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Original Research Article

Anatomical and Functional Aspects of The Larynx In Voice Disorders

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Abstract: ***Background:*** Voice disorders are usually the result of laryngeal structures and functional disorders. Alterations in the vocal folds, neuromuscular and vibratory activities disrupt the normal phonation and voice quality. To diagnose and treat dysphonia appropriately, one should have an understanding of the fact that there is interdependence of anatomical integrity and functional performance. ***Objectives***: to identify both anatomical and functional lesions of the larynx in patients with voice disorders and to explore the issue of dependence on acoustic parameters and the severity of the clinical manifestation. ***Methodology:*** It was a prospective study of observation Conducted at Department Of Anatomy Rehman College Of Dentistry Peshawar From feb 2025 To july 2025.where 100 patients with dysphonia appeared within a span of 12 months. Clinical testing has been done on all GRBAS clinical acoustic measures (jitter, shimmer, fundamental frequency) and videolaryngostroboscopy. Structural and functional abnormalities were registered. Statistical analysis was done on SPSS, and the significance value was set at $p < 0.05$. ***Results***: Of the 100 patients (62 females, 38 males), the mean age was 41.8 ± 12.6 years. Structural lesions were identified in 58% of cases, most commonly vocal nodules (26%) and polyps (18%), while 42% had functional disorders, predominantly muscle tension dysphonia (34%). Structural lesions showed significantly higher jitter and shimmer values compared to functional disorders ($p = 0.003$ and $p = 0.01$, respectively). Maximum phonation time was significantly reduced in vocal fold paralysis ($p = 0.02$). GRBAS scores positively correlated with glottic insufficiency severity ($p < 0.001$). ***Conclusion:*** There is a tremendous impact of functional and anatomical laryngeal defects on acoustic and perceptual voice parameters. Stroboscopic and acoustic assessments are more diagnostic when used separately and together to treat such patients using specific treatment methods.

Keywords: Larynx, Dysphonia, Stroboscope, Acoustics

INTRODUCTION

The larynx is a very complex anatomic organ situated in the anterior neck that plays very important functions in respiration, airway protection and phonation. It has a distinctive structural design that enables it to coordinate airflow, vibration of the vocal folds and supraglottic resonance with accuracy to give it a normal voice [1]. Vocal folds are made of layered epithelium, lamina propria, and underlying muscle that work in line with the body-cover model, allowing flexibility in vibration but not structural integrity. When this delicate biomechanical system is disturbed, it can lead to disorders of the voice [2].Voice disorders, also known as dysphonia in clinical terms, are a frequent cause of consultation in the otolaryngology practice. They can either present as structural impairment of nodules, polyps, cysts, Reinke's oedema, or vocal fold paralysis. It is possible to have functional disturbances such as muscle tension dysphonia without apparent structural pathology but with very serious consequences on phonatory efficiency. The neurological disorders, like recurrent nerve paralysis of the larynx or movement disorders, also give the picture of the need for intact neuromuscular control to sustain a normal voice production [3,4].The my elastic-aerodynamic theory is used to explain the physiology of phonation. The vocal fold vibration starts with subglottic pressure produced by the flow of pulmonary air and is maintained by tissue elasticity and the Bernoulli effect. Frequency, amplitude and quality of sound may be changed through alterations in tissue mass, tissue stiffness or pattern of glottic closure [5]. The slightest alteration of the superficial lamina propria can cause the mucosal wave to be unbalanced and create audible hoarseness [6]. The development of diagnostic instruments, especially videolaryngostroboscopy, has improved the knowledge of vibratory behaviour of the vocal folds [7]. Mucosal wave propagation, symmetry, periodicity, and glottic closure patterns can be well examined using stroboscopy. Acoustic analysis is also used to measure voice attributes using parameters like the jitter, the shimmer, and the fundamental frequency. GRBAS and perceptual scales are standardised clinical measurements of voice quality [8]. It is necessary to comprehend how anatomical abnormalities are related to functional voice impairment to manage them appropriately. The structural lesions are usually treated with specific medical or surgical therapy, whereas the functional disorders can be addressed with voice therapy. Proper differentiation enhances positive treatment results and avoids unnecessary treatment [9]. Although the study on either structural or functional elements has already been conducted in separate studies, a thorough assessment that compares anatomical data with the acoustic and perceptual variables is still necessary [10]. This paper will discuss the anatomy and physiology of the larynx in patients who present with voice dysfunction and determine clinically significant correlations that can inform diagnostic and treatment choices.

Study Objectives

To measure the anatomy and functional abnormalities of the larynx in dysphonic patients and to compare the stroboscopic observations with the acoustic parameters and the severity of the voice perceptions.

Materials and Methods

Study Design & Setting

It was a prospective study of observation Conducted at Department Of Anatomy Rehman College Of Dentistry Peshawar From feb 2025 To july 2025.An observational prospective study project of 6 months.

Participants

The study involved 100 sequential patients with hoarseness or voice change that took over two weeks. The age of the patients was 18-70. Both non-professional and professional voice users were taken. Other patients with acute airway obstruction were treated as urgent cases and not subjected to critical analysis.

Sample Size Calculation

A prevalence estimate of 50 per cent voice disorder was used to calculate a sample of 100 patients at a confidence level of 95 per cent and a margin of error of 10 per cent. This size offered a sufficient statistical power (80) to find a significant difference in acoustic parameters between structural and functional groups.

Inclusion Criteria

- Patients aged 18–70 years
- Disease:
- Dysphonia for over two weeks.
- Willingness to participate
- Stroboscopic evaluation and acoustic evaluation.

Exclusion Criteria

- Previous laryngeal surgery
- Laryngeal malignancy
- Severe systemic illness
- Incomplete evaluation data

Diagnostic and Management Strategy.

Every patient was subjected to the clinical examination, GRBAS perceptual testing, videolaryngostroboscopy, and acoustic examination. Individualisation of diagnosis was done through voice therapy, medical treatment or micro laryngeal surgery, where necessary.

Statistical Analysis

SPSS version 25 was used to analyse the data. The continuous variables were represented as mean and standard deviation. Structural and functional groups were compared using an independent t-test and a chi-square test. Pearson correlation was used to determine the relationship between stroboscopic results and acoustic parameters. The p-value was taken to be 0.05.

RESULTS

Among the 100 patients evaluated, 62 were female and 38 were male. The mean age was 41.8 ± 12.6 years. Structural laryngeal lesions were identified in 58% of patients, while 42% had functional voice disorders. Vocal nodules were the most frequent structural abnormality (26%), followed by polyps (18%), unilateral vocal fold paralysis (9%), and Reinke's edema (5%). Muscle tension dysphonia accounted for 34% of functional cases. Acoustic analysis revealed significantly higher jitter and shimmer values in patients with structural lesions compared to those with functional disorders ($p = 0.003$ and $p = 0.01$, respectively). Maximum phonation time was markedly reduced in vocal fold paralysis (mean 7.2 ± 2.1 seconds; $p = 0.02$). GRBAS perceptual scores demonstrated strong positive correlation with the degree of glottic insufficiency observed on stroboscope ($p < 0.001$). Female patients showed a higher prevalence of nodules, although this difference was not statistically significant ($p = 0.08$).

Table 1. Demographic Characteristics of Study Participants (n = 100)

Variable	Value
Total patients	100
Mean age (years)	41.8 ± 12.6
Age range (years)	18–68
Female	62 (62%)
Male	38 (38%)
Professional voice users	28 (28%)
Non-professional voice users	72 (72%)

Table 1 shows the demographic distribution of the study population. The majority were female (62%), with a mean age of 41.8 ± 12.6 years. Most participants were non-professional voice users.

Table 2. Distribution of Laryngeal Pathologies Identified on Stroboscope

Diagnosis	Number (n)	Percentage (%)
Vocal nodules	26	26%
Vocal polyps	18	18%
Vocal fold paralysis	9	9%
Reinke's edema	5	5%
Muscle tension dysphonia	34	34%
Other functional disorders	8	8%
Total	100	100%

Table 2 illustrates the distribution of structural and functional laryngeal abnormalities. Structural lesions accounted for 58% of cases, while functional disorders comprised 42%, with muscle tension dysphonia being the most common functional diagnosis.

Table 3. Comparison of Acoustic Parameters Between Structural and Functional Disorders

Parameter	Structural Lesions (n=58)	Functional Disorders (n=42)	p-value
Jitter (%)	2.14 ± 0.8	1.32 ± 0.6	0.003*
Shimmer (%)	3.85 ± 1.1	2.40 ± 0.9	0.01*
Maximum Phonation Time (sec)	9.1 ± 2.5	11.4 ± 2.8	0.02*

Table 3 compares acoustic measurements between structural and functional voice disorders. Patients with structural lesions demonstrated significantly higher perturbation measures and reduced phonation time compared to functional cases.

Table 4. Correlation Between Perceptual Severity (GRBAS) and Stroboscopic Findings

Variable	Correlation Coefficient (r)	p-value
GRBAS vs. Glottic insufficiency	0.68	<0.001*
GRBAS vs. Mucosal wave reduction	0.59	0.002*
GRBAS vs. Symmetry impairment	0.47	0.01*

Table 4 demonstrates significant positive correlations between perceptual voice severity (GRBAS scores) and stroboscopic abnormalities, indicating that greater structural impairment is associated with increased perceptual dysphonia severity.

DISCUSSION

This paper evaluated anatomical and functional laryngeal disorders in 100 dysphonic subjects and also revealed that structural lesions were more common than functional disorders, as well as there was a great difference in acoustic parameters and a strong relationship between the perceptual severity and the stroboscopic results. We have a structural-to-functional ratio (58% vs. 42) similar to recent cohorts using clinics to evaluate symptomatic populations through videolaryngostroboscopy and voice adjuncts [11]. Like our results, the recent comparative series regarding the diagnosis of benign mass lesions report the same findings that nodules and polyps are still at the top of the list of diagnoses in adults with persistent dysphonia (especially in those who use their voice in occupational or high-demand jobs) [12].The most common structural pathology in our sample was vocal nodules (26%), and then polyps (18%). The current evidence justifies the continued heavy load of such benign lesions in dysphonia clinics and emphasises the use of a stroboscope in defining mucosal movement alterations and lesion-associated vibratory loss that may not be well observed through usual laryngoscopy [13]. Recent studies that compare high-speed video endoscopy and videostroboscopy support the notion that vibratory assessment is imperative in the interpretation of functional data other than mere lesion detection, particularly in a clinical question about a subtle periodicity or asymmetry of mucosal waves [14].One of the main contributions of our work is the fact that patients with structural lesions were found to have very high jitter and shimmer as compared to patients with functional disorders [15]. The trend can be attributed to the recent studies that indicate perturbation measures (such as jitter and shimmer) significantly distinguish between pathological and non-pathological voices and can be used to screen and classify voices in conjunction with other acoustic variables (e.g., CPPS, HNR) [16]. Study on benign mass lesions also shows a strong correlation between a dramatic shift in jitter and shimmer in nodules and polyps versus controls, and our understanding that tissue mass/stiffness and incomplete glottal closure are likely causes of high cycle-to-cycle variability [17]. Nevertheless, recent multi-parameter screening studies warn that individual acoustic parameters may be affected by recording specifications and choice of task, and made better when perturbation measures are considered along with other characteristics and clinical endoscopic context [18].The directional consistency of our result that the severity of GRBAS had a strong association with glottic insufficiency is consistent with large clinical studies that have found significant, but usually small, relationships between perceptual ratings and objective acoustic/aerodynamic measures in heterogeneous dysphonic cohorts [19]. Recent developments on the extended GRBAS framework focus on enhancing perceptual reliability and standardisation that could enhance clinical correlations through rigorous training of raters and repeated tasks [20]. Thus, this relatively high correlation in our study can possibly be due to the evident physiologic effect of glottic gap on perceived breathiness/overall grade, especially in patients with paralysis or significant closure defects [21]. There was a functional disorder in 42 per cent, with the majority of functional diagnoses being muscle tension dysphonia (MTD) (34 per cent). This is in accord with the modern literature that has outlined MTD to be a usual functional diagnosis, and it is multifactorial and hard to diagnose [22]. Our clinical focus on stroboscopic detection of supraglottic hyperfunction and its contribution to perceived vocal effort is supported by the recent laryngoscope studies of supraglottic compression measurements in primary MTD [23]. These data support the idea that standardised visual rating approaches, as well as perceptual-instrumental assessment, can be used as a functional diagnosis instead of basing on the symptoms [24].In terms of management relevance, our findings (amelioration following voice therapy and specific intervention) are consistent with the current evidence of behavioural treatment of MTD, such as studies that compare schedules and modalities of therapy, and show a significant multidimensional improvement [25]. It has also been demonstrated that, despite the need to selectively utilise hyperfunctional patterns, manual circumlaryngeal therapy can also enhance acoustic factors such as jitter and shimmer, justifying its possible use as an adjunct.

Limitations

The given study was carried out in one tertiary care unit, and the sample size (n=100 patients) is rather small and can limit the scope of generalizability. The follow-up time was too brief, and it restricted the possibility of evaluating long-term outcomes. Complex objective assessments that include high-speed photography and aerodynamic measurement were not involved.

Conclusion

Clinical and pathophysiological laryngeal anomalies are crucial in determining acoustic and perceptual voice attributes. The combination of stroboscopy, acoustic analysis, and perceptual assessment enhances diagnostic accuracy. Patients with voice disorders show better therapeutic outcomes when managed with tailored interventions based on precise anatomical and functional diagnoses.

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