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Original Research Article

The impact of adenotonsillectomy on the acoustic parameters of voice

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ABSTRACT

Background: The aim of the study was to evaluate and compare the changes in the acoustic parameters of voice and nasalance in individuals with chronic adenotonsillitis, before and after surgery.
Methods: A pospective case-control study conducted in the department of ENT and HNS of a tertiary care centre from September 2014 to June 2016 with 120 patients aged between 5 to 16 years. 60 cases and 60 controls were assessed aged between 5 to 16 years. Cases included patients who underwent adenotonsillectomy in the inpatient department of ENT at Father Muller Medical College, Mangalore, India. Acoustic analysis of 5 parameters (fundamental frequency, jitter, shimmer, noise harmonic ratio and nasalance) was done 1day pre-operatively and at 4 weeks post-operatively by means of a VAGMI, Voice and Speech Systems, Bangalore, India, providing normative data for analysed measures.
Results: The results of the study showed that pre-operative cases exhibited significant alterations in Jitter, Shimmer and NHR, compared to the control group. No significant differences were observed in the F0. Nasalance significantly reduced post-operatively and were almost normalized after the surgery.
Conclusions: Chronic adenotonsillar hypertrophy causes transient changes in acoustic parameter of voice, which makes the voice disharmonic and harsh. Adenotonsillectomy eliminates the nasalance. Hence, parents should be warned for changes in voice after surgery.

Keywords: Adenotonsillectomy, Acoustic parameters, Fundamental frequency, Jitter, Shimmer, NHR, Nasalance, VAGMI

INTRODUCTION

Chronic adenotonsillitis is a common ailment in the paediatric age group. Adenoids and tonsils undergo physiological enlargement during childhood. The growth of adenoidal tissue peaks at or near six years of age, and begins to undergo involution at or near this age as well. The tonsils increase in size until 4 years of age and its involution begins just before puberty. Certain children have a propensity to generalized hyperplasia of lymphoid tissue which may affect the adenoid gland and tonsils as well.[1]

The vocal tract, which starts from the glottis and extends to the lips, is considered to be a resonator for speech. Enlarged adenoids and palatine tonsils, by mass effect, can cause obstructive symptoms of varying degrees and by protruding into the pharyngeal air passages can influence the shape and resonating qualities of this vocal tract, and negatively affect several aspects of the speech spectrum.[2] Adenotonsillectomy has been reported to affect the characteristics of voice causing changes in the contour of the vocal tract post-surgery.

Aim

The aim of the study was to evaluate and compare the changes in the acoustic parameters of voice and nasalance in individuals with chronic adenotonsillitis, pre and post-operatively

Objectives

The objectives of this study were to compare the differences in the acoustic parameters of voice between children with chronic adenotonsillitis, (a) before and after surgery; and (b) before and after surgery with that of normal children.

METHODS

The study was conducted at Father Muller Medical College, Mangalore, Karnataka, India, over a period of 22 months from September 2014 to June 2016.

Study setting

The study was carried out at department of ENT, Father Muller Medical College Hospital, Mangalore, Karnataka.

Study design

The study was prospective case control study with purposive sampling technique.

Study duration

The study duration was of 22 Months, from September 2014 to June 2016.

Study population

The study population is divided into 2 groups (a) group 1 consisted of normal healthy children aged 5 to 16 years, without chronic adenotonsillitis (controls); and (b) group 2 consisted of patients, aged 5 to 16 years, presenting to the hospital with chronic adenotonsillitis, who will undergo adenotonsillectomy (cases). Chronic tonsillitis will be diagnosed by history and clinical examination of the oral cavity and oropharynx. Size of the tonsils will be graded (according to Brodsky's classification) on a scale of 1 to 4. Chronic adenoiditis will be diagnosed by history, clinical examination and X-ray of the nasopharynx (soft tissue)- lateral view. Size of the adenoid will be graded (according to Fujioka et al classification) by adenoid-nasopharynx ratio (A/N ratio).

Inclusion criteria

Patients aged 5 to 16 years, with chronic adenotonsillitis, undergoing adenotonsillectomy and those willing to participate in the study were included.

Exclusion criteria

Patients younger than 5 years and older than 16 years, and with craniofacial anomalies, neurological problems, acute tonsillitis, previous attacks of quinsy, sensorineural hearing loss and children who undergo speech or language therapy before surgery were excluded.

Sample size

For a power of 90%, level of significance of 5%, and confidence interval of 95%, a sample size of 27 cases and 27 controls was calculated. However, for ease of separation of the cases into 2 groups a sample size of 30 cases and 30 controls is chosen. Therefore, n was 60.

However, due to availability of ample cases and controls the sample size was increased to 60 cases and 60 controls, to make a total of 120 cases.

Sampling method

All patients, aged 5 to 16 years fulfilling inclusion and exclusion criteria, diagnosed to have chronic adenotonsillitis and have undergone adenotonsillectomy, for whom consent has been given by the parents/ guardians for voice analysis 1 day prior to surgery and 4 weeks after surgery were chosen as cases in the study.

Normal children, aged 5 to 16 years, without symptoms or signs of chronic adenotonsillitis, for whom consent has been given by the parents/ guardians for voice analysis were chosen as controls in the study.

Voice laboratory assessment

Objective voice analysis was done on each case with the use of a software called VAGMI, voice and speech systems, a clinical application for the analysis of nasalance.

The recording and the analysis were done in a sound proof room by using the microphone meant for the purpose. Only the sound 'a' was used for the purpose of analysis. The prolonged vowel 'a' was chosen because it is considered to be the most sensitive indicator of difference in vowel production.

The microphone was on the stand and during recording the distance between the mouth and the microphone was 4 to 6cms. The programme automatically extracts and displays 33 separate voice parameters that can be compared to threshold values and displayed graphically. For the evaluation of nasalance, a nasometer module of VAGMI software was used. Nasometer uses a handheld separator baffle plate that is held over the upper lip of the patient, which helps separate the oral and nasal cavities. Microphones mounted on the top and bottom of the plate collect acoustic energy during speech.

The following parameters were assessed in this study (a) fundamental frequency (F0) is defined as the number of glottal pulses divided by time. It represents the number of times the vocal folds open and close per second and is measured in hertz; (b) jitter is a cycle to cycle variation in time or period with fundamental frequency. It is measured in percentage; (c) shimmer is a measure of the fluctuation in the amplitude of a sound signal from vibratory cycle to vibratory cycle. It is measured best during sustained phonation of a vowel. It is measured in decibels; (d) noise to harmonics ratio contrasts the periodic or regular signal produced by the vocal folds with the 'noise' or aperiodic signal from the vocal folds and vocal tract. This is usually expressed in decibels. The hoarser or noisy a voice is the higher is the noise to harmonics ratio; and (e) nasalance is a measure of the degree of velopharyngeal opening in voiced speech formed by computing the ratio of the amplitude of the acoustic energy at the nares, An, to amplitude of the acoustic energy at the mouth, Am. It is a highly sensitive diagnostic method for evaluation of hypo/hypernasality.

RESULTS

In our study the maximum number of patients were in the age group of 5 to 7 years, followed by the 8 to 10 years' age group overall. The youngest patient was 5 years of age and the oldest, 16 years of age. The mean age of the children in the control group was 10.37 years and in the adenotonsillectomy group was 9.07 years. Out of the 120 patients studied, 62 were female and 58 were male. The mean pre-operative fundamental frequency when compared to the mean post-operative fundamental frequency showed no statistical significance (p=0.25). The mean jitter percentage in the adenotonsillectomy dropped from 3.62 to 0.64 post surgery. These results were noted to be statistically highly significant (p=0.000). The mean shimmer value was observed to be decreased from 5.75 pre-operatively to 2.57 post-operatively (p=0.000). The mean NHR in the adenotonsillectomy group changed from 36.20 to 13.98 following the surgery (p=0.000). The mean pre-operative nasalance score in the adenotonsillectomy was 47.30 which dropped to 16.85 post-operatively (p=0.000) as shown in Table 1.

The five vocal parameters, fundamental frequency, jitter, shimmer, noise to harmonics ratio and nasalance of the study groups were compared with that of the control group, both pre-operative and post-operative values. This enabled us to check the comparability of the pre-operative values with that of normal children, and to compare the post-operative values to see if it comes close to normal post-surgery. The fundamental frequency values in the group (adenotonsillectomy) pre-operatively were comparable to that of normal children in the control group (p=0.002) indicating the disease conditions effect on the vocal mechanism. Post-operatively there was significant change in the value and the fundamental frequency of the study group was comparable to that of the control group (p=0.001), suggesting alterations in acoustic parameters post-operatively.

When comparing the pre-operative jitter values of the case group to the control group, a statistically significant difference was observed (p=0.000), suggesting a vocal system influence of the disease. When the case group's post-operative jitter values were compared to those of the control group, there was a significant difference (p=0.000), indicating that the acoustic characteristics had changed after surgery. Additionally, the post-operative results that were obtained were rather near to the control group's normative range. When compared to the control group, the case group's pre-operative shimmer values were found to be greater, indicating a poor correlation. After the procedure, the shimmer values in the group that had adenotonsillectomy had altered, but they were still on par with the youngsters in the control group who were not affected by the procedure (p=0.094). The pre-operative evaluation of the noise to harmonics ratio in the case group differed from that in the control group. Compared to the control group, the post-operative NHR values of the children who had adenotonsillectomy were nearly within normative limits (p=0.120). The nasalance values of the adenotonsillectomy group were not the same as those of the control group prior to surgery. After surgery, the group who underwent adenotonsillectomy showed a drop in nasalance values, albeit it wasn't significant.

Table 1: Wilcoxon signed rank test to evaluate the differences between pre-operative and post-operative values of each case group with that of control.

Parameters	Groups	N	Mean	SD	Median	Wilcoxon signed rank test		Significance
						Z value	P value	
Fundamental frequency	Pre-op	60	244.67	41.21	247.49	-1.134	0.257	NS
	Post-op	60	242.32	40.41	242.70			
Jitter	Pre-op	60	3.62	1.36	3.54	-6.736	0.000	HS
	Post-op	60	0.64	0.37	0.70			
Shimmer	Pre-op	60	5.75	1.71	5.54	-6.652	0.000	HS
	Post-op	60	2.57	1.01	2.63			
Noise harmonics	Pre-op	60	36.20	7.69	35.00	-6.738	0.000	HS
	Post-op	60	13.98	2.65	14.00			
Nasalance	Pre-op	60	47.30	16.17	43.50	-6.737	0.000	HS
	Post-op	60	16.85	5.25	16.50			

Note: HS- Highly significant, NS- non-significant.

Table 2: Mann Whitney test to evaluate differences between pre-operative and post-operative values of each case group with that of the control.

Groups		N	Mean	SD	Median	Mann Whitney test	
						Z value	P value
F0 pre-op	Case	60	244.67	41.21	247.49	-3.086	0.002 HS
	Control	60	256.31	70.05	289.21		
F0 post-op	Case	60	242.32	40.41	242.70	-3.422	0.001 HS
	Control	60	256.31	70.05	289.21		
Jitter pre-op	Case	60	3.62	1.36	3.54	-7.668	0.000 HS
	Control	60	1.47	1.28	1.05		
Jitter post-op	Case	60	0.64	0.37	0.70	-4.475	0.000 HS
	Control	60	1.47	1.28	1.05		
Shimmer pre-op	Case	60	5.75	1.71	5.54	-8.075	0.000 HS
	Control	60	2.95	1.02	2.81		
Shimmer post-op	Case	60	2.57	1.01	2.63	-1.674	0.094 NS
	Control	60	2.95	1.02	2.81		
NHR pre-op	Case	60	36.20	7.69	35.00	-9.455	0.000 HS
	Control	60	14.80	3.42	15.00		
NHR post-op	Case	60	13.98	2.65	14.00	-1.556	0.120 NS
	Control	60	14.80	3.42	15.00		
Nasal pre-op	Case	60	47.30	16.17	43.50	-9.453	0.000 HS
	Control	60	8.43	4.32	8.50		
Nasal post-op	Case	60	16.85	5.25	16.50	-7.163	0.000 HS
	Control	60	8.43	4.32	8.50		

Note: HS- Highly significant, NS- non-significant.

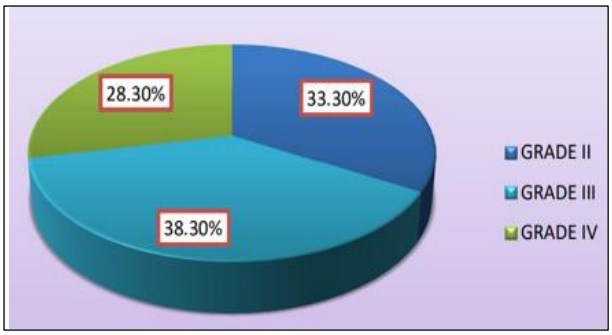

Figure 1: Adenoid grades of patients studied.

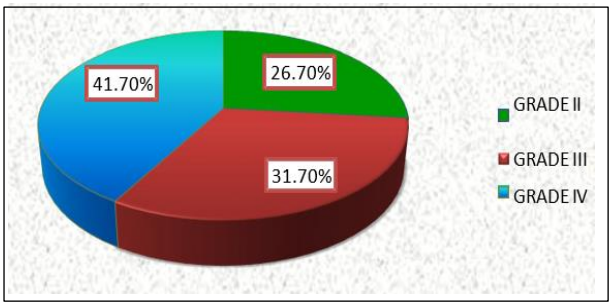

Figure 2: Tonsil grades of patients studied.

DISCUSSION

Adenotonsillitis is a common illness in the pediatric age group. Vocal tract morphology changes that occur postoperatively due to adenoidectomy, tonsillectomy, or both have been reported to impact voice characteristics.[1] The sound is produced by vibrations in the vocal folds. Resonance has an impact on sounds due to the vocal tract's physical features. The vocal tract, which extends from the lips to the glottis, is mostly made up of the tonsils, which are located in the oropharynx, and the adenoids, which are located in the nasopharynx. They can change the shape of the vocal tract merely by making the lymphoid tissue grow. Changes in the architecture and resonance of the vocal tract are caused by the following factors: when it comes to children, adenotonsillitis is a common illness. Vocal tract morphology changes that occur post-operatively due to adenoidectomy, tonsillectomy, or both have been reported to impact voice characteristics.[1] The sound is produced by vibrations in the vocal folds. Resonance has an impact on sounds due to the vocal tract's physical features. The vocal tract, which extends from the lips to the glottis, is mostly made up of the tonsils, which are located in the oropharynx, and the adenoids, which are located in the nasopharynx. They can change the shape of the vocal tract merely by making the lymphoid tissue grow. The architecture and resonance of the vocal tract are altered by the following factors.

Before surgery, the jitter values of all the children in the current study with adenotonsillar hypertrophy were changed, and these values differed significantly from those of the control group. This illustrated that the illness results in a hoarse voice. After surgery, it was discovered that the children having adenotonsillectomy had far lower jitter levels. There was a postoperative normalization of jitter levels as evidenced by the post-operative values being

found to be comparable to the values obtained in the control group of children who were normal (for an adenotonsillectomy, p=0.000).

Our findings showed that children with postoperative persistent adenotonsillitis had score values comparable to those of children without the illness (p=0.000 for adenotonsillectomy), proving that vocal diversity and roughness existed even in the young children in the control group (perhaps due to sensitive vocal tracts). The study group's voice did not exhibit any postoperative hoarseness or roughness, and its shimmer values decreased following surgery. Because the shimmer values obtained following surgery were comparable to those of children who are regularly developing, postoperative normalization can be proposed. As evidenced by the studies conducted by Salami et al, Jankowska et al, Celebi et al, Mora et al, and other authors, both levels significantly decline, and normalize post-surgery.[2,6-8] Comparable Lundeborg et al to our study, showed a decrease in jitter and shimmer percent post-surgery however the reduced 65 measures were still not normalized and remained higher compared to the control group of normal children.[5]

The quality and precision of the vocal sound output are decreased as a result of tissue hypertrophy's dampening impact during the vocal transfer function. One metric used to quantify the amount of aperiodic noise in a voice signal under analysis is the noise harmonics ratio.[11] When compared to the children in the control group, the children recruited for our study with chronic adenotonsillitis had higher noise-to-harmonics ratios during the pre-operative evaluation. As a result, statistical analysis revealed no similarities between the pre-operative NHR of the study subjects and the controls (adenotonsillectomy p=0.120). Children who had adenotonsillectomy saw a drop in NHR after surgery, to the point where the obtained values were almost at normative values. However, a number of studies confirm that NHR returns to normal after adenotonsillectomy, such as the studies by Mora et al, Lundeborg et al, Salami et al, Jankowska et al, Celebi et al, and Gokhan et al.[2,5-9] Subramaniam et al noticed that NHR was lower in patients than in the controls and that post-operative NHR was higher in all the age groups.[4]

Using the Nasometer sub-module of the VAGMI Software, the study's final parameter to be analyzed was Nasalance. According to our research, children with chronic adenotonsillitis had higher nasalance values prior to surgery (47.30). There was a considerable disparity in the pre-operative values between the normal children and the control group, with the normal children having far lower nasalance levels (8.43% in the control group). Following adenotonsillectomy, children with chronic adenotonsillitis showed a statistically significant drop in nasalance scores, from 47.30% to 16.85% (p=0.000). Nasalance was shown to decrease following surgery in the study by Subramaniam et al however the drop was not statistically significant, and only nasalance demonstrated a meaningful link between the size of the adenoid and the tonsil grade.[4] Changes in nasal resonance as demonstrated by him following adenotonsillectomy were reported by Kummer et al.[10] After surgery, 47% of the participants in their research saw improvement from their pre-operative hyponasality and nearly returned to their pre-operative nasality. Following the removal of the lymphoid tissues from the pharynx, one patient experienced a hypernasal voice, which resolved over time to become normal nasality. Other patients continued to have hyponasality as a result of nasal mucosal edema brought on by allergic rhinitis.

CONCLUSION

Due to tonsil and adenoidal enlargement, the voice becomes harsh and discordant. This was demonstrated by variations in the several attributes that we measured for our study: noise-to-harmonic ratio, shimmer, and jitter. Adenotonsillectomy has been shown to enhance and return voice qualities to normal. The fundamental frequency stayed constant due to the fact that adenotonsillectomy is a procedure that does not modify the vocal tract's anatomy, which could impact resonance during speech production, or the larynx, which could alter the vocal fold vibratory rate.[11] After surgery, nasal resonance became better and was discovered to be comparable to children in the normal range. It was noted that after adenotonsillectomy, hyponasality could occasionally continue. More research is needed to determine the factors that lead to hyponasality in pediatric patients after adenotonsillectomy surgery.

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