International Journal of Speech and Audiology

**E-ISSN:** 2710-3854
**P-ISSN:** 2710-3846
Impact Factor (RJIF): 6.4
IJSA 2025; 6(2): 139-145

Journal's Website
Received: 10-08-2025
Accepted: 15-09-2025

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# Impact of steroid medications on voice: An insight into steroid inhaler laryngitis: A single case study

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**DOI:** https://www.doi.org/10.22271/27103846.2025.v6.i2b.95

**Abstract**
Inhaled corticosteroids (ICS), used for obstructive lung diseases may cause steroid inhaler laryngitis (SIL). This study examines the impact of ICS on voice, the reversibility of symptoms after discontinuation, and clinical strategies for managing SIL**.** A 79-year-old male with SIL, post-ICS treatment was evaluated through medical history, management and voice therapy interventions. Perceptual and acoustic voice analyses using GRBASI and PRAAT were conducted across treatment phases. Voice therapy techniques included circumlaryngeal massage and head positioning exercises. Significant hoarseness and oropharyngeal candidiasis were observed post-ICS use. Targeted therapy and reduced steroid usage aided in gradual improvement in voice quality.ICS can impair vocal function causing dysphonia and mucosal changes. Regular laryngeal examination, early voice therapy, educating patients on possible impacts of ICS on voice and its preventive measures are vital. Effective management requires coordination among pulmonologists, otolaryngologists, and speech-language pathologists.

**Keywords:** Steroid inhaler laryngitis (SIL), inhaled corticosteroids (ICS), dysphonia, oropharyngeal candidiasis

## Introduction
Voice is a unique sound produced by the vibration of the vocal folds, which are located within the larynx. This sound is shaped into recognizable patterns by the vocal tract, allowing listeners to identify individual speakers based on their voice characteristics [1]. The vocal folds, made up of layers including the epithelium, lamina propria, and the thyroarytenoid muscle, vibrate in response to airflow from the lungs, producing sound. The vocal tract, comprising the throat, mouth, and nasal passages, modifies this sound to create distinct vocal qualities.

Voice disorders arise when there are deviations in the quality, pitch, or loudness of the voice compared to what is typically expected for an individual's age, gender, cultural background, or geographic location [2]. These disorders can be broadly classified into organic, functional, and neurogenic categories. Organic disorders stem from structural abnormalities like nodules or polyps on the vocal folds. Functional disorders are due to improper use of the voice, such as excessive tension in the vocal muscles. Neurogenic disorders result from nerve damage affecting vocal fold movement. Each type of disorder can significantly impact an individual's ability to communicate effectively.

Coughing, a reflexive response to irritants in the respiratory tract, involves a complex sequence of events involving the vocal folds. Initially, the vocal cords open widely to allow additional air into the lungs. This is followed by the closure of the epiglottis and the simultaneous contraction of the abdominal and rib muscles, which increases the pressure behind the epiglottis. When the epiglottis opens suddenly, the high-pressure air is expelled forcefully, creating a rushing sound as it passes rapidly through the vocal cords. This forceful expulsion helps dislodge the irritant, making it possible to breathe comfortably again. Chronic coughing, however, can lead to significant changes in vocal cord structure and function leading to Acute Laryngitis, resulting in hoarseness and other vocal issues [3].

These conditions not only impact the quality of voice but can also cause significant discomfort and impair communication. Managing these conditions often involves treating the

underlying cause of the cough and providing supportive care to reduce inflammation and irritation of the vocal cord [6].

Steroids, particularly corticosteroids, are commonly used to treat conditions causing chronic cough due to their anti-inflammatory properties. However, these medications can also have significant side effects on the vocal folds. The use of ICS can have adverse effects on the voice According to Gregory J. Gallivan *et al.* [3], the use of inhaled corticosteroids (ICS) can cause the vocal cords to thicken and swell, leading to changes in voice quality, which may be permanent [4-7]. Their study highlighted that hoarseness and dysphonia are dependent on the specific ICS used, the inhalation device, delivery system, dosage, frequency of use, and the lactose content of the medication.Fluticasone-containing ICS,Budesonide in particular, has been identified as a major cause of hoarseness, subglottic vocal fold (SVL) abnormalities, and steroid inhaler laryngitis (SIL) [8]. One significant side effect is Steroid Inhaler Laryngitis (SIL), a condition characterized by hoarseness and dysphonia. SIL occurs due to mucosal irritation and other pathological changes in the larynx caused by the direct deposition of the steroid medication on the vocal folds (candidiasis) [4].

The pathophysiology of SIL involves several mechanisms. Firstly, the corticosteroids can cause thinning or atrophy of the vocal fold mucosa, making it more susceptible to injury and irritation. Secondly, the propellants used in inhalers can also irritate the mucosal surface. Thirdly, ICS can alter the production and composition of mucus in the respiratory tract, leading to changes in the protective mucus layer on the vocal folds. These changes can result in swelling, erythema (redness), and thickening of the mucosa, all of which contribute to the symptoms of hoarseness and dysphonia [9-11].

Patients with SIL often experience persistent hoarseness, a breathy voice, vocal fatigue, and voice breaks. The risk of developing SIL increases with higher doses and more frequent use of ICS, as well as with improper inhalation techniques that lead to more medication depositing on the vocal folds [10]. Therefore, it is crucial for healthcare providers to educate patients on the correct use of inhalers to minimize these risks.

The management of steroid inhaler laryngitis (SIL) necessitates a multidisciplinary approach, encompassing both pharmacological and therapeutic interventions. As outlined by Sivasankar *et al.* [11], a critical component of medical management involves optimizing inhaled corticosteroid (ICS) therapy, as these agents are known to exacerbate laryngeal irritation. This may involve tapering the ICS dosage or transitioning to alternative pharmacotherapies, such as leukotriene receptor antagonists or long-acting bronchodilators, in order to minimize laryngeal inflammation while maintaining adequate control of the underlying respiratory pathology.

On the behavioural front, voice therapy, administered by speech-language pathologists (SLPs), is instrumental in facilitating vocal recovery. Sivasankar *et al.* [11] emphasize that voice therapy targets phono trauma reduction through advanced techniques, such as circum-laryngeal manual therapy to alleviate hypertonicity in the extrinsic laryngeal musculature. Additionally, therapeutic manoeuvres aimed at optimizing vocal biomechanics, including cervical realignment and specific head positioning exercises, are implemented to enhance glottal competence and improve phonatory efficiency.

Vocal hygiene education forms a cornerstone of the treatment regimen, focusing on hydration, avoidance of vocally abusive behaviours, and strategies to minimize compensatory hyperfunction, such as throat clearing or excessive voice use. Ongoing surveillance through regular follow-up ensures the efficacy of therapeutic interventions and stability of the respiratory condition, while promoting optimal vocal health [11].

## Aim

This study examines the deleterious effects of inhaled corticosteroids (ICS) on vocal function and evaluates the potential reversibility of these adverse outcomes following cessation of therapy. Additionally, it delves into advanced clinical management protocols for steroid inhaler laryngitis (SIL) and the restoration of optimal phonatory performance, emphasizing therapeutic interventions aimed at mitigating ICS-induced vocal impairment.

## Ethical considerations

The study's aims and protocols were thoroughly explained to the patient, and written informed consent was obtained prior to his formal inclusion in the observational study aimed at evaluating the impact of corticosteroid therapy on vocal health and respiratory outcomes.

## Materials and Methods

### Client history

A 79-year-old male patient, designated as D, was admitted to Meitra Hospital in Calicut on January 5, 2023, with a primary complaint of an unrelenting, non-productive cough persisting for ten days. While he remained afebrile, he reported notable dyspnoea, particularly post-tussive, which significantly impaired his ability to speak in full sentences due to acute wheezing episodes. His extensive medical history included significant cardiovascular and metabolic conditions, most notably a three-vessel coronary artery disease, for which he underwent coronary artery bypass graft surgery (CABG) 20 years prior. Additionally, he had longstanding systemic hypertension, type 2 diabetes mellitus, and hypothyroidism, all of which had been managed effectively with pharmacological interventions over the past decade.

Upon initial evaluation, a transthoracic echocardiogram revealed evidence of mild pulmonary hypertension, raising concerns about underlying pulmonary and cardiovascular interactions. Subsequent high-resolution computed tomography (HRCT) of the chest showed multifocal pulmonary involvement, including mild interstitial reticulation indicative of early fibrosis, bronchiectasis localized to the middle lobe, and areas of consolidation involving the lingula of the left upper lobe and the basal segments of the left lower lobe. These findings were consistent with a diagnosis of left-sided bronchopneumonia, likely secondary to an unresolved lower respiratory tract infection.

The patient’s therapeutic management was promptly initiated with a multidisciplinary approach. He was started on a course of intravenous antibiotics targeting both typical and atypical respiratory pathogens, as well as corticosteroid therapy, which included both intravenous and nebulized budesonide to reduce bronchial inflammation. Bronchodilators were administered to alleviate airway constriction, while diuretics were used to manage any

potential fluid overload contributing to his pulmonary hypertension. Additional supportive measures included oxygen supplementation.

By the third day of hospitalization, D reported new-onset pharyngeal discomfort and developed mild hoarseness, likely a consequence of the inhaled corticosteroid therapy and underlying inflammation. This progressively worsened, and by day four, he experienced marked dysphonia, severely impacting his vocal quality. Concomitantly, he developed signs of oropharyngeal candidiasis, presenting as white, confluent patches on the oropharyngeal mucosa, a well-recognized complication associated with prolonged corticosteroid use, especially in immunocompromised or elderly patients.

Given the progression of his symptoms and the clinical challenges posed by both his respiratory condition and the corticosteroid-induced side effects, a tailored management plan was developed. The therapeutic regimen was adjusted to mitigate the adverse effects, with antifungal treatment initiated to address the oral thrush. Additionally, the patient was educated on optimal inhaler techniques and the importance of post-inhalation oral hygiene to reduce the risk of recurrent oropharyngeal fungal infections.

**Voice Evaluation**

Upon otolaryngological evaluation, including video-laryngoscopy, no significant phonatory gap was detected. However, a subtle laxity and inferior displacement of the lower segment of the right vocal fold were noted, suggestive of mild vocal fold insufficiency. As a result, the patient was advised to pursue a regimen of structured voice therapy combined with cough suppression strategies to alleviate these symptoms and enhance vocal function.

A comprehensive voice assessment was conducted by a certified speech-language pathologist, encompassing perceptual, acoustic, and aerodynamic analyses pre and post therapy. Acoustic evaluation was performed using PRAAT Software in a sound-treated environment to ensure accuracy in voice measurement. For aerodynamic assessment, Maximum Phonation Duration (MPD) and the s/z ratio were utilized to gauge the efficiency of the patient's respiratory and phonatory coordination. Perceptual voice evaluation was conducted using the GRBASI scale (Hirano, 1981), a standardized clinical tool used to assess voice quality based on five parameters: Grade, Roughness, Breathiness, Asthenia, Strain and Instability on phonation and spontaneous speech. This method aimed to provide an objective and reliable comparison of the patient's vocal performance before and after therapeutic intervention.

**Voice Therapy Program**

The secondary objective of this study was to rigorously evaluate the impact of non-medical treatment, specifically voice therapy, on the pathological vocal condition. The voice therapy regimen was meticulously designed with the following goals: (1) to alleviate functional voice disorders by attenuating laryngeal muscle tension, (2) to induce vocal relaxation through targeted interventions, and (3) to optimize vocal efficiency. This therapeutic approach employed a diverse array of techniques, including:

1. **Circumlaryngeal Massage**: This technique aimed to release tension in the extrinsic laryngeal muscles, which can contribute to voice disorders and discomfort.
2. **Head Positioning Exercises**: Specific exercises were utilized to enhance vocal fold alignment and improve glottal closure, thereby promoting more efficient phonation.
3. **Breathing Strategies**: Structured breathing exercises were implemented to support adequate airflow and respiratory coordination, crucial for effective voice production.
4. **Vocal Hygiene Practices**: These practices included recommendations for hydration, vocal rest, and strategies to minimize harmful vocal behaviors, such as excessive throat clearing and loud speaking.

The primary objectives of the therapy were to improve vocal quality by reducing strain, preventing vocal fatigue, and fostering habits that promote long-term vocal health. The therapy addressed both the physiological aspects of voice production, such as muscle relaxation and postural adjustments, and behavioural modifications, including increased hydration and reduced phono trauma.

The voice therapy was administered over a ten-day period following the patient's discharge, with each session lasting 40 minutes and scheduled on alternate days. This modified schedule was necessitated by the patient's frequent coughing episodes, which hindered the consistency of regular therapy sessions.

To comprehensively evaluate the effectiveness of the therapy, a series of post-therapy assessments were conducted across multiple domains: acoustic, aerodynamic, and perceptual.

**Results and Discussion:** The comprehensive analysis of pre- and post-therapy data aimed to quantify improvements in vocal function and validate the therapeutic efficacy of the voice therapy regimen. The post-therapy measures on all the domains (acoustic, aerodynamic, perceptual measures) were obtained after 10 sessions of voice therapy, and pre- and post-therapy measures on all the domains were compared.

**Table 1:** Comparison of pre-therapy and post therapy voice parameters

| | | /a/ | | /i/ | | /u/ | |
|---|---|---|---|---|---|---|---|
| **Sl No** | **Parameters** | **Pre therapy** | **Post therapy** | **Pre therapy** | **Post therapy** | **Pre therapy** | **Post therapy** |
| 1 | Mean pitch | 123.8 | 129.94 | 153.07 | 156.03 | 172.01 | 177.30 |
| 2 | Jitter | 1.45 | 1.39 | 1.4 | 1.09 | 0.81 | 0.69 |
| 3 | Shimmer | 1.62 | 1.46 | 1.5 | 1.1 | 3.01 | 2.6 |
| 4 | Voice breaks | 6 | 4 | 0 | 0 | 1 | 1 |
| 5 | HNR | 7.41 | 9.05 | 4.12 | 4.69 | 5.8 | 6.4 |

**Table 2:** GRBASI-Pretherapy and Post-Therapy

| GRBAS Scale | Pre therapy | | Post therapy | |
|---|---|---|---|---|
| | **Judge 1** | **Judge 2** | **Judge 1** | **Judge 2** |
| Grade | 0 | 1 | 1 | 1 |
| Roughness | 0 | 0 | 0 | 0 |
| Breathiness | 3 | 3 | 1 | 1 |
| Asthenia | 2 | 2 | 0 | 0 |
| Strain | 0 | 0 | 0 | 0 |
| Instability | 0 | 0 | 0 | 0 |

**Table 3:** MPD and s/z ratio

| | **Pre therapy** | **Post therapy** |
|---|---|---|
| MPD (sec) | /a/- 6s | /a/- 9s |
| | /i/- 5s | /i/- 7s |
| | /u/- 4s | /u/- 6s |
| s/z ratio | /s/ - 7s | /s/ - 10s |
| | /z/ - 3.7s | /z/ - 5.9s |
| | s/z- 1.89 | s/z- 1.69 |

**Voice characteristics in Client 'D'**

In the pre therapy assessment client D exhibited several vocal abnormalities before therapy, evident from the acoustic and perceptual voice evaluations. In the acoustic evaluation (Table 1), in terms of mean pitch, all vowels (/a/, /i/, /u/) were slightly lower, with values of 123.8 Hz, 153.07 Hz, and 172.01 Hz, respectively. Perturbation measures such as jitter and shimmer were elevated, with jitter values of 1.45%, 1.4%, and 0.81% and shimmer values of 1.62%, 1.5%, and 3.01%, indicating irregularities in frequency and amplitude modulation, especially for /u/. Additionally, there were voice breaks noted, particularly for /a/ (6 breaks) and /u/ (1 break), reflecting vocal instability. Harmonics-to-noise ratio (HNR) was also low across all vowels, especially for /i/ (4.12 dB), indicating increased breathiness and less efficient vocal fold vibration.

The GRBAS scale (Table 2) revealed mild vocal issues, with notable breathiness (3) and asthenia (2) pre-therapy, while roughness, strain, and instability were not present. These perceptual features, particularly the high breathiness score, further corroborate the acoustic findings of vocal inefficiency and weak vocal output.

The maximum phonation duration (MPD) **(**Table 3) was reduced, especially for /u/ (4 seconds), indicating limited respiratory-phonatory coordination. The s/z ratio pre-therapy was 1.89, which is above the normal range, reflecting possible vocal fold insufficiency or airflow imbalance during phonation.

After ten days of voice therapy, significant improvements were observed. The acoustic analysis (Table1) revealed that the mean pitch increased for all vowels, with /a/ rising to 129.94 Hz, /i/ to 156.03 Hz, and /u/ to 177.30 Hz, suggesting better vocal control and possibly improved vocal fold tension. Perturbation measures showed a reduction in both jitter (1.39%, 1.09%, 0.69%) and shimmer **(**1.46%, 1.1%, 2.6%), indicating more stable and efficient vocal fold vibration. Notably, there was a decrease in voice breaks, with /a/ dropping to 4 breaks, and no voice breaks for /i/ and /u/. HNR values improved across all vowels, with /a/ reaching 9.05 dB, /i/ 4.69 dB, and /u/ 6.4 dB, reflecting a cleaner, more resonant voice with less noise interference.

On the GRBAS scale (Table 2)**,** breathine**ss** reduced from 3 to 1, and asthenia was eliminated (0 post-therapy). This indicates a stronger, more supported voice post-intervention. The MPD (Table 3) increased for all vowels, with /a/ extending to 9 seconds, /i/ to 7 seconds, and /u/ to 6 seconds, demonstrating better breath support and sustained phonation. The s/z ratio improved to 1.69, reflecting more balanced airflow and vocal fold function during voiced and unvoiced sound production.

**Effect of voice therapy**

The voice therapy regimen, which integrated circumlaryngeal massage, head positioning exercises, controlled breathing techniques, and rigorous vocal hygiene practices, yielded substantial improvements in vocal function and a marked reduction in symptoms such as hoarseness and frequent throat clearing. Post-therapy acoustic voice analysis (refer to Table 1) of the sustained vowels /a/, /i/, and /u/ revealed notable enhancements in several key parameters.

An overall increase in mean fundamental frequency (pitch) was observed across all vowel sounds, indicating improved vocal control and pitch stability. This can be attributed to the enhanced coordination of the vocal folds and the reduction of intrinsic laryngeal muscle tension achieved through the therapy. The reduction in jitter and shimmer values, both of which are indicative of irregularities in vocal fold vibration, suggests that vocal fold oscillation became more stable and regular post-therapy. This improvement points to more efficient and consistent vocal fold closure, leading to smoother phonation.

Moreover, the frequency of voice breaks for the vowel /a/ diminished, further demonstrating increased stability in vocal fold function. While the other vowels remained stable in terms of voice breaks, these findings collectively reflect a more controlled and reliable vocal mechanism. The Harmonics-to-Noise Ratio (HNR), a measure of vocal clarity, increased across all vowel sounds. This improvement in HNR underscores a clearer, more resonant voice with diminished interference from noise components, a result likely driven by enhanced glottal closure and reduced strain on the vocal mechanism.

In the perceptual evaluation conducted using the GRBASI scale (as seen in Table 2), the overall voice quality, or Grade, transitioned from a mildly abnormal classification to normal. The perceptible reduction in breathiness suggests significant improvements in glottal competence, reducing the amount of excess air escaping during phonation. This indicates a more complete and effective glottal closure.

Additionally, asthenia, representing vocal weakness, showed considerable improvement, likely due to the increased vocal strength and stamina developed through targeted exercises. Notably, there were no perceptible signs of roughness, strain, or instability in the vocal quality, either before or after therapy, further emphasizing the therapeutic success.

Aerodynamic measures further supported the efficacy of the intervention. The Maximum Phonation Duration (MPD), which evaluates the duration a patient can sustain a vowel sound, demonstrated a marked increase for all vowel sounds post-therapy (refer to Table 3). This suggests a significant enhancement in both breath support and vocal endurance, indicating the positive effects of the respiratory training and breath control techniques included in the therapy. Additionally, the s/z ratio, a measure used to assess laryngeal efficiency, improved from 1.89 to 1.69. This decrease in the ratio reflects more efficient phonatory control and a better balance between voiced and voiceless sounds, signifying enhanced vocal fold function.

Overall, the voice therapy protocol produced significant improvements in vocal quality, stability, and overall endurance. These advancements are reflected in the increased mean pitch, reduced jitter and shimmer, fewer voice breaks, higher HNR values, and improvements across perceptual domains such as breathiness, asthenia, and MPD. The reduction in the s/z ratio further underscores the improvement in laryngeal efficiency and phonatory control. Ultimately, the therapy effectively addressed issues related to laryngeal tension, breath support, and overall vocal health, leading to substantial enhancements in both acoustic and perceptual voice parameters, as evidenced by the data.

**Follow-Up and Recurrence**

Post-therapy, D's voice quality gradually returned to normal as the dosage of steroid medications was reduced. However, on September 27, 2023, the client reported of similar episodes of cough, for which steroid medications were again prescribed following which client developed, throat clearing, and burning sensation in the tongue, which was diagnosed as oropharyngeal candidiasis. GRBASI and subsequent evaluations showed:

**Table 4:** GRBASI results post recurrence (27/09/23)

| GRBASI | Judge 1 | Judge 2 |
|---|---|---|
| Grade | 1 | 1 |
| Roughness | 0 | 0 |
| Breathiness | 1 | 1 |
| Asthenia | 0 | 0 |
| Strain | 1 | 1 |
| Instability | 0 | 0 |

**Table 5:** MPD and s/z ratio

| Post recurrence | |
|---|---|
| MPD (sec) | /a/- 11s |
| | /i/- 8s |
| | /u/- 8s |
| s/z ratio | /s/ - 11s |
| | /z/ - 7s |
| | s/z- 1.57 |

**Table 6:** Voice parameters

| | /a/ | /i/ | /u/ |
|---|---|---|---|
| Mean pitch | 152.15 | 190.9 | 188.68 |
| Jitter | 0.86 | 0.25 | 0.92 |
| Shimmer | 1.24 | 0.96 | 1.46 |
| Voice breaks | 0 | 0 | 0 |
| HNR | 7.97 | 10.4 | 10.9 |

The recurrence of symptoms for D, including cough, throat clearing, and a burning sensation in the tongue, which was diagnosed as oropharyngeal candidiasis, has impacted his vocal quality and function. A follow-up evaluation on September 27, 2023, revealed changes in several voice parameters, as shown in the GRBASI scale, maximum phonation duration (MPD), s/z ratio, and acoustic measures. Below is a detailed analysis of the changes post-recurrence.

**1. GRBASI Results (Table 4)**

- **Grade**: Both judges rated the overall voice quality as mildly impaired (1), showing a decline compared to the post-therapy improvement where the grade was normal (0). This indicates a deterioration in overall vocal quality due to the recurrence of symptoms.
- **Roughness**: Rated as 0 by both judges, indicating that roughness is not present, which aligns with previous results post-therapy.
- **Breathiness**: Increased from 0 post-therapy to 1 post-recurrence, showing a mild breathiness. This suggests that the vocal folds are not closing as efficiently, possibly due to irritation or inflammation from oropharyngeal candidiasis.
- **Asthenia**: Remained at 0, indicating that the voice is not weak or lacking power, which is consistent with the improvement seen post-therapy.
- **Strain**: Rated as 1 by both judges, indicating mild strain. This suggests that D is exerting more effort while speaking, likely due to discomfort from throat clearing and irritation caused by the infection.
- **Instability**: Remained at 0, showing no significant fluctuations in voice stability, which is a positive indicator of vocal control.

**2. MPD and s/z Ratio (Table 5)**

- **MPD (Maximum Phonation Duration):**
  - **/a/**: Increased from 9 seconds post-therapy to 11 seconds post-recurrence.
  - **/i/**: Increased from 7 seconds to 8 seconds.
  - **/u/**: Increased from 6 seconds to 8 seconds.
  - **Interpretation**: The increased MPD suggests that despite the recurrence of symptoms, D's breath support and phonation endurance have improved, which could be attributed to the vocal exercises from previous therapy. However, this does not fully reflect the discomfort or vocal strain observed in the GRBASI scores.

**s/z Ratio**

- **/s/**: Increased from 10 seconds to 11 seconds.
- **/z/**: Increased from 5.9 seconds to 7 seconds.
- **s/z Ratio**: Decreased from 1.69 post-therapy to 1.57 post-recurrence.

**Interpretation**: The decrease in the s/z ratio indicates improved vocal fold efficiency, suggesting that the vocal folds are functioning more evenly between voiced and unvoiced sounds. This contrasts with the observed breathiness and strain, which might reflect short-term irritation from the infection.

**3. Acoustic Voice Parameters (Table 6)**

**Mean Pitch**

- **/a/**: Increased from 129.94 Hz post-therapy to 152.15 Hz post-recurrence.
- **/i/**: Increased from 156.03 Hz to 190.9 Hz.
- **/u/**: Increased from 177.3 Hz to 188.68 Hz.

**Interpretation**: The significant increase in mean pitch post-recurrence suggests that D is using a higher pitch, potentially as a compensatory strategy for vocal discomfort or as a result of tension in the vocal folds, possibly related to throat irritation from candidiasis.

**Jitter**

- **/a/**: Decreased from 1.39% post-therapy to 0.86% post-recurrence.
- **/i/**: Decreased from 1.09% to 0.25%.
- **/u/**: Increased slightly from 0.69% to 0.92%.

**Interpretation**: Jitter has generally decreased for /a/ and /i/, reflecting more stable frequency modulation, which is a positive sign of vocal control. The slight increase in jitter for /u/ might be related to localized vocal fold tension or irregularities caused by irritation.

**Shimmer**

- **/a/**: Decreased from 1.46% to 1.24%.
- **/i/**: Decreased from 1.1% to 0.96%.
- **/u/**: Increased from 2.6% to 1.46%.

**Interpretation**: The overall reduction in shimmer for /a/ and /i/ shows improved amplitude stability, while the reduction in shimmer for /u/ also reflects better vocal fold vibration efficiency. However, the higher shimmer values for /u/ could indicate slight irregularities due to strain or irritation.

**Voice Breaks**

No voice breaks were observed for any of the vowels post-recurrence, which is consistent with previous results post-therapy. This suggests that despite the recurrence of symptoms, D's voice remains relatively stable in terms of continuity.

**Harmonics-to-Noise Ratio (HNR)**

- **/a/**: Decreased from 9.05 dB post-therapy to 7.97 dB post-recurrence.
- **/i/**: Increased from 4.69 dB to 10.4 dB.
- **/u/**: Increased from 6.4 dB to 10.9 dB.

**Interpretation**

HNR measures the amount of noise in the voice signal, with higher values indicating a clearer voice. While there was a slight decline in HNR for /a/, the sharp increases for /i/ and /u/ suggest improved vocal clarity and reduced noise interference for these vowels, which is a positive outcome. The drop in /a/ may be due to localized vocal fold strain or irritation affecting the lower vowel sounds.

**Overall Interpretation of Post-Recurrence Findings**

The data post-recurrence indicates that while D's voice quality has been impacted by the return of symptoms due to oropharyngeal candidiasis, several vocal measures show both positive and negative effects:

**Positive Changes**

- Increased MPD and improved s/z ratio suggest that D's overall breath support and vocal endurance remain strong, likely due to the residual benefits from the initial therapy.
- Acoustic parameters such as jitter and shimmer show reductions for most vowels, indicating more stable vocal fold vibrations and better vocal efficiency.
- HNR values for /i/ and /u/ have improved, suggesting greater vocal clarity for these vowels, despite the recurrence.

**Negative Changes**

- The GRBASI scale reflects mild impairment in overall voice quality, with increased breathiness and strain. This is likely a result of irritation and inflammation caused by the oropharyngeal candidiasis, contributing to vocal discomfort and inefficiency in glottal closure.
- The rise in mean pitch suggests that D may be compensating for vocal strain or discomfort by using a higher pitch, which could contribute to long-term vocal fatigue if not addressed.

**Conclusion**

This study sought to elucidate the impact of inhaled corticosteroids (ICS) on vocal function and to evaluate the reversibility of these effects upon cessation of the medication[3-8]. Additionally, it aimed to identify effective clinical strategies for restoring voice function. The subject of the study was a 79-year-old male with a multifaceted medical history, including chronic conditions and a recent diagnosis of bronchopneumonia, who demonstrated significant alterations in vocal function during and following ICS therapy.

Voice therapy, which was administered over a ten-day period, produced notable improvements across several acoustic parameters. These included:

- **Mean Fundamental Frequency (Pitch)**: An increase in mean pitch was observed, indicating enhanced control and stability in pitch modulation.
- **Jitter and Shimmer**: Reductions in jitter (frequency perturbation) and shimmer (amplitude perturbation) were noted, reflecting a stabilization of vocal fold vibration and a more consistent phonatory output.
- **Voice Breaks**: A decrease in the frequency of voice breaks, particularly for the vowel /a/, highlighted improved continuity in vocal production.
- **Harmonics-to-Noise Ratio (HNR)**: An elevation in HNR was documented, signifying a clearer voice with reduced noise interference, attributable to more effective vocal fold closure and diminished phonatory strain.

**Further, improvements were observed in**

- **Maximum Phonation Duration (MPD)**: This parameter showed a significant increase, indicating enhanced breath support and sustained vocal endurance.
- **s/z Ratio**: A decrease in the s/z ratio from 1.89 to 1.69 suggested improved laryngeal efficiency and better management of voiced and voiceless sounds.

**Perceptual evaluations utilizing the GRBAS scale corroborated these findings, revealing:**

- **Grade**: An overall enhancement in vocal quality, shifting from a mildly abnormal rating to normal.
- **Breathiness**: A marked reduction in breathiness, suggesting improved glottal closure and reduced air leakage.
- **Asthenia**: Improved vocal strength and stamina, with a reduction in vocal weakness.
- **Roughness, Strain, and Instability**: The absence of these perceptual markers post-therapy highlighted the therapy's effectiveness in stabilizing vocal function and eliminating negative vocal qualities.

Despite these improvements, the emergence of oropharyngeal candidiasis introduced new challenges. This condition exacerbated symptoms such as increased breathiness and vocal strain, which necessitated adaptive management strategies. However, it is noteworthy that some of the initial therapeutic gains persisted, indicating the enduring impact of the voice therapy despite the infection's localized effects.

The increase in mean pitch and alterations in HNR suggest that the candidiasis had a specific, localized impact on vocal function. This underscores the necessity for continuous monitoring and flexible therapeutic strategies to address evolving vocal health issues. Overall, the study highlights the complex interplay between medication, therapy, and underlying health conditions, emphasizing the need for an integrative approach to managing and restoring voice function.

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