fold and eight (57 per cent) had involvement of the false vocal fold. The glottis was the less commonly involved part of the larynx, including the true vocal fold (28 per cent, $n = 4$) and the posterior commissure (14 per cent, $n = 2$). Laryngeal tuberculosis manifested as a single lesion in three patients, whereas 11 showed multiple lesions. The result of medical treatment was satisfactory in all cases, as the larynx returned to a near normal appearance over a period of six weeks to nine months (average, 18 weeks). The patient with a resolution period of six weeks had a single granular lesion and irregularity on the right false vocal fold, indicating that more extensive laryngeal involvement requires longer to resolve with treatment.

In cases with glottic involvement, before treatment, videostroboscopy showed: incomplete glottic closure due to irregularity and granular lesions on the vocal folds (21 per cent, $n = 3$); non-vibrating portion (21 per cent, $n = 3$); severe asymmetry and aperiodicity (28 per cent, $n = 4$); and severely decreased amplitude (28 per cent, $n = 4$). In cases with supraglottic involvement, before treatment, videostroboscopy showed: mild to moderate asymmetry; mild aperiodicity in two cases; and slightly decreased amplitude in three cases. In all supraglottic cases, vocal fold edges were smooth and vocal fold closure was complete.

After treatment, videostroboscopy showed normal findings, except for the cases with glottic involvement. In one case, mild asymmetry and aperiodicity, mildly decreased amplitude and a small, non-vibrating portion on the right vocal fold persisted. In three cases, mild to moderate asymmetry, mild aperiodicity and slightly decreased amplitude were

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TABLE I

CLINICAL CHARACTERISTICS AND ENDOSCOPIC FINDINGS OF PATIENTS

Case no*	Age, sex	Lesion	Symptom	Diagnosis
1	46, M	Granular lesion Irregularity on right FVF	Hoarseness	Quick regression after enhancement of treatment
2	45, M	Ulcerovegetative lesion on epiglottis	Hoarseness Odynophagia	Biopsy
3	42, M	Ulcerovegetative lesion on epiglottis	Hoarseness Odynophagia	Biopsy
4	28, M	Ulcerovegetative lesion on epiglottis & aryepiglottic fold Irregularity on right FVF	Hoarseness Odynophagia	Biopsy
5	49, M	Granular lesion on right TVF Diffuse oedema on bilateral TVF & arytenoids	Hoarseness	Biopsy
6	64, F	Granular lesion on posterior commissure Diffuse oedema on bilateral TVF	Hoarseness	Biopsy
7	71, F	Ulcerovegetative lesion on epiglottis Irregularity on bilateral FVF	Odynophagia Dysphagia	Biopsy
8	48, M	Irregularity Granular lesion on right TVF Diffuse oedema on bilateral TVF & FVF	Hoarseness	Biopsy
9	39, M	Ulcerative lesion on epiglottis Irregularity on aryepiglottic fold & FVF	Hoarseness Odynophagia	Biopsy
10	41, M	Granular lesion on epiglottis Oedema & irregularity on aryepiglottic fold	Hoarseness Odynophagia	Biopsy
11	35, M	Vegetative lesion on epiglottis Irregularity on aryepiglottic fold & FVF	Hoarseness Odynophagia	Biopsy
12	49, F	Granular lesion & diffuse oedema on bilateral FVF & arytenoids	Hoarseness	Quick regression after enhancement of treatment
13	64, M	Irregularity & diffuse oedema on bilateral TVF Granular lesion on posterior commissure	Hoarseness	Biopsy
14	69, F	Ulcerovegatative, marked mass extending from epiglottis to bilateral FVF	Odynophagia Dysphagia	Biopsy

*Cases numbered sequentially according to time of diagnosis. No = number; M = male; FVF = false vocal fold; TVF = true vocal fold; F = female

found. In all cases, vocal fold edges were smooth and glottic closure was complete.

On the basis of perceptual evaluation, using a scale of zero to three, the patients showed a median score of six (minimum four, maximum eight) at the time of diagnosis. After the commencement of treatment, the median score decreased to two (minimum one, maximum three). This difference was statistically significant ($p = 0.017$) (Table II).

Similar results were obtained from patients' self-assessments. The voice handicap index-10 results revealed a median score of 24 (minimum 22, maximum 28) before treatment. After treatment, when the larynx had returned to its normal appearance, the median score significantly lessened, to 11.5 (minimum nine, maximum 15) ($p = 0.023$) (Table II).

Before treatment, scores obtained from perceptual assessments, using either the observer-scored zero to three scale or the patient-assessed voice handicap index-10, were high in the patients with glottic lesions (Figure 1). After treatment, when the lesions had resolved, the same perceptual assessments again scored highest in cases with glottic involvement (Figure 1).

The results of acoustic analysis are shown in Table II. Median fundamental frequency and intensity were found to significantly increase after commencement of treatment, to 24 Hz and 2.5 dB SPL, respectively ($p = 0.018$). The perturbation measures (jitter and shimmer) were observed to decrease ($p = 0.018$). An obvious improvement in harmonic to noise ratio was also seen after commencement of treatment ($p = 0.018$). Patients with glottic lesions were found to have the worst acoustic

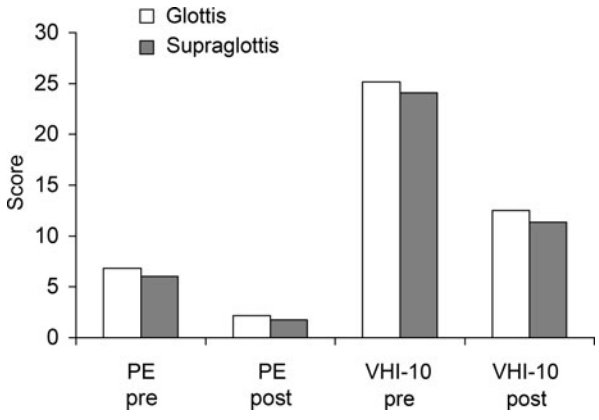

FIG. 1

Results for observer-based, 1–3 scored perceptual evaluation (PE) and voice handicap index-10 (VHI-10), before (pre) and after (post) treatment, according to site of pathology.

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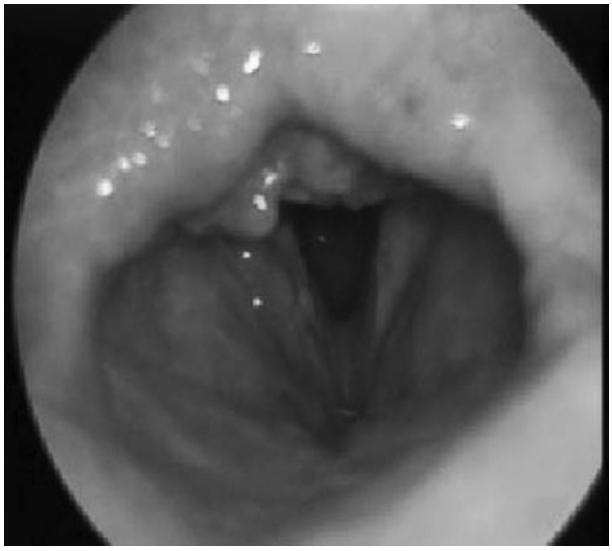

FIG. 2
Laryngoscopic view of case 6 (see Table I), showing granular lesion on posterior commissure and diffuse oedema on bilateral true vocal folds.

analysis results, both before and after treatment (Figure 2).

Discussion

Laryngeal tuberculosis begins with exudation in the subepithelial space, followed by round cell infiltration.[7] Inflammation of the mucosa and granuloma formation eventually leads to necrosis of the overlying epithelium, which sloughs and ulcerates.[7] Hence, laryngeal functions such as phonation worsen. Healing, with fibrosis or sometimes tuberculomas, may cause permanent deterioration in voice quality.

According to Fant's acoustic theory, three mechanisms contribute to voice production: glottal sound source, vocal tract filtering and resonating characteristics.[8] When a disease involves the glottis, it may disrupt the glottal sound source by interfering with the vibratory movement of the vocal folds and the completeness of glottic closure. It may also hinder the filtering and resonating components of the voice by changing the shape and size of the vocal tract. The supraglottic contribution to pitch elevation may also be adversely affected. As the expiratory volume supplies aerodynamic energy for phonation, pulmonary spread of tuberculosis may cause a decline in vocal power, leading to a decrease in intensity and pitch.[8] These factors, either singly or in combination, contributed to the considerable vocal impairment found (via perceptual and acoustic evaluations) in the present study. However, the same perceptual and acoustic evaluations showed that antituberculosis treatment significantly improved voice quality in all patients.

Using a zero to three scale of perceptual evaluation, we observed a significant degree of harsh, hoarse, strained and strangled voice quality in all patients before treatment. A median score of six at the time of diagnosis was decreased to two after commencement of treatment, indicating an almost complete recovery. Ozudogru *et al.* assessed vocal fold function in a single laryngeal tuberculosis case, using computer-assisted voice quality evaluation, and found that harshness disappeared and hoarseness decreased to one degree, whereas breathiness worsened.[9] The disappearance of oedema and tumoural masses cause vibratory movement of vocal fold mucosa to become symmetric and periodic. As a result perceptual voice quality parameters improved. However, they stated that permanent breathy voice might result from irreversible fibrotic changes in the lamina propria after healing of the infection.[9]

Patients' self-assessment gave similar results to the observer-based perceptual evaluation. The median voice handicap index-10 score decreased from 24 to 11.5 following treatment.

TABLE II
RESULTS OF PERCEPTUAL ASSESSMENTS* AND ACOUSTIC ANALYSIS, BEFORE AND AFTER TREATMENT

Parameter	Median (range)		z	p
	Pre-treatment	Post-treatment		
PE	6 (4–8)	2 (1–3)	−2.392	0.017
VHI-10	24 (22–28)	11.5 (9–15)	−2.271	0.023
F_o	125 (101–226)	149 (107–273)	2.366	0.018
Intensity	70.1 (63–72)	72.6 (65–74)	2.366	0.018
Jitter	2.01 (1.28–3.32)	0.19 (0.14–0.31)	−2.366	0.018
Shimmer	4.02 (2.28–5.27)	0.36 (0.15–1.28)	−2.366	0.018
HNR	13.4 (10.2–15.2)	20.3 (19.5–23.9)	2.366	0.018

*Observer-based, 1–3 scored perceptual evaluation (PE) and self-administered voice handicap index-10 (VHI-10). F_o = fundamental frequency; HNR = harmonic to noise ratio

- **This study aimed to evaluate the effects of antituberculosis treatment on the voice quality of laryngeal tuberculosis patients, using patient self-assessment, perceptual analysis and acoustic analysis**
- **Fourteen laryngeal tuberculosis patients were enrolled, the diagnosis being established either by biopsy and histopathological examination, or by response to antituberculosis chemotherapy**
- **Antituberculosis treatment clearly improved the voice outcomes of the laryngeal tuberculosis patients, for all self-assessment, observer-based perceptual analysis and acoustic analysis parameters**

Acoustic analysis revealed a significant change in the fundamental frequency and intensity (24 Hz and 2.5 dB SPL, respectively), comparing pre- and post-treatment states. Ozudogru *et al.* stated that the fundamental frequency increased 45 Hz after treatment. Contrary to our results, these authors found an increase in perturbation measurements (jitter and shimmer).[9] Perturbation measurements offer valuable information about short-term

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phonatory instabilities. We observed a decrease in both jitter and shimmer values following treatment. We postulate that this improvement in vocal stability occurred due to resolution of inflammation, granulation formation and necrosis. Therefore, we cannot explain the increase in perturbation values found by Ozudogru *et al.* after treatment. These authors did however find an improvement in the harmonic to noise ratio, an indicator of laryngeal stability. We also found improvements in this parameter, and, again, believe this to be due to reduction of inflammation.

It has been stated that the laryngeal area most frequently affected by tuberculosis is the true vocal folds and posterior commissure.[10] However, the glottis was the least commonly involved laryngeal site in this study. In our study, the worst cases of vocal impairment, measured by vocal handicap index-10 scale, zero to three perceptual evaluation scale and acoustic analysis, were found in cases with glottic involvement, both before and after treatment. As phonation quality is highly affected by the integrity of the glottal valving waveform (defined by regularity, symmetry, phase shape of tissue deformation across vibratory cycles, and slope of glottal flow waveform), it would be expected that the greatest vocal impairment would occur in patients with glottic involvement.[11,12] Pease *et al.*, in their study of videostroboscopic findings in laryngeal tuberculosis, stated that videostroboscopy showed normal laryngeal structure two months after treatment.[13] These laryngostroboscopic findings (mild asymmetry, aperiodicity in the vibratory movement, and small, nonvibrating portions) are belong to our patients with glottic involvement after antituberculosis treatment. In patients with involvement at other sites, laryngostroboscopy showed normal findings after treatment.

Conclusion

This study found that laryngeal tuberculosis caused impairment in voice quality. Antituberculosis treatment significantly improved voice quality in all patients, measured by perceptual assessments and acoustic analysis. However, glottic lesions were found to have the worst vocal impairment, both before and after treatment.

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