



Voice and Speech Changes after Obstructive Sleep Apnea Surgery

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General Note



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ABSTRACT

Surgical intervention for patients with snoring and sleep apnea may change the voice acoustics and speech resonance. The objectives of current research is to study the changes in the acoustic characteristics of the voice and speech of the patients after surgical correction. This study included 52 adult patients (40 males and 12 females) with snoring and/or OSA syndrome. The patients ranged in age from 22 to 57 years. The patients were classified into three groups. Patients in group 1 had retro-palatal obstruction with redundant soft palate. Ten patients in this group also had large tonsils. Patients in group 2 presented with retro-palatal obstruction and had redundant soft palate. However, group 3 patients had retro-lingual obstruction because of a large tongue base. Group 1: 24 patients underwent uvulopalatopharyngoplasty (UPPP); Group 2: 16 patients underwent laser-assisted uvulopalatoplasty (LAUP) and Group 3: 12 patients underwent tongue base suspension technique (TBS). The patients' voices were subjected to acoustic

analysis and Nasometric evaluation preoperatively and three months postoperatively. The results showed Formant changes occurred in patients subjected to TBS and no changes occurred in patients after UPPP and LAUP. We concluded that surgical intervention (UPPP, LAUP, and TBS) in sleep apnea patients results in mild voice and speech changes in some patients detected only by acoustic analysis of the patients' voices.

Key words: voice acoustics, snoring, sleep apnea, uvulopalatoplasty

1. INTRODUCTION

Snoring causes medical disorders as well as social troubles. The most advanced stage of snoring is obstructive sleep apnea (OSA), which causes profound cardiac, pulmonary, and behavioral problems (Lin, 2018). OSA is caused by either complete occlusion (apnea) or partial collapse (hypopnea) of the upper airway despite the presence of simultaneous effort (Farrell et al., 2017). Diagnosing OSA syndrome is done with an overnight polysomnography recording, a method that is both time-consuming and costly. The need remains for rapid, direct means of assessing individuals at high risk of OSA (Hirshkowitz, 2016).

Snoring and sleep apnea syndrome are treated both by behavior modification therapy, continuous positive airway pressure, or surgical intervention. However, surgical intervention might alter patients' voices or speech resonance. The current study aims to investigate the occurrence of changes in patients' voices or speech after various surgical techniques (Lin & Suurna, 2018).

The acoustic analysis deals with the study of sound. It permits measurements or quantification of the sound's physical signal. Formants are terms used to describe the vocal resonance. For the human vocal tract, several resonances are visible in a spectrogram. On the spectrum, each formant appears as a dark band that is oriented horizontally on the page. Each vowel has a particular pattern of formants. When Speech displayed on acoustic display, the formants appear as dark bands of energy (Nowosielska et al., 2019). The formants are a feature of the resonating cavities lying above the vocal folds. As changes in the positions of the tongue, jaw, and lips reshape these cavities, the vocal tract's shape and length determine the formant structure. On the other hand, the vocal folds' length and tension determine the vocal vibration frequency (fundamental frequency) (Karakurt et al., 2019).

Aim of the work

To study the changes in the acoustic characteristics of the voice and speech of the patients after surgical correction.

2. PATIENTS AND METHODS

This study included 52 adult patients (40 males and 12 females) with snoring and/or OSA syndrome. Informed consent was obtained from each patient, and the study was approved by the local ethical committee. The age of the patients ranged from 22 to 57 years. None of the patients had previous surgery for snoring or sleep apnea. The patients were selected according to history, clinical examination, and polysomnography.

According to Muller's maneuver, using a Fiberoptic-nasolaryngoscope, the patients were classified into three groups. Patients in group 1 had retro-palatal obstruction with redundant soft palate. Ten patients in this group also had large tonsils. Patients in group 2 presented with retro-palatal obstruction and had redundant soft palate. However, group 3 patients had retro-lingual obstruction because of a large tongue base.

Group 1: 24 patients underwent uvulopalatopharyngoplasty (UPPP).

Group 2: 16 patients underwent laser-assisted uvulopalatoplasty (LAUP).

Group 3: 12 patients underwent tongue base suspension technique (TBS).

All the patients had visited the ENT Outpatient Clinic between May 2017 and December 2019. The patient assessment was conducted preoperatively and three months postoperatively according to the following protocol (Fig. 1).

1- Auditory perceptual assessment (APA):

After three trained phoniatricians carefully listened to each patient's voice and speech, they reported any deviation from normal voice (dysphonia) or speech (open- or closed-nasality) in each group according to the following protocol of assessment.

APA of voice (Assessment of dysphonia):

- Overall grade: [0] Normal, [1] Slight, [2] Moderate, [3] Severe

- Character (Quality): -Strained, -Leaky, -Breathy, -Rough(irregular)
- Pitch: -Overall increase, -Decrease, -Diplophonia
- Register: -Habitual register, -Modal, -Falsetto, -Tendency of vocal fry at the end of the phrase, -Register break
- Loudness: -Excessively loud, -Soft, -Fluctuating
- Glottal attack: -Normal, -Soft, -Hard
- Associated laryngeal functions: -cough, -whisper, -cough *Modified GARBAS Scale* (Kotby, 1986)

APA of speech (Assessment of nasality):

- Type of nasality: -Open, -Closed, -Mixed
- Degree of nasality: -Mild, -Moderate, -Sever Speech unintelligibility: -I, -II, -III, -IV (Kotby, 1981)

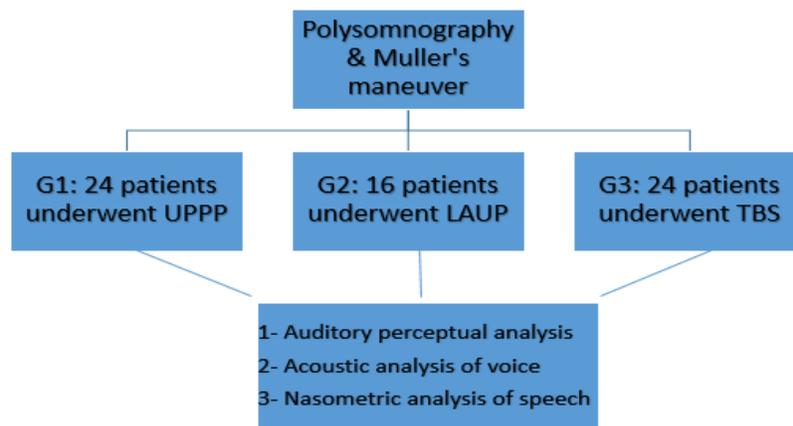


Figure 1 Study protocol

2- Acoustic analysis of voice:

Acoustic analysis for the patients' voices using computerized speech lab (CSL) model 4300 from Kay Elemetrics. The patient was seated in front of the microphone, and the mouth-microphone distance was about 10 cm. The patient was asked to produce a sustained vowel /a/ in a flat tone at a comfortable pitch and constant amplitude. The following parameters were measured for the three groups: average pitch, jitter, shimmer, and harmonic to noise ratio. Formant frequencies were observed and reported for the vowels (a, i, and u), and the first two formants (F1 and F2) were tested for the preceding vowels. Acoustic voice analysis was completed preoperatively and three months postoperatively.

3- Acoustic analysis of speech: (Nasometric evaluation):

Nasality measurement was carried out using Nasometer Model 6200 from Kay Elemetrics. The patient was instructed to produce an oral sentence (/alj rañ wl?ab kora/) and nasal sentence (/mama betnajem manal/). Nasometric studies of each patient's speech were conducted to monitor possible postoperative nasality after various operative procedures.

Statistical analysis:

Statistical analyses were performed using SPSS version 18 (IBM Corporation, Chicago, Illinois. Quantitative variables are presented as mean and SD; qualitative variables are presented as frequencies and percentages. A paired t-test was used to analyze the interval differences between pairs of parametric variable follow-up measurements in each group. P-values less than 0.05 were considered significant.

3. RESULTS

The patients in this study ranged in age from 22 to 57 years, with a mean age of 37 ± 13 years. There were 52 patients, 40 of whom were male (77%) and 12 females (23%). Four patients in the first group had hypo-nasality reported by the professional listeners. Two patients developed open-nasality immediately after UPPP and they improved spontaneously after one month. According to

professional listeners, no changes occurred in all patients' voices after different operations. There were insignificant differences in all patients (subjected to various operations) between preoperative and postoperative voice parameters, namely, average pitch, jitter, shimmer, and harmonic to noise ratio (Table 1). We found insignificant preoperative and postoperative differences in F1 and F2 values for /i/, /u/ and /a/ vowels in patients subjected to both UPPP and LAUP. There were significant preoperative and postoperative differences in F1 and F2 values for /i/ and /u/ vowels in patients subjected to tongue base suspension. Also, we found significant preoperative and postoperative differences in F2 value for /a/ vowel in patients subjected to tongue base suspension (Fig. 2, 3, 4 & Table 1).

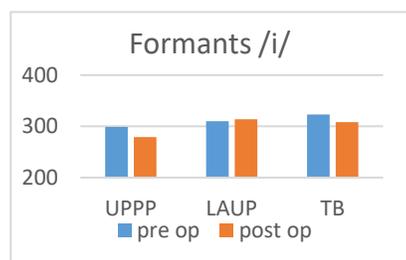


Fig. 2: Formants /i/

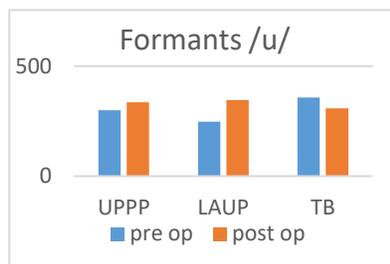


Fig. 3: Formants /u/

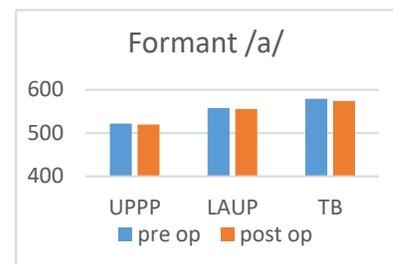


Fig. 4: Formants /a/

There were insignificant preoperative and postoperative differences in nasalance scores in all patients subjected to UPPP, LAUP, and TBS (Fig. 5, 6 & Table 1).

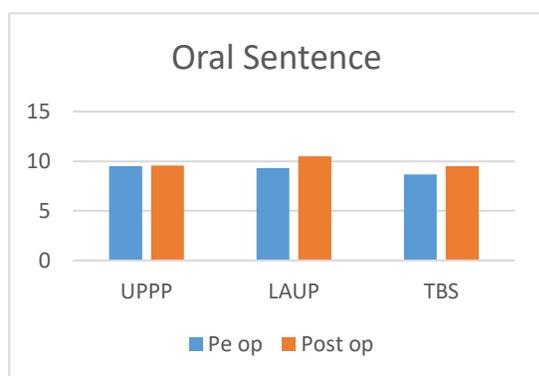


Fig. 5: Oral sentence

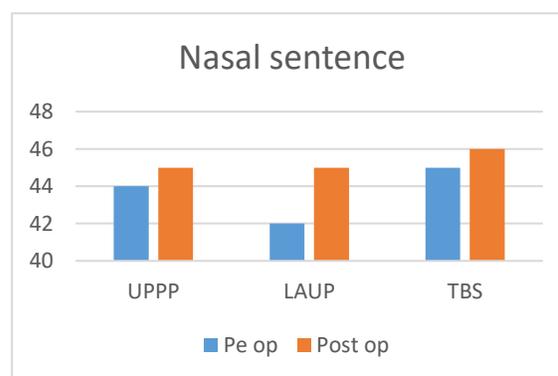


Fig. 6: Nasal sentence

Table 1: Acoustic analysis of voice, Formant Frequencies, and Nasalance scores

Variable	UPPP			LAUP			TBS		
	Pre-Op means	Post-Op means	p-V	Pre-Op Means	Post-Op means	p-V	Pre-Op means	Post-Op means	p-V
Acoustic analysis									
Average pitch (Hz)	167 ± 29	165 ± 32	>0.05	170 ± 38	168 ± 40	>0.05	171.7 ± 36	168.8 ± 30	>0.05
Jitter (%)	0.21 ± 0.1	0.19 ± 0.1	>0.05	0.13 ± 0.12	0.14 ± 0.14	>0.05	0.20 ± .22	0.19 ± 0.11	>0.05
Shimmer (Hz)	0.4 ± 0.25	0.51 ± 0.2	>0.05	0.61 ± 0.11	0.53 ± 0.25	>0.05	0.41 ± 0.19	0.43 ± 0.17	>0.05
H/N(Hz)	12.2 ± 3	12.18 ± 3	>0.05	13.9 ± 3.5	12.9 ± 4	>0.05	11.13 ± 2.45	12.65 ± 3.28	>0.05
First formant (F1) of vowels /i/, /u/, and /a/									
/i/	299 ± 22	279 ± 77	>0.05	310 ± 21	314 ± 20	>0.05	323 ± 20	308 ± 22	<0.001
/u/	335 ± 30	336 ± 27	>0.05	348 ± 20	346 ± 21	>0.05	358 ± 12	309 ± 35	<0.05
/a/	522 ± 143	520 ± 140	>0.05	558 ± 30	556 ± 32	>0.05	579 ± 22	574 ± 44	>0.05

Second formant (F2) of vowels /i/, /u/, and /a/									
/i/	1808 ± 83	1408 ± 78	>0.05	1841 ± 69	1850 ± 58	>0.05	1826 ± 73	1705 ± 31	<0.001
/u/	767 ± 46	766 ± 43	>0.05	788 ± 18	785 ± 17	>0.05	772 ± 23	681 ± 32	<0.001
/a/	971 ± 39	965 ± 48	>0.05	963 ± 34	960 ± 33	>0.05	966 ± 34	921 ± 68	<0.001
Nasalance Scores									
Oral sentence	9.49 ± 1.19	9.58 ± 1.03	>0.05	9.3 ± 1.5	10.5 ± 3.16	>0.05	8.67 ± 3.07	9.5 ± 1.34	>0.05
Nasal sentence	44.8 ± 4.3	44.7 ± 3.5	>0.05	42.6 ± 4.48	45.3 ± 9.04	>0.05	45.22 ± 3.54	46.2 ± 3.2	>0.05

4. DISCUSSION

1- Auditory assessment of voice and speech:

In the current study, auditory perceptual assessment of the patients' voices, judged by three professional listeners, revealed no voice changes preoperatively and three months postoperatively in all patients who were subjected to operative intervention for snoring and/or sleep apnea. Three patients in the first group who were subjected to UPPP presented with mild open-nasality, but they improved spontaneously after one month. One patient presented by postoperative open-nasality after LAUP with nasal regurge of fluids one week after the operation. Three months after the operation, no further nasal regurge or open-nasality remained. Also, there were four patients of the first group presented by closed-nasality. This may be explained by the presence of large tonsils obstructing the post-nasal space, as those patients had large tonsils in this group. After the surgical operation (UPPP and LAUP) on cases of snoring and sleep apnea syndrome, there was velopharyngeal insufficiency and open-nasality in 3.9% of the total patients involved in the study (Wischhusen et al., 2019; Michel et al., 2004).

II- Acoustic analysis of voice:

Average pitch, jitter, shimmer, and harmonic to noise ratio:

In the current study, there were no significant statistical changes of voice parameters, namely, pitch, jitter, shimmer, and harmonic to noise ratio among all patients, both preoperatively and three months postoperatively. The formerly mentioned operations did not affect the voices of the patients because the vocal folds were not involved during surgery.

UPPP and TBS could help with airway collapse and might be considered a safe, simple, and effective technique in the management of selected patients experiencing OSA. Also, the former operations did not affect the different functions of the vocal tract as voice and swallowing (Faheem et al., 2014). In contrary to our findings Faheem et al. (2020) mentioned that the modifications in the anatomical structure and volume of the vocal tract, induced by the surgical intervention used for the treatment of snoring, can affect the acoustic characters of the voice reflected by formants changes. Also, the patient can experience the changes in voice quality during reading or singing (Abhang et al., 2016).

There is always worry by patients and physicians of the effect of surgical modalities used for the treatment of OSA on voice. However, the auditory perceptual assessment of the voice revealed that the surgical techniques did not affect the voice quality, and no one could distinguish voice changes both preoperatively and postoperatively. Professional voice users and singers should be aware about these minor voice and speech changes that might disturb their career. In addition, surgeons should consult singers before operative interventions for medico legal issues.

Formant frequencies:

Formant frequencies reflect the sound resonating properties of the vocal tract during vowel production. Vowels yield three distinct vocal tract resonances, formant 1 (F1), formant 2 (F2), and formant 3 (F3), (Bertino et al., 2006).

In the present work, studying the preoperative and postoperative analysis of F1 and F2 values of different vowels (/i/, /u/ and /a/), we found no statistically significant differences between patients who underwent LAUP or UPPP. However, we found statistically significant differences between preoperative and postoperative values of F1 and F2 in patients who underwent tongue suspension technique. The average values of F1 and F2 for the vowels /i/ and /u/ tend to be lower postoperatively after tongue base suspension; this may be explained by the change in tongue shape as well as the change in tongue base position because the base of the tongue was advanced anteriorly with a suspension suture.

All operative procedures for the treatment of snoring and OSA alter the anatomy and the resonance characteristics of the vocal tract. A total of 40 snoring or OSA syndrome patients, F0, were unchanged. The formant frequencies of the first and second formants of the vowels /a/ and /i/ showed mild changes after surgical correction of the palate (Eun et al., 2013).

UPPP and LAUP have an impact on the formant frequencies of vowels. It is apparent that LAUP influences the voice quality of the professional voice users. So, surgeons should consult those patients before any palatal repair (Han et al., 2012).

The acoustic and articulatory characteristics of obstructive sleep apnea-hypopnea syndrome patients differed from those of normal subjects. After UPPP, tissues causing oropharyngeal airway narrowing are removed, the oropharynx is widened and resonance is changed yielding higher formant frequencies than before surgical intervention (Greenet al., 2004).

III- Nasometric evaluation after different kinds of operations:

In the current study, there were no objective statistically significant differences between patients underwent different kinds of operative interventions in terms of oral and nasal sentence preoperatively and three months postoperatively. This means that the used operative techniques (UPPP, LAUP, and TBS) did not affect the oral and nasal resonance. Our study coincides with the study done by Greene et al. (2004), who mentioned that UPPP has no effect on both voice and speech of the patients.

The effect of UPPP does not result in significant changes in voice either by acoustic analysis measures or by clinical assessment. Although the risk of open-nasality after UPPP is low, the results of this study suggest preoperative counseling for the patients. The patients should be aware about the potential voice and speech changes after the operation.

Velopharyngeal insufficiency (VPI) results from excessive excision of the palate in the midline during UPPP. While VPI can cause temporary open-nasality, permanent VPI is rare after surgery. VPI may also occur after LAUP owing to the over-excision of a thin, soft palate (Mora et al., 2009).

Also, Mora et al., (2009) studied velopharyngeal functions, voice and speech changes after tonsillectomy and UPPP. They found insignificant changes in the two groups. They found that most of the patients had open-nasality and nasal escape of air one week after UPPP. Three to four months later, three patients only had open-nasality. More than one year after surgery, palatal incompetence was no longer detectable (Mora et al., 2009).

5. CONCLUSION

Surgical intervention (UPPP, LAUP, and TBS) in sleep apnea patients results in mild voice and speech changes in some patients detected only by acoustic analysis of the patients' voices. Professional voice users should be aware about the changes that can occur after surgical intervention.

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Conflict of Interest:

The author declare that they have no conflict of interest.

Informed consent:

Written & Oral informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

Ethical approval:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards (Ethical approval no.282/003).

Data and materials availability:

All data associated with this study are present in the paper.

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