Voice Assessment Pre- and Post-Adenotonsillectomy in Children

Mohammed A Gomaa[a], Ahmed A Sadek[a], Zienab K Mahmoud[b], Waleed A Abdel Monhem[a]

[a] Otorhinolaryngology Department, Faculty of Medicine, Minia University.
[b]Audiology Department,Faculty of Medicine, Minia University.

Objective

Changes in vocal patterns after adenotonsillectomy are questionable. Few studies have assessed acoustic voice changes before and after adenotonsillectomy. The objective of this study wasto evaluate the impact of adenotonsillectomy on the voice of children with adenotosillarhypertrophy.

Participants **and** Methods

The study included fifty children ranging in age between 4 and 12 years, with adenotonsillar hypertrophy, indicated for adenotonsillectomy. Auditory perceptual assessment of speech included nasality, degree of hyponasality, degree of open nasality, and degree of dysphonia. Acoustic analysis was carried out before and after one month and three months of surgery, using multidimensional voice program software (MVDP). The vowels were analyzed as to their acoustic parameters: fundamental frequency (Hz), jitter (%), shimmer (dB) and noise-harmony ratio (NHR; dB).

Results

At oneand threemonths after surgery, preoperative readings were of F0 score while jitter and shimmer normalized only at the 3rd month. There were significant differences between readings at one month and threemonths of F0 and jitter. Auditory perceptual assessment(APA) of voice (dysphonia) and APA of speech (hyponasality) significantly improved at 1st and 3rd month after surgery with significant differences between results of 1st and 3rd month. Harmonic noise ratio (HNR) had negative, significantly fair correlation with APA of Voice (dysphonia).

Conclusion

Hyponasal speech and with dysphonia preoperatively often have normal resonance and voice following adenotonsillectomy. Objective and subjective evaluation of speech and voice can help the specialist in the management of patients with adenotonsillar hypertrophy.

Keywords: Voice analysis, resonance, tonsillectomy, adenoidectomy

Introduction

The voice is basically a product of three physiological processes: a constant expiratory airflow controlled by chest muscles; production of glottal sound through vibration of the vocal folds, and a change in this sound with amplification and muffling of sound frequencies resulting from the action of pharyngeal, oral and nasal resonant structures (vocal tract) [1].

Hypertrophic palatine tonsils reduce the oropharyngeal air space and push the tongue forward, causing mouth breathing, abnormal nasality and a muffled voice. It is, also, reported that adenoid and tonsil hypertrophy cause obstruction of the nasopharyngeal region and a decreased mobility of velopharyngeal muscles (*i.e.* soft palate) [2]. Adenotonsillectomy is the

most common surgery performed by otolaryngologists, especially in children. Among the most frequently voiced concerns regarding this procedure are questions about changes in vocal patterns after surgery and whether they are temporary or permanent [1].

Multiple studies;using generally subjective voice analysistechniques; found significant changes in nasality and a decrease in nasal airway resistance [3, 4]. Acoustic analysis of voice correlated well with other methods (such as perceptual analysis, indirect laryngoscopy, laryngostroboscopy) in the examination of voice disorders and, also, stated that it might be used as a complementary method [5].However, to date, few studies have assessed voice changes before and after adenotonsillectomy, and most of these did so using only subjective measures (perceptual-auditory voice analysis).Therefore, the aim of this study wasto evaluate the impact of adenotonsillectomy on the voice of children with hypertrophy of tonsils and adenoid.

Participants and Methods

This prospective study included 50 children ranging in age between 4 and 12 years, who were indicated for adenotonsillectomy at the department of Otorhinolaryngology,Minia University Hospital.They all went to the outpatient clinic in the Unit of Phonetics at Minia University Hospital. The inclusion criteria wereadenotonsillarhypertrophy.Exclusion criteria included other causes of chronic nasal obstruction, chronic sinusitis, chronic rhinitis, nasopharyngeal swelling as cyst, angiofibroma, carcinomaandlymphoma, congenital choanal atresia, nasal polyps, cleft palate either frank or sub-mucous, history of misuse and abuse of voice, those complaining of dysphonia since birth, and children with sensorineural or family history of hearing loss. The study was approved by the Ethics Committee for Research atthe Faculty of Medicine, Minia University. The subjects were informed about the goal, procedure and disclosure of its results.

All patients were subjected to full clinical history and physical examination of head and neck, nose, nasopharynx, mouth, pharynx, and mandible.Allpatients underwent standard lateral soft tissue X-ray on the nasopharynx.Auditory perceptual assessment of speech included nasality (closed, open, mixed or normal), degree of hyponasality (0 absent, 1 mild, 2moderate, 3 severe), and degree of open nasality (0 absent, 1 mild, 2moderate, 3 severe).This was performedby simple clinical tests:Gutzman (A/I) test, and the mirror fogging test.Dysphoniawasassigned as 0 for no dysphonia, 1 for mild, 2 for moderate, and 3 for severe.Acoustic analysis was carried out before and after one month and three months of surgery in a sound treated room, using multidimensional voice program software(MVDP). The microphone used was kept at a fixed distance of 10 cm in front of the subject's mouth. We used the sustained vowels /a/, /i/and /u/ in a comfortable and habitual way, after deep inhaling.The vowels were analyzed as to their acoustic parameters: fundamental frequency (Hz), jitter (%), shimmer (dB) and noise-harmony ratio (NHR; dB).

The statistical analysis was performed using SPSS program (Statistical Package for Social Sciences) software version 24. Test of normality (Kolmogorov-Smirnov) was done to determine the distribution of the quantitative data.Quantitative data were expressed as mean, standard deviation and range. On the other

hand, non-parametric quantitative data were expressed as median while categorical data were shown as numbers and percentages.Analyses between different times were done using Wilcoxon signed rank test for qualitative and non-parametric quantitative data, and using paired samples *t*test for parametric quantitative data.Correlation between two qualitative and quantitative variables was done by using non-parametric Spearman's rho correlation coefficient. The level of significance was taken at P value < 0.05.

Results

The study included 50 children withadenotonsillarhypertrophy,of whom 26 (52%) were males and24(48%) were females. Theirageranged from 4 to12 years, with an average of 7.6±2.2 years.

As shown in Table 1, readings of preoperative F0 was significantly reduced at 1 month (P = 0.025) and 3 months (P < 0.001) after surgery with a significant difference still between readings of 1st and 3rd month (P = 0.018). The preoperative readings of Jitter were significantly reduced at 3rd month (P < 0.001), with a significant difference between readings of 1st and 3rd month (P = 0.004). Preoperative Shimmer had a significant reduction at the 3rdmonth after surgery (P = 0.003). Comparison of HNR at different time points showed no significant differences.

As shown in Table 2, APA of voice and APA of speech significantly improved at 1st and 3rd month after surgery with significant differences between results of 1st and 3rd month.

Preoperatively; there were 30(60%) patients who had no dysphonia, 16 patients (32%) who had mild dysphonia, 4 patients (8%) who had moderate dysphonia. At postoperative 1 month; there were 38patients (76%) who had no dysphonia,and 12 patients (24%) who had mild dysphonia. At postoperative 3 months; there were 45(90%) patients who had no dysphonia, and 5 patients (10%) who had mild dysphonia. The dysphonia improved postoperatively in 15 (30%) patients while 5 (10%) patients still hadmild dysphonia.

Preoperatively; there were 19 patients (38%) with normal nasality, 24 patients (48%) who had mild hyponasality, and 7 patients (14%) who had moderate hyponasality. At postoperative 1month; there were 36 patients (72%) with normal nasality, 13 patients (26%) with mild hyponasality, one patient with moderate hyponasality. At 3 months post operatively, there were 45 patients (90%) with normal nasality, and 5 patients (10%) with mild hyponasality. The hyponasality improved post operatively in 26 (52%) patients while 5 patients (10%) did not improve post operatively.

As regards correlation of APA of voice, APA of speech with the acoustic parameters at onemonthpostoperatively (Table 3) and three months postoperatively (Table 4),HNR had negative fair correlation with (APA of voice).This may be due to improvement of dysphonia accompanied with elevation of HNR (r-value: -0.282, p-value: 0.047).

Table 1: Statistical comparisons between pre-operative, post-operative 1month, and post-operative 3 month as regards fundamental frequency (F0), jitter 1st, shimmer db, and harmonic noise ratio (HNR).

Parameter	Pre	Post 1	Post2	P value		
				Pre vs Post 1	Pre vs Post 2	Post 1 vs Post 2
F0 Range	(219.4-431.8)	(226.5-365.6)	(220.8-377.7)	0.025*	<0.001*	0.018*
Mean± SD	293±47.1	284.2±40.7	279.9±39.7			
Median	281.8	278.8	274.6			
Jitter 1st Range	(0.5-76.7)	(0.3-21.4)	(0.5-10.3)	0.137	<0.001*	0.004*
Mean ±SD	5.7±11.2	4±4.6	2.3±2.4			
Median	2.7	2.4	1.4			
Shimmer Range	(0.3-4.5)	(0.3-3.6)	(0.3-3.2)	0.193	0.003*	0.142
Mean ±SD	1.5±0.8	1.3±0.8	1.1±0.5			
Median	1.4	1.1	1			
($)HNR Range	(6-21.2)	(5.8-20.3)	(7.1-19.3)	0.513	0.557	0.965
Mean ±SD	14.1±3.2	13.8±3.2	13.8±3.1			
Median	14.2	14	14.3			

Wilcoxon signed rank test for non-parametric quantitative data; ($) Paired sample t test for parametric quantitative data; *: Significant level at P< 0.05

Table 2: Comparisonsof pre-operative, post-operative 1month and post-operative 3 months results as regards auditory perceptual assessment of voice (APA of voice) and speech (APA of speech).

Variables	Pre	Post 1	Post 2	P value		
				Pre vs Post 1	Pre vs Post 2	Post 1 vs Post 2
APA of Voice No dysphonia	30(60%)	38(76%)	45(90%)	0.001*	<0.001*	0.008*
Mild dysphonia	16(32%)	12(24%)	5(10%)			
Moderate dysphonia	4(8%)	0(0%)	0(0%)			
APA of Speech No hypo-nasality	19(38%)	36(72%)	45(90%)	<0.001*	<0.001*	0.002*
Mild hypo-nasality	24(48%)	13(26%)	5(10%)			
Moderate hypo-nasality	7(14%)	1(2%)	0(0%)			

Wilcoxon signed rank test qualitative data;*: Significant level at P< 0.05

Table 3: Correlation of APA of voice, APA of speech with the acoustic parameters at 1 month post-operatively.

Parameter	APA of voice post 1		APA of speech post 1	
	R value	P value	R value	P value
FO post 1	-0.159	0.270	0.055	0.704
Jitter post 1	-0.029	0.840	0.211	0.142
Shimmer post 1	0.177	0.219	0.016	0.914
HNR post 1	-0.282	0.047*	-0.010	0.946

Non-parametric Spearman's rho correlation;*: Significant level at P< 0.05

Table 4: Correlation of APA of voice, APA of speech with the acoustic parameters at 3 months post operatively.

Parameter	APA of Voice post 2		APA of Speech post 2	
	R value	P value	R value	P value
FO post 2	0.058	0.690	0.159	0.269
Jitter post 2	-0.049	0.738	0.030	0.836
Shimmer post 2	-0.146	0.313	-0.136	0.345
HNR post 2	0.081	0.577	0.062	0.667

Non-parametric Spearman's rho correlation;*: Significant level at P< 0.05

Discussion

In addition to subjective assessment of voice, the present study used MDVP to evaluate objective acoustic analysis parameters including F0, jitter, shimmer, and NHR were used to evaluate voice in the preoperative and post adenotonsillectomy in children.

Our results revealed a significant reduction in the severity of preoperative hyyponasality and dysphonia after adenotonsillectomy. These results are in agreement with other report [5, 7] that showedthatadenotonsillar hypertrophy was considered the most common cause of upper respiratory tract obstruction among children. It results in a spectrum of symptoms from mouth breathing, nasal obstruction, hyponasal speech, snoring, and obstructive sleep apnea (OSA) to growth failure and cardiovascular morbidity. The hyponasalitycan be explained bythe fact that nasality reflects the listener's subjective judgment of air space into the nose and nasal resonance, based on change in sound and a decision as to whether this is normal or not.However, some authors reported that the presence of hypertrophic tonsils reduces the oropharyngeal space, project the tongue forward and causeshypernasality, mouth breathing and muffled voice [2].

Improvement of voice and speech of the patients by perceptual assessment of the voice and speech after adenotonsillectomyis in agreement with other studies.Onestudy[8] indicated that velopharyngeal insufficiency, mostly of idiopathic cause, can exist without overt clefts of the hard or soft palate and often remain undetected until adenoidectomy deprives the patient of tissue mass in the nasopharynx and veloadenoidalclosure.Ifperceptual auditory voice analysis carried out during a chained speech (counting numbers, narrating months of the year, or reading a predefined text), this analysis is more comprehensive and also includes vocal aspects related to articulation and resonance, thus being considered by many authors as the gold standard of vocal assessment.

We found a statistically significant difference between the assessments in the 1st and 3rd months after the surgery. We, also, noticed a tendency in favor of a difference between before and at the 1st month after the surgery. These findings support the hypothesis that adenotonsillectomy procedures are responsible for transient changes in the pattern of vocal emission, creating a temporary phonation instability that disappears throughout the post-operative period.

Regarding evaluation of acoustic parameters after adenotonsillectomy, the present study revealed normalization of F0 normalized significantly at 1st month after surgery, while the significant changes in Jitter and Shimmer were delayed to the 3rd month with non-significant changes in HNR.In literature, there is a controversy in the dataof acoustic analysis after adenotonsillectomy in children, ranging from no improvement [1, 9], minimal improvement [10], to improvement in all the acoustic parameters after adenotonsillectomy [2, 11].

We found a significant normalization in F0 after surgery since 1st month. F0 is indicative of the vocal fold vibratory rate and reflects resonance characteristics, of the supralaryngeal vocal tract, related to tongue articulation and placement. Early normalization of F0 indicates that adenotonsillectomy, although a procedure that does not affect the

larynx, changes the structure of the vocal tract and thus the resonance of speech production (lowering the pitch of the voice often decreases the resonance and consequently can decrease the nasal resonance values), and is; thus; a surgery capable of improving speech quality [2, 12]. The delay in normalization of jitter and shimmer to 3rd month after surgery in our study, may be partly attributed to theuse of electro-cautery during adenotonsillectomy, which results in residual tissue edema.

In the present study, NHR had a negative fair correlation with APA of voice.This may be due to improvement of dysphonia that is accompanied with elevation of NHR.Other authors have found low NHR values to correlate with particular aspects of dysphonia, such as hoarseness, roughness, and breathiness [13]. The effect of tonsillar and adenoid hypertrophy in the voice resonators is reflected as low NHR [14].

From our results, we can emphasize that adenotonsillectomy can improve acoustic parameters, nasality and dysphonia within three months after surgery in children with hypertrophied tonsils and/or adenoids.

Conclusion

This study concluded that adenotonsillectomy can improve voice quality and improve resonance; if well done; and well preoperative assessment to prevent complications related to resonance.Resonance and dysphonia often change because of adenotonsillectomy.Patients with hyponasal speech and with dysphonia preoperatively often have normal resonance and voice following surgery.The information obtained in this study helps the physicians and phoneticians to predict and document how a patient speech and voice might be affected by surgery so that the parents can be appropriately counseled.Adentonsillectomy should be the first surgical consideration when speech abnormalities are present.Therefore, objective and subjective evaluation of speech and voice could be recommended to help the specialist in the management of the patients with adenotonsillar hypertrophy.

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