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A COMPARATIVE STUDY OF ACOUSTIC CHARACTERISTICS OF THE VOICE BEFORE AND AFTER TONSILLECTOMY

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ABSTRACT

Introduction: *tonsillectomy as one the most common surgeries in children is recommended.Since tonsillectomy causes a change in the shape and size of the inferior areas of glottis, researchers are looking for the presence or absence of significant difference in the acoustic and perceptual characteristic of the voice before and after tonsillectomy.* ***Methods:*** *It's a descriptive-analytical study. 15 patients aged 3 to 10 years old with tonsillitis were participated by available sampling.Having a normal IQ and without the history of certain diseases, neurologic problems or structural problems of head and face and voice disorder before the surgery.Before surgery as well as 3 to 4 weeks after that, voice samples of patients including 6 Persian vowels of /æ/, /e/, /o/, /a/, /i/ and /u/ were recorded in an acoustic room.Recording and analysis of the collected data were done by the software of MDVP/Computerized Speech Lab (CSL) model KAY 4500. The examined acoustic parameters in this study include fundamental frequency average, construction formant of F1, F2, F3, jitter, shimmer and harmonic-to-noise ratio (NHR).The acoustic data were analyzed in SPSS.22 software.* ***Results:*** *variation of F1 after the surgery was reducing and these variation were increasing regarding the vowel /u/ and /i/ only and variation of the F3 for all vowels (except /æ/ and /e/) were increasing.Mean variation of the fundamental frequency before and after the surgery for the vowel /æ/ (p-value=0.03), the vowel /e/ (p-value<0.01) and the vowel /i/ (p-value<0.01) has a significant difference, while for the vowels /o/, /â/ and /u/, there was not a significant difference before and after the surgery (p-value>0.05).The mean variation of jitter was reduced after surgery in all sounds. Shimmer average was decreased for all sounds except /e/ and /u/. NHR was in normal distributed only for two sounds; so that these changes for the vowel /o/ is reducing and for the vowel /e/ was increasing. However, changes in any type of these variables were not significant (p-value>0.05).* ***Conclusion:*** *It can be concluded from this study that an objective evaluation of the voice which was used in this study, showed the little effect of tonsillectomy on the acoustic parameters and so the voice quality. So acoustic analysis of voice can be served as a tool to help the ear, throat and nose specialists and predict the effect of surgery on the probable recovery of the patient situation.*

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KEY WORDS

Voice, acoustic analysis, tonsillectomy, sound

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INTRODUCTION

Language is a coding system that refers to the environmental objects and their relationships and helps the human beings to arrange objects as the special systems [1]. Language is established in two main levels of speaking and writing. On the first levels of system, speaking codes replaced the objects and phenomena and can be used to communicate. In speaking, there are some kind of controlled movements of mouth, tongue and lips. The human brain controls all these more complex movement to product he meaningful speech and high quality of voice [2]. The speech includes some fluency components of production, resonance and voice. Vocal track is considered as a resonator for sound production which is started from glottis and continued to the lips [3]. Normal speaking growth of a child depends on his/hergenetic abilities and environmental features. One of them is structural changes in the vocal track that maybe effect the voice of human.Physiological hypertrophy of the tonsils during childhood can cause changes that effects on speaking [4].Arrangement of the lymphoid tissue in the oral cavity and nose-pharynx is known as tonsillar ring [5]that has an immunologic role [3]and includes anterior lingual tonsil, around palatine tonsils and pharyngeal tonsil behind this ring [5]. The growth of pharyngeal tonsil located on

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nasopharynx caused by infection is called Adenoids [6]that interferes breathing through nasal path and phonation [5]and lead to oral breathing in children [6]. Removing it through a surgery is called adenoidectomy [6]. In some texts, when they talk about voice disorders related to tonsils, palatine tonsils are the aim [6]that are located between palatoglossal and palatopharyngealmembrane [3,4, 5]. Tonsil infection which is released into the nasal cavity, ear and respiratory tract is called tonsillitis [6]. Removing tonsils through surgery is called tonsillectomy [6].

Prevalence of voice disorders in children with hypertrophic tonsils is not clear yet, but Salami et al in a study have reported that sound deviation in production /s/ before tonsillectomy is 42.5% [7]. Hypertrophic tissue has a destructive effect of the quality of voice [7]. During producingoral sound, the soft palate moves and tenses to the back of pharynx and separates nasal cavity in above from the oral cavity in bottom. Large tonsils may inhibit this process and cause an air escape from the oral cavity and a hyper nasal speech. Other effects of large tonsils may include mouth breathing, respiratory apnea and muffled voices [3]. To resolve these problems, tonsillectomy as one the most common surgeries in children is recommended [3]. Tonsillectomy may be associated with pain after surgery as well as bleeding [8].

Since tonsillectomy causes a change in the shape and size of the inferior areas of glottis [9], researchers are looking for the presence or absence of significant difference in the acoustic and perceptual characteristic of the voice before and after tonsillectomy. In this regard, a confliction is seen between the conducted studies. Some researchers like D.Antonio et al (1996) acquired significant differences in the acoustic parameters of the voice before and after surgery in adults [10], but another did not find significant differences. For example, Chuma et al (1999) reported that tonsillectomy has a little effects on different voice parameters [11]. On the other hand, some parents say about acoustic producing changes of their children in a short period after the surgery.They mention that tonsillectomyhas changes acoustic features from hyper nasal to normal mode or normal to denasality speech. [11].most of these studies have been conducted on adults and they investigate the effect of tonsillectomy on the voice rather than intensification [11]present study was conducted to evaluate the effect of tonsillectomy on voice recovery after the surgery by acoustic parameters in children to introduce risk factors of tonsillectomy on voice features to determine successes fullness of surgery .

METHODS

This is a descriptive-analytical and non-interventional study. All patients aged 3 to 10 years old with tonsillitis were selected by available sampling from the educational, research and treatment centers of 3 main hospital of Mashhad from December 21th, 2014 to December 21th, 2015 were evaluated for vocal analysis.The number of participants were 15. Inclusion criteria of the study includedchildren with tonsillitis in the mentioned age range, having a normal IQ and without the history of certain diseases, neurologic problems or structural problems of head and face and voice disorder before the surgery. Exclusion criteria included non-cooperation of subjects and deficit in one or more acoustic data related to each subject which causes the acoustic data of each subject was not complete.None of them were not treated by language and speaking pathology services before and after the surgery.These patients were in the waiting list of tonsillectomy. The surgery was performed with general anesthesia and lasted about half an hour.The surgeon accessed to the tonsils through the oral cavity and then proceed to the surgery. Data collection and analysis in this study were evaluated acoustically and analysis was conducted by SPSS.22 software.

Collecting acoustic data of the voice

Before surgery as well as 3 to 4 weeks after that, voice samples of patients including 6 Persian vowels of /æ/, /e/, /o/, /a/, /i/ and /u/ were recorded in an acoustic room. After making the initial communication with the child, the test implementation method was performed. The child was asked to pronounce each vowel for 5 seconds with the habitual loudness and pitch. Microphone was placed with an angle of 90 degrees in front of the child's mouth and at a distance of 15 cm. during recording samples, a short opportunity was given to the participant to rest. To ensure about the adequacy of the data recording, three samples were recorded from each vowel to use the second and third samples if the first and second recorded samples were not appropriate, respectively. In case of inappropriateness of any of the samples, the child was excluded from the study at each stage of sampling. Recording and analysis of the collected data were done by the software of MDVP/Computerized Speech Lab (CSL) model KAY 4500.

The examined acoustic parameters in this study include fundamental frequency average, construction formant of F1, F2, F3, jitter, shimmer and harmonic-to-noise ratio (NHR). The fundamental frequency defined as the lowest frequency of a periodic signal which can be measured in hertz scale [3].Formants are referred to the resonant frequencies of the audio track in time of vowels production which are detectible by sound spectrograph. Jitter is measured as cycle to cycle changes of the fundamental frequency that determines small random perturbations during a voice cycle. Shimmer notes to cycle to cycle changes of the

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amplitude in aharmonic voice cycle and the NHR is the ratio of pressure level of harmonic sound to noise in a voice signal that makes the confusions and noises quantitatively [3].

Analysis of the voice acoustic data

The acoustic data were analyzed in SPSS.22 software. Paired t-test was used to analyze these data. Distribution of the data related to shimmer mean variation of vowel /æ/ and mean variation of NHR for the vowels /u/, /i/, /â/ and /æ/ using Kolmogorov-Smirnov test showed that their distribution is not normal, so we must use non-parametric Wilcoxon Signed Rank test.

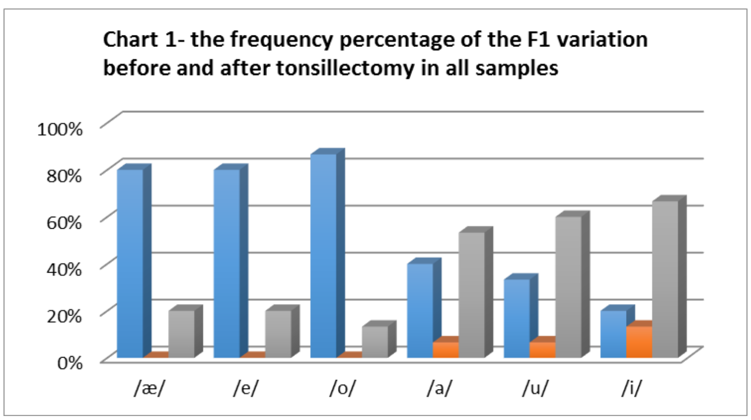
RESULTS

In this section, comparingfundamental frequency changes after the surgery was reported analytically and evaluation of other variables due to low power of the samples was reported as descriptive.

Formants variability

According to the obtained results, the variation of the first, second and third formants which were shown in the **[Figures- 1, 2, 3]** for all vowels was as follows: the variation of F1, F2 & F3 for the vowels of /æ/ and /e/ was reducing in most cases. For the vowel /o/, variation of F1 and F2 were reducing and changes of the F3 was more increasing. For the vowel /a/, variation of the F1 and F2 were more increasing and reducing, respectively but variation of the F3 was remained flat mode in most cases. Also for the vowels of /i/ and /u/, variation of F1, F2 & F3 were increasing, reducing and increasing in most cases, respectively.

In general, according to the **[Figures- 1, 2, 3]**, variation of F1 after the surgery was reducing and these variation were increasing regarding the vowel /u/ and /i/ only and variation of the F3 for all vowels (except /æ/ and /e/) were increasing.



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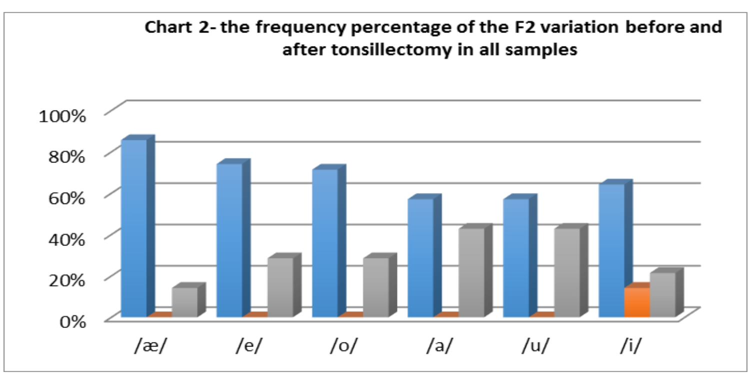

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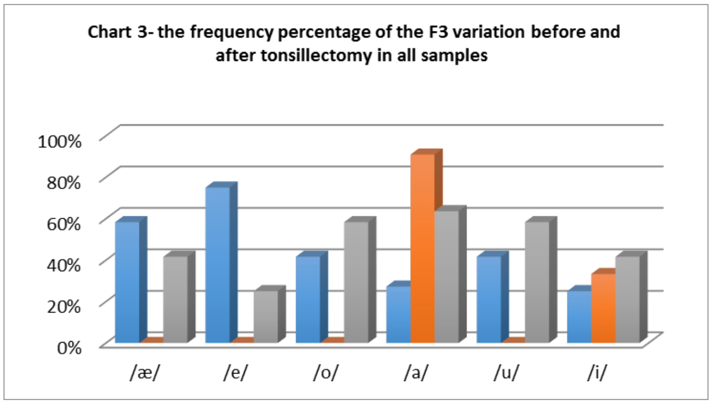

Increasing ■without change■decreasing■

Fig: 1, 2, 3

Mean variation of the formants is given in **[Table-1].**The variation were not significant for any formants (P-value>0.05)

Table:1. Mean variation of the fundamental frequencyand formants before and after tonsillectomy in all samples

Variables/ group		Mean ±			
		Fundamental frequency	F1	F2	F3
Before the surgery	/æ/	333.08±57.27	2459.90±1601.25	6767.93±2347.77	9922.80±2360.94
	/e/	343.34±52.66	3801.83±3449.77	6915.15±2851.17	8856.70±2810.50
	/o/	356.48±76.10	1078.49±211.82	5471.80±1232.53	9391.88±1103.99
	/a/	319.85±59.91	1279.29±197.44	5565.10±1972.61	9470.07±2441.98
	/i/	365.49±80.68	943.62±380.88	5704.53±2100.37	9076.81±1937.63
	/u/	361.02±70.65	2357.00±2194.89	4944.49±1842.37	7867.15±2129.26
After the surgery	/æ/	385.43±69.27	3808.62±3185.46	8761.76±3429.80	10843.63±5055.78
	/e/	387.19±64.34	3172.35±2782.86	6722.45±2786.38	9584.23±2290.53
	/o/	383.13±68.55	1175.91±243.96	5640.03±1384.18	9677.90±2563.72
	/a/	352.09±51.27	1424.80±411.52	6259.56±1678.73	10261.99±1709.45
	/i/	439.52±84.46	1123.72±1232.21	6356.47±2054.54	7980.16±3220.12
	/u/	417.37±64.48	1929.05±1919.65	4590.82±1859.99	7013.65±1883.58

Mean variation of the fundamental frequency

Mean variation of the fundamental frequency before and after the surgery for the vowel /æ/ (p-value=0.03), the vowel /e/ (p-value<0.01) and the vowel /i/ (p-value<0.01) has a significant difference, while for the vowels /o/, /â/ and /u/, there was not a significant difference before and after the surgery (p-value>0.05). **[Table-3].**

The meanvariation of jitter, shimmer and NHR

The mean variation of jitter was reduced after surgery in all sounds. Shimmer average was decreased for all sounds except /e/ and /u/. NHR was in normal distributed only for two sounds; so that these changes for the vowel /o/ is reducing and for the vowel /e/ was increasing **[Table-2].**However, changes in any of these variables were not significant (p-value>0.05). **[Table-3].**

Table: 2. Mean variation (standard deviation) of the other acoustic parameters of the sound before and after tonsillectomy

Variables/ group		jitter	shimmer	Harmonic-to-noise
Before the surgery	/æ/	.92253 (0.600849)	*	*
	/e/	.89236 (0.602653)	2.22050 (0.723368)	.11293 (.038490)
	/o/	.98075 (0.942665)	2.53325 (1.301210)	.10475 (.019932)
	/a/	1.28292 (.931131)	3.29438 (1.429942)	*
	/i/	1.48160 (1.929236)	2.35210 (1.225994)	*

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	/u/	.91089 (0.921690)	2.10522 (0.551100)	*
After the surgery	/æ/	.83380 (0.722780)	*	*
	/e/	.81557 (0.534828)	2.88300 (1.513683)	.11479 (.043892)
	/o/	.62908 (0.309234)	2.11958 (0.873160)	.09658 (.016790)
	/a/	.84985 (0.473424)	2.80985 (0.868349)	*
	/i/	1.04240 (0.918656)	1.77200 (1.496624)	*
	/u/	.85400 (0.375552)	2.20522 (804148)	*

Explanation: the variables with * were not normal distributed.

Table:3. Comparing acoustic parameters of sound before and after tonsillectomy

	Vowel type	p_{value}
F_0	/æ/	0.035
	/e/	0.012
	/o/	0.153
	/a/	0,142
	/i/	0.011
	/u/	0.216
F_1	/æ/	0,583
	/e/	0,098
	/o/	0,290
	/a/	0,651
	/i/	0,373
	/u/	0,056 *
F_2	/æ/	0,124
	/e/	0,360
	/o/	0,104
	/a/	0,054
	/i/	0,672
	/u/	0,094
F_3	/æ/	0,188
	/e/	0,165
	/o/	0,592
	/a/	0,189
	/i/	0,389
	/u/	0,673
jitter	/æ/	0,744
	/e/	0,716
	/o/	0,225
	/a/	0,153
	/i/	0,575
	/u/	0,844
shimmer	/æ/	0,218
	/e/	0,354
	/o/	0,281
	/a/	0,448
	/i/	0,758
	/u/	0,570
NHR	/æ/	0,221
	/e/	0,342
	/o/	0,914
	/a/	0,071
	/i/	0,415
	/u/	0,314

DISCUSSION

The objective of this study was to evaluate the effect of tonsillectomy on voice recovery after the surgery by the acoustic parameters in 3 to 10 years old children. Our findings in this study showed that after tonsillectomy, the average of fundamental frequency in frontal vowels sound has found a significant variation, but in case of the posterior vowels sound, variation have not been significant. We also found that although the mean variation of the first formant after the surgery for the vowels of /u/ and /i/ was increasing and for the other vowels was decreasing and mean variation of the third formant for all vowels except /æ/ and /e/ was increasing, but these changes were

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not significant. Given that the fundamental frequency has variated in the mentioned items but has not had a significant effect on formants, it seems that this phenomenon is occurred due to the constant resonant source [12]. The jitter mean variation after surgery in all sounds and mean variationfor frequency rangin all sounds except /e/ and /u/ were decreasing. NHR was only for two sounds normally distributed; so that these changes for the vowel /o/ is reducing and for the vowel /e/ is increasing. In general, it would be seen that decreasing in frequency and perturbation rang after surgery is proven [13, 14].

The fundamental frequencyand formants are under influence of aerodynamic characteristics and the musclesin the voice tract [3]. Tonsillectomy can effect on the sound by increasing the cavity of resonator or change in formant or a part of soft palatine muscle [11, 15]. Theoretically, it can lead to scaring and limitation in fine motor control or even closure of the velopharyngeal sphincter [12]. Formants are the same harmonic spectrograph peaks of a complex waves. It would be different in various people but it has a stable pattern which facilitates the reading of a sound sample [16].

Sunborg has determined some parts of anatomy in the voice track and has related it to the formant frequencies [12]. The F1 is associated with the open jaw which has limited the sound track and will be increased by open jaw. The F2 is more sensitive to the shape of tongue body and the F3 is sensitive to the tip of the tongue [12].

Although some authors do not distinguish a relationship between tonsillectomy and voice variation, but the others insist on such relationship. Jarboe et al (2001) indicate that tonsillectomy does not involve laryngeal tissue; so the audio features remains relatively stable [17]. Chuma et al showed that tonsillectomy has a little qualitative and quantitative effects on the acoustic parameters [11]. Saida et al also obtained same findings [15, 18]. Lin ei al showed in their studies that the third formant is reduced by tonsillectomy, but F0, F1 and F2 has no variation [19]. The researchers who disagree with this idea/, like Finkelstein [20]et al (1994) and Antonio [10] et al (1996)/, indicate that the removal of the oral pharyngeal soft tissue changes the anatomy acoustic transmission path of the upper pharynx and acoustic scales that is related to the intensified voice track. Antonio reported that tonsillectomy significantly improve the abnormal pitch and breathe noise. Tonsillectomy changes the pharyngeal resonator, so phonation characteristics may be effected [10].

Ilk et al reported that after tonsillectomy, specific parameters of speaking was changed. These changes are basically were the third central frequency of formant and the third broadband of formant for the vowel /o/ and a little decrease in the first and second broadband of formant (B1, B2) of this vowel. Whatever a tonsil is larger, more changes can be seen in the speech spectrograph. Changes in the speech characteristics which lead to improve, express the involvement of aural feedbackand or replacement of the new soft tissue instead of tonsil [3]. So in general, it seems that tonsillectomy has a little effect on the voice [15, 18, 19, 20, 21, 22]that these studies are corresponded to the results of our study.

CONCLUSION

It can be concluded from this study that an objective evaluation of the voice which was used in this study, showed the little effect of tonsillectomy on the acoustic parameters and so the voice quality. So it can be served as a tool to help the ear, throat and nose specialists and predict the effect of surgery on the probable recovery of the patient situation.

Study limitations and recommendations

The small sample size due to the time limitation as well as excluding some samples makes it difficult to interpreted variables. It is recommended that more research will be conducted in this field especially in larger sample size or as a longitudinal study. Also, doing the comprehensive evaluations including physiological evaluation, patient-based cognitive and expert-based cognitive evaluations and determining relationship between these evaluations to understand better about the voice problems of clients seems useful. It is also recommended for future study that the effect of tonsil size, type of surgical tools (scalpel, laser and …) and the comparison of tonsillectomy effect with adenoidectomy on the voice as well as resonance in children and adults are examined.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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FINANCIAL DISCLOSURE

None declared.

REFERENCES

[1] Yule G. [2006].The study of language.3rded.NewYork: Cambridge university press

[2] shipley k G,McAfee JG.[2006] Assessment in speech-language pathology. 1nd ed

[3] Ilk HG, Erogul O, Satar B and Ozkaptan Y. [2002] Effects of tonsillectomy on speech spectrum. *J of Voice* 16:580-586

[4] Schiff-Myers N.[1993] Hearing children of deaf parents. In: Bishop D andMogford K, editors. Language development in exceptional circumstances. Hove: Lawrence Earlbaum ass p.47

[5] Hinrichsen C.[2008] A Synopsis of Regional Anatomy.Australia:World scientific.

[6] SinghI B.[2008] Essentials of Anatomy.2nded.New Delhi:Jaypee Brothers Publishers;

[7] Salami A, Jankowska B, Dellepiane M, Crippa B and Mora R. [2008] The impact of tonsillectomy with or without adenoidectomy on speech and voice. *International Journal of Paediatric Otorhinolaryngology* 72(9):1377-1384.

[8] Koempel JA, Solares CA and Koltai PJ. [2006] The evolution of tonsil surgery and rethinking the surgical approach to obstructive sleep-disordered breathing in children. *The Journal of Laryngology and Otology* 120: 993-1000.

[9] Tolga K, Burcu C, Taskin T, Ziya O.[2006] Effects of Tonsillectomy on Acoustic Parameters. *The Internet Journal of Otorhinolaryngology*. 6(2)

[10] D'Antonio LL, Snyder LS and Samadani SS. [1996] Tonsillectomy in children with or at risk for velopharyngeal insufficiency: effects on speech. Otolaryngology. *Head Neck Surg* 115: 319-323

[11] Chuma AV, Cacace AT, Rosen R, Feustel p, KoltaiiPJ.[1999] Effects of tonsillectomy and/or adenoidectomy on vocalfunction: laryngeal, supralaryngeal and perceptualcharacteristics. *Int J Pediatric Otolaryngology* (47): 1-9

[12] Forming the Vowel Sounds, Vocal Formants.http://hyperphysics.phyastr.gsu.edu/Hbase/music/vowel.html

[13] Smith J, Rey G, Dickens P, Fletcher N. Hollenberg L and Wolfe J. [2007] Vocal tract resonances and the sound of the Australian didjeridu (yidaki). 111. Determinants of playing quality, *J Acoust. Soc Am* 121: 547-558

[14] Van Lierde KM, Claey S, De Bodt M. and Van Cauwenberge P. [2004]Vocal quality characteristics in children with cleft palate: a multi-parameter approach. *J Voice* 18: 354-362

[15] Hori Y, Koike Y, Ohyama G, Otsu SY, Abe K. [1996]Effects oftonsillectomy on articulation. *ActaOtolaryngolSuppl*1(523):248-251

[16] Pranav Chitkara, Mark Yeh, Chris Forbis. Background onFormants http://cnx.org/content/m11733/latest/

[17] Jarboe JK, Zeitels,SM. and Elias B.[2001] tonsillectomy and adenoidectomy in singers. *J Voice* 15(4):561-564

[18] Saida H, Hirose H.[1996] Acoustic changes in voice aftertonsillectomy. *ActaOtolaryngol. Suppl* (523) :239-41

[19] Lin P, Gould WJ, Fukazawa T, et al.[1989] Acoustic analysis ofvoice in tonsillectomy. *J Voice* (3):81-86

[20] Finkelstein Y, Nachmani A, and Ophir D.[1994] The functional role of the tonsils in speech, Arch. Otolaryngol. *Head Neck Surg*. 120: 846-851

[21] Gould WJ.[1987] Surgery in professional singers. *Ear Nose Throat J* 66(8):327-332.

[22] Brosch S, Matthes C, Pirsig W, Verse T[2000].Uvulopalatopharyngoplasty changes in fundamentalfrequency of the voice: a prospective study. *J LaryngolOtol* (114):113-118 .