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Audiological Assessment in Patients with Adenoid Hypertrophy Undergoing Adenoidectomy

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Abstract

Background: Adenoid hypertrophy is a common cause of Eustachian tube dysfunction and otitis media with effusion (OME) in children, often resulting in conductive hearing loss and impaired middle-ear ventilation. Persistent OME may adversely affect speech development, academic performance, and quality of life. Adenoidectomy is widely performed to alleviate nasopharyngeal obstruction and improve middle-ear function; however, the extent of postoperative audio logical improvement requires further evaluation.

Objectives: To assess hearing status before and after adenoidectomy in children with adenoid hypertrophy and to evaluate changes in Eustachian tube function using tympanometric findings.

Methods: This prospective longitudinal observational study was conducted among 66 children aged 5–12 years with adenoid hypertrophy undergoing adenoidectomy. Preoperative evaluation included clinical assessment, nasal endoscopy, pure-tone audiometry (PTA), and tympanometry. Audiological assessments were performed on 132 ears. Follow-up evaluations were conducted at 1, 3, and 6 months postoperatively. Changes in hearing thresholds and tympanometric patterns were analyzed using repeated-measures analysis of variance and Chi-square test, with $p < 0.05$ considered statistically significant.

Results: The mean age of the study population was 8.4 ± 2.1 years, and 60.6% were males. Preoperatively, mild

conductive hearing loss was observed in 54.5% of ears, while Type B tympanogram was the most common finding (54.5%). The mean PTA improved significantly from 28.6 ± 7.4 dB HL preoperatively to 23.1 ± 6.5 dB HL at 1 month, 20.2 ± 5.8 dB HL at 3 months, and 18.4 ± 5.3 dB HL at 6 months postoperatively ($p < 0.001$). Tympanometric evaluation demonstrated progressive normalization, with Type Atympanograms increasing from 15.2% preoperatively to 78.8% at 6 months, while Type B tympanograms decreased from 54.5% to 6.1% ($p < 0.001$).

Conclusion: Adenoidectomy significantly improved hearing thresholds and middle-ear function in children with adenoid hypertrophy and OME. The procedure resulted in progressive audio logical recovery and restoration of Eustachian tube function, supporting its role as an effective treatment modality in appropriately selected Pediatric patients.

Keywords: Adenoid Hypertrophy, Adenoidectomy, Otitis Media with Effusion, Conductive Hearing Loss, Pure-Tone Audiometry, Tympanometry, Eustachian Tube Dysfunction, Pediatric Otolaryngology.

Introduction

Otitis media with effusion (OME) is one of the most common causes of hearing impairment in childhood and is characterized by the presence of non-purulent fluid within the middle ear without signs of acute infection. Persistent OME may result in conductive hearing loss, speech and language delays, behavioral problems, and impaired academic performance if left untreated. [1–3] The condition is particularly prevalent among school-aged children and is frequently associated with adenoid hypertrophy, which contributes to Eustachian tube dysfunction through mechanical obstruction and chronic inflammation of the nasopharynx. [4–6]

Adenoid hypertrophy has long been recognized as an important etiological factor in the development and persistence of OME. Enlargement of adenoid tissue may obstruct the nasopharyngeal opening of the Eustachian tube, impair middle-ear ventilation, and serve as a reservoir for pathogenic microorganisms, thereby promoting middle-ear effusion.[7–9] Several studies have demonstrated a significant association between adenoid size and the occurrence of OME in children.[8,9] Endoscopic assessment has emerged as a reliable method for grading adenoid hypertrophy and evaluating its potential impact on Eustachian tube function.[10]

Adenoidectomy has been widely employed in the management of OME, particularly in children with persistent disease and coexisting adenoid hypertrophy. Early randomized controlled trials reported that adenoidectomy improves middle-ear ventilation and reduces the recurrence of middle-ear effusion.[11–13] Subsequent meta-analyses have further supported the beneficial role of adenoidectomy, either alone or in combination with ventilation tube insertion, in improving hearing outcomes and reducing the duration of OME.[14,15] Recent evidence from the Cochrane review by Mackeith et al. also suggests that adenoidectomy may provide clinically meaningful benefits in selected children with OME, although the magnitude of benefit may vary depending on patient characteristics and disease severity.[1]

Several contemporary studies have demonstrated significant postoperative improvement in hearing thresholds and tympanometric findings following adenoidectomy in children with OME.[2–5] However, variations in patient selection, disease severity, and follow-up duration continue to influence reported outcomes. Therefore, the present study was undertaken

to assess hearing status before and after adenoidectomy and to evaluate changes in Eustachian tube function using audiological and tympanometric parameters in children with adenoid hypertrophy and OME.

Material and Methods

This prospective longitudinal observational study was conducted in the Department of Otorhinolaryngology and Head–Neck Surgery of a tertiary care teaching hospital over a period of 6 months to evaluate the effect of adenoidectomy on hearing status and Eustachian tube function in children with adenoid hypertrophy and otitis media with effusion (OME). Children aged 5–12 years who were diagnosed with adenoid hypertrophy by nasal endoscopy and were scheduled for elective adenoidectomy were enrolled in the study. OME was diagnosed based on clinical findings, otoscopic examination, conductive hearing loss and/or abnormal tympanometric findings indicative of middle-ear effusion. Children with previous adenoidectomy or middle-ear surgery, congenital ear anomalies, sensorineural hearing loss, craniofacial syndromes such as cleft palate or Down syndrome, acute upper respiratory tract infection at the time of assessment, or incomplete follow-up were excluded from the study.

The sample size was calculated for comparison of paired mean hearing thresholds before and after surgery. Based on previous studies reporting postoperative hearing improvements of approximately 5–13 dB and assuming a standard deviation of 10 dB, a minimum sample size of 60 participants was required at a 95% confidence level and 80% statistical power using the formula $n = (Z\alpha + Z\beta)^2\sigma^2/d^2$. After accounting for a possible 10% attrition rate, a total of 66 children were recruited. [2–4]

Written informed consent was obtained from the parents or legal guardians of all participants prior to enrolment. A detailed clinical history was obtained, including symptoms such as nasal obstruction, mouth breathing, snoring, recurrent upper respiratory tract infections, hearing difficulty, and ear fullness. All children underwent comprehensive otorhinolaryngological examination. Adenoid size was assessed using rigid nasal endoscopy and graded according to the classification described by Clemens and McMurray. [10] Otoscopic examination was performed to assess tympanic membrane appearance and evidence of middle-ear pathology.

Baseline audio logical assessment was performed in a sound-treated room by a certified audiologist using a calibrated clinical audiometer. Air-conduction thresholds were measured at frequencies of 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, and 8 kHz, while bone-conduction thresholds were assessed between 500 Hz and 4 kHz. Pure-tone average (PTA) was calculated as the mean hearing threshold at 500 Hz, 1 kHz, and 2 kHz. Tympanometry was performed using a calibrated impedance audiometer, and tympanograms were classified as Type A, Type B, or Type C according to standard criteria. Type Atympanograms represented normal middle-ear function, Type B indicated middle-ear effusion, and Type C reflected negative middle-ear pressure suggestive of Eustachian tube dysfunction. [3,8,9]

All adenoidectomies were performed under general anaesthesia by experienced otolaryngologists using the conventional curettage technique with endoscopic assistance to ensure complete removal of adenoid tissue while preserving the Eustachian tube openings. Following surgery, all patients were reviewed at 1 month, 3 months, and 6 months. At each follow-up visit, repeat pure-tone audiometry and tympanometry were performed to evaluate changes in hearing thresholds and

middle-ear function. Hearing status and tympanometric findings obtained during follow-up were compared with preoperative values. [1–4]

Data were entered into Microsoft Excel and analyzed using SPSS version 22.0 (IBM SPSS Statistics, Somers, NY, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Audio logical and tympanometric findings were analysed on an ear-wise basis, with a total of 132 ears included in the analysis. Changes in hearing thresholds across the different follow-up periods were analysed using repeated-measures analysis of variance (ANOVA) with Bonferroni-adjusted pairwise comparisons. Changes in tympanometric findings during follow-up were analysed using the Chi-square test. A two-tailed p-value of less than 0.05 was considered statistically significant.

The study protocol was approved by the Institutional Ethics Committee [Approval No.: CIMS/ IEC -08/03/ 2024] prior to commencement of the study. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki, and confidentiality of participant information was maintained throughout the study.

Results

A total of 66 children with adenoid hypertrophy were included in the study. The majority of participants belonged to the 8–10 years age group (42.4%), followed by 5–7 years (36.4%) and 11–12 years (21.2%), with a mean age of 8.4 ± 2.1 years. There was a male predominance, with 40 (60.6%) males and 26 (39.4%) females. Nasal obstruction was the most common presenting symptom, reported by 60 (90.9%) patients, followed by mouth breathing in 54 (81.8%), snoring in 49 (74.2%), hearing difficulty in 46 (69.7%), recurrent upper respiratory tract infections in 42 (63.6%), and ear fullness in 30 (45.5%) patients. Endoscopic assessment of adenoid size revealed that Grade III adenoid hypertrophy was the most frequent finding, observed in 28 (42.4%) patients, followed by Grade II and Grade IV hypertrophy in 16 (24.2%) patients each, while Grade I hypertrophy was present in 6 (9.1%) patients (Table 1).

Preoperative audiological assessment was performed on 132 ears. Mild conductive hearing loss was the most common hearing impairment, observed in 72 (54.5%) ears, followed by moderate conductive hearing loss in 36 (27.3%) ears and moderately severe conductive hearing loss in 8 (6.1%) ears. Normal hearing thresholds were observed in 16 (12.1%) ears. The mean preoperative pure-tone average (PTA) was 28.6 ± 7.4 dB HL. Tympanometric evaluation demonstrated that Type B tympanograms were the most prevalent finding, occurring in 72 (54.5%) ears, followed by Type C tympanograms in 40 (30.3%) ears and Type A tympanograms in 20 (15.2%) ears (Table 2).

Comparison of hearing thresholds at different follow-up intervals demonstrated a significant improvement in hearing following adenoidectomy. The mean PTA decreased from 28.6 ± 7.4 dB HL preoperatively to 23.1 ± 6.5 dB HL at 1 month, 20.2 ± 5.8 dB HL at 3 months, and 18.4 ± 5.3 dB HL at 6 months postoperatively. The mean improvement from baseline was 5.5 dB at 1 month, 8.4 dB at 3 months, and 10.2 dB at 6 months. Bonferroni-adjusted pairwise comparisons showed that the reductions in PTA at all postoperative follow-up visits were statistically significant when compared with baseline values ($p < 0.001$). Repeated-measures ANOVA demonstrated a significant overall improvement in hearing thresholds over time ($F = 96.8$,

$p < 0.001$), with a large effect size (partial $\eta^2 = 0.69$) (Table 3).

A significant improvement in tympanometric findings was also observed during the follow-up period. The proportion of ears demonstrating a normal Type A tympanogram increased from 15.2% preoperatively to 36.4% at 1 month, 63.6% at 3 months, and 78.8% at 6 months following surgery. Conversely, the proportion of Type B tympanograms decreased from 54.5% preoperatively to 30.3% at 1 month, 15.2% at 3 months, and 6.1% at 6 months. Similarly, the prevalence of Type C tympanograms declined from 30.3% before surgery to 15.1% at the final follow-up. The overall change in tympanometric patterns over time was statistically significant ($\chi^2 = 112.4$, df = 6, $p < 0.001$), indicating progressive restoration of middle-ear function following adenoidectomy (Table 4).

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population (n = 66).

	Variable	Frequency (n)	Percentage (%)
Age Group (years)	5–7	24	36.4
	8–10	28	42.4
	11–12	14	21.2
	Mean Age (years), Mean ± SD	8.4 ± 2.1	—
Gender	Male	40	60.6
	Female	26	39.4
Presenting Symptoms	Nasal obstruction	60	90.9
	Mouth breathing	54	81.8
	Snoring	49	74.2
	Hearing difficulty	46	69.7
	Recurrent upper respiratory tract infection	42	63.6
	Ear fullness	30	45.5
Adenoid Grade (Endoscopic Assessment)	Grade I	6	9.1
	Grade II	16	24.2
	Grade III	28	42.4
	Grade IV	16	24.2

*Multiple responses were possible; therefore, percentages may exceed 100%.

Table 2: Preoperative Audio logical Profile and Tympanometric Findings (132 Ears)

	Variable	Number of Ears (n)	Percentage (%)
Hearing Status (PTA)	Normal hearing (<20 dB HL)	16	12.1
	Mild conductive hearing loss (21–40 dB HL)	72	54.5
	Moderate conductive hearing loss (41–55 dB HL)	36	27.3
	Moderately severe conductive hearing loss (56–70 dB HL)	8	6.1

Mean PTA (dB HL) (Mean ± SD)		28.6 ± 7.4	
Tympanogram Type	Type A	20	15.2
	Type B	72	54.5
	Type C	40	30.3
	Total	132	100

Table 3: Comparison of Pure Tone Average (PTA) Thresholds Before and After Adenoidectomy (132 Ears)

Time Point	Mean PTA (dB HL) ± SD	Mean Difference from Baseline (dB)	95% CI of Difference	p-value†
Preoperative	28.6 ± 7.4	—	—	—
1 Month Postoperative	23.1 ± 6.5	5.5	4.4–6.6	<0.001*
3 Months Postoperative	20.2 ± 5.8	8.4	7.1–9.7	<0.001*
6 Months Postoperative	18.4 ± 5.3	10.2	8.8–11.6	<0.001*

Repeated Measures Analysis	Value
F statistic	96.8
Degrees of freedom	3, 129
Overall p-value	<0.001*
Partial Eta Squared (η^2)	0.69

†Bonferroni-adjusted pairwise comparison versus baseline.

Table 4: Changes in Tympanometric Findings Following Adenoidectomy (132 Ears)

Tympanogram Type	Preoperative n (%)	1-Month n (%)	3 Months n (%)	6 Months n (%)	P value
Type A	20 (15.2)	48 (36.4)	84 (63.6)	104 (78.8)	<0.001*
Type B	72 (54.5)	40 (30.3)	20 (15.2)	8 (6.1)	
Type C	40 (30.3)	44 (33.3)	28 (21.2)	20 (15.1)	
Total Ears	132 (100)	132 (100)	132 (100)	132 (100)	

Chi-square (χ^2), Degrees of freedom = 6.

Discussion

The present study evaluated the effect of adenoidectomy on hearing status and Eustachian tube function in children with adenoid hypertrophy and otitis media with effusion. The study population consisted predominantly of children aged 5–10 years, with a mean age of 8.4 ± 2.1 years and a male predominance (60.6%). These findings are comparable to previous studies that reported OME and adenoid hypertrophy to be most prevalent among school-aged children.[2–4]

Nasal obstruction, mouth breathing, and snoring were the most frequent presenting symptoms, reflecting the clinical manifestations of significant adenoid hypertrophy. Similar symptom profiles have been reported by Biswas et al.[4] and Satish,[7] highlighting the role of enlarged adenoids in upper airway obstruction and Eustachian tube dysfunction. In the present study,

most patients had Grade III or Grade IV adenoid hypertrophy, which is consistent with observations by Augustian et al.[8] and Billah and Leera,[9] who reported a higher prevalence of OME among children with larger adenoids.

Preoperative audiological assessment demonstrated that the majority of ears had mild to moderate conductive hearing loss, with a mean PTA of 28.6 ± 7.4 dB HL. Type B tympanogram was the predominant tympanometric pattern, observed in 54.5% of ears. These findings are consistent with those reported by Rajan et al.,[2]Halder et al.,[3] and Biswas et al.,[4] who similarly found conductive hearing loss and Type B tympanograms to be common among children with OME.

A significant improvement in hearing thresholds was observed following adenoidectomy. Mean PTA improved from 28.6 ± 7.4 dB HL preoperatively to 18.4 ± 5.3 dB HL at 6 months postoperatively, representing a mean hearing gain of 10.2 dB. Repeated-measures analysis demonstrated a highly significant improvement over time ($p < 0.001$). These findings are in agreement with studies by Halder et al.,[3] Rajan et al.,[2] Biswas et al.,[4] James et al.,[5] Ajayan et al.,[6] and Satish,[7] all of whom reported significant postoperative improvement in hearing thresholds following adenoidectomy. The observed hearing gain is also supported by earlier randomized studies demonstrating improved middle-ear function after adenoidectomy.[11–13] Furthermore, the findings are consistent with the individual patient data meta-analysis by Boonacker et al.[14] and the recent Cochrane review by Mackeith et al.,[1] which concluded that adenoidectomy can improve hearing outcomes in appropriately selected children with OME.

Tympanometric findings also showed significant improvement during follow-up. The proportion of Type Atympanograms increased from 15.2% preoperatively to 78.8% at 6 months, whereas Type B tympanograms decreased from 54.5% to 6.1%. These findings indicate restoration of middle-ear ventilation and improvement in Eustachian tube function following adenoidectomy. Similar improvements in tympanometric patterns have been reported by Rajan et al.,[2]Halder et al.,[3] and Biswas et al.[4] The results also support the pathophysiological concept that removal of hypertrophied adenoid tissue relieves nasopharyngeal obstruction and reduces inflammatory influences on the Eustachian tube.[11,15]

Although spontaneous resolution of OME has been reported in some children,[13] the magnitude and consistency of improvement observed in the present study suggest a substantial therapeutic benefit of adenoidectomy. The findings are further supported by evidence demonstrating improved middle-ear outcomes following adenoidectomy compared with observation alone.[11,12,14]

Overall, the present study demonstrates that adenoidectomy significantly improves hearing thresholds and tympanometric outcomes in children with OME associated with adenoid hypertrophy. These findings support the role of adenoidectomy as an effective intervention for restoring middle-ear function and reducing conductive hearing impairment in appropriately selected pediatric patients.

Conclusion

The present study demonstrated that adenoidectomy resulted in significant improvement in hearing status and middle-ear function among children with adenoid hypertrophy and otitis media with effusion. Progressive reductions in pure-tone average thresholds were

observed throughout the follow-up period, indicating substantial recovery of conductive hearing loss after surgery. Tympanometric findings also showed marked improvement, with a significant increase in normal Type A tympanograms and a corresponding decrease in Type B and Type C patterns, reflecting restoration of Eustachian tube function. These findings support adenoidectomy as an effective intervention for improving hearing outcomes and middle-ear ventilation in appropriately selected pediatric patients.

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