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Clinical Study on Tympanometric Changes in Post-Adenoidectomy Patients

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ABSTRACT

Background: Adenoid hypertrophy is a common condition in the pediatric age group and a well-established cause of Eustachian tube dysfunction, leading to middle ear pathologies such as otitis media with effusion. Tympanometry is an objective and reliable tool for assessing middle ear function. The present study was undertaken to evaluate the effect of adenoidectomy on middle ear function in children with adenoid hypertrophy using tympanometry.

Methods: This prospective observational study included 50 children aged 5–12 years with adenoid hypertrophy. All patients underwent detailed clinical evaluation, otoscopic and nasal endoscopic examination, radiological assessment, and preoperative tympanometry. Following adenoidectomy, tympanometry was repeated at 7 days and 1 month postoperatively. Statistical analysis was performed using the chi-square test and paired t-test, with $p<0.05$ considered significant.

Results: Most patients were in the 7–9 years age group (44%), with male predominance (56%). Preoperatively, Type B tympanogram was seen in 52%, Type C in 36%, and Type A in 12%. At 7 days, Type A increased to 28%, and at 1 month to 64%, while Type B and C reduced to 20% and 16%, respectively ($p<0.001$). Mean hearing thresholds improved from 28.4±6.2 dB to 16.8±4.5 dB, and middle ear pressure improved from –178±45 daPa to –62±28 daPa ($p<0.001$).

Conclusion: Adenoidectomy significantly improves middle ear function, as evidenced by normalization of tympanometric findings, improved hearing thresholds, and restoration of middle ear pressure. Tympanometry is an effective tool for both preoperative assessment and postoperative follow-up.

Key-words: Adenoid hypertrophy, Tympanometry, Adenoidectomy, Middle ear function, Eustachian tube dysfunction

INTRODUCTION

Adenoid hypertrophy is one of the most common disorders encountered in paediatric otorhino-laryngology. Adenoids are rudimentary at birth and undergo progressive enlargement during early childhood as part of normal immunological development. They reach their maximum size between 2 and 7 yrs of age, then tend to atrophy at puberty and almost completely disappear by age 20.

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Persistent adenoid enlargement beyond physiological limits contributes significantly to nasal obstruction, mouth breathing, and recurrent upper respiratory infections.[1]

Otitis media with effusion is a common paediatric condition and represents a major public health concern due to its high prevalence and potential impact on hearing and child development [2]. It is characterized by the accumulation of non-purulent serous or mucoid fluid within the middle ear cleft, often occurring silently without overt clinical symptoms. The insidious nature of this condition frequently leads to delayed diagnosis, particularly in younger children who may be unable to articulate hearing difficulties.[3] It is recognized as one of the most common causes of hearing impairment in childhood, with significant implications for speech acquisition and educational performance.[3]

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Among the various etiological factors implicated in the development of Otitis media with effusion, adenoid hypertrophy and Eustachian tube dysfunction play a central role.[4] The adenoids, due to their anatomical proximity to the nasopharyngeal opening of the Eustachian tube, have a significant influence on middle ear ventilation.[4] Enlarged adenoid tissue may mechanically obstruct the Eustachian tube orifice, thereby impairing pressure equalization within the middle ear.[4] Additionally, adenoids can serve as reservoirs for pathogenic microorganisms, promoting chronic inflammation of the nasopharynx and middle ear.[5]

Nasal endoscopy allows direct visualization and grading of adenoid hypertrophy. Clemens and McMurray's system classify adenoid size by choanal obstruction: Grade I (<25%), Grade II (25–50%), Grade III (50–75%), and Grade IV (>75%).[4,7] This classification provides an objective method for assessing the severity of adenoid hypertrophy and aids in clinical decision-making regarding surgical intervention.[5,6] Higher grades of adenoid hypertrophy are more frequently associated with Eustachian tube dysfunction and middle ear pathology.[5]

Tympanometry is an objective, non-invasive diagnostic tool that measures the compliance of the tympanic membrane and the middle ear system in response to changes in air pressure.[3] It provides valuable information regarding middle ear pressure, tympanic membrane mobility, and the presence of middle ear effusion.[4] The test is particularly useful in paediatric populations where conventional audiometry may be difficult to perform reliably.[4]

Tympanometric findings are typically categorized into three main types. A Type A tympanogram indicates normal middle ear pressure and compliance, suggesting an intact, normally functioning middle ear system.[4] Type B tympanogram, characterized by a flat tracing, is indicative of middle ear effusion and is most commonly observed in cases of Otitis media with effusion.[4] Type C tympanogram reflects negative middle ear pressure and is usually associated with Eustachian tube dysfunction.[4] These patterns allow clinicians to objectively monitor middle ear status before and after therapeutic interventions.[4]

Adenoidectomy remains a commonly performed surgical procedure for children with adenoid hypertrophy. Removal of the adenoid tissue aims to restore Eustachian tube function by eliminating mechanical obstruction and reducing nasopharyngeal bacterial load.[5] Several studies have demonstrated improvement in middle ear ventilation and resolution of effusion following adenoidectomy.[5] Objective assessment of postoperative outcomes is essential to evaluate the effectiveness of surgical management.

This study evaluates the effect of adenoidectomy on middle ear function in children with adenoid hypertrophy using tympanometry. By correlating adenoid size with pre- and postoperative tympanometric findings, it assesses the efficacy of adenoidectomy in improving middle-ear function.

MATERIALS AND METHODS

Study Design and Setting- This prospective comparative study was conducted in the Department of Otorhinolaryngology (ENT), Pacific Medical College and Hospital, Udaipur, Rajasthan, from May 2024 to November 2025.

Study Population and Sample Size- A total of 50 pediatric patients aged 5–12 years with Grade III and Grade IV adenoid hypertrophy were included. The sample size was calculated using the formula $n = Z^2 \times p(1-p)/e^2$, where p = 34% and e = 13%, yielding 50.66, which was rounded to 50 for feasibility.

Inclusion and Exclusion Criteria- Patients with endoscopically confirmed Grade III/IV adenoid hypertrophy and relevant clinical features were included after obtaining informed consent. Patients with suppurative otitis media, acute upper respiratory infection, contraindications to surgery, age outside the 5–12-year range, or those lost to follow-up were excluded.

Data Collection and Clinical Evaluation- Data were collected using a pre-designed proforma. A detailed history and clinical examination were performed, including ENT examination (otoscopy, anterior and posterior rhinoscopy, and oropharyngeal examination). Patients were evaluated for symptoms such as nasal obstruction, mouth breathing, snoring, hearing difficulty, adenoid facies, and dental malocclusion.

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Diagnostic and Investigative Procedures- Diagnostic nasal endoscopy was performed to assess the nasal cavity, the Eustachian tube opening, and adenoid size, graded according to choanal obstruction. Radiological evaluation included X-ray soft tissue nasopharynx (lateral view). Pure tone audiometry and tympanometry were performed preoperatively. Routine blood investigations and pre-anaesthetic assessment were conducted.

Surgical Procedure and Follow-up- All patients underwent coblation adenoidectomy under general anaesthesia. Postoperative tympanometry was performed at 7 days and 1 month, and findings were compared with preoperative values.

Statistical Analysis- Quantitative data were expressed as mean±standard deviation and percentages. Statistical analysis was performed using SPSS version 21. The chi-square test was used for categorical variables, and $p<0.05$ was considered statistically significant. Phi coefficient was used to assess the strength of association.

Ethical Considerations- Ethical clearance was obtained from the institutional ethics committee, and informed consent was obtained from parents or guardians. No investigational drugs or experimental devices were used; hence, DCGI approval was not required.

RESULTS

The demographic and clinical profile of the study population (n = 50) showed that most patients belonged to the 7–9 years age group (44%), followed by the 10–12 years (36%) and 5–6 years (20%) age groups. There was a slight male predominance, with males accounting for 56% and females 44% of the study population. Regarding adenoid grading, Grade III hypertrophy was more common (56%) than Grade IV (44%), suggesting a higher prevalence of moderate adenoid enlargement in the study group.

Table 1: Demographic and Clinical Profile (n = 50)

Parameter	Category	Number (n)	Percentage (%)
Age (years)	5–6	10	20
	7–9	22	44
	10–12	18	36
Gender	Male	28	56
	Female	22	44
Adenoid Grade	Grade III	28	56
	Grade IV	22	44

Mean Age±SD = 6.8±2.5 years
Male: Female ratio = 1.27: 1

Clinical features of adenoid facies were common, with mouth breathing (84%) and snoring (76%) most frequent, and a high-arched palate in 36%. Overall, 60% of patients exhibited adenoid facies (Table 2).

Table 2: Presence of Adenoid Facies (n = 50)

Feature	Present (n)	Percentage (%)
Mouth breathing	42	84
Snoring	38	76
High-arched palate	18	36
Adenoid facies overall	30	60

Higher adenoid grades were significantly associated with clinical severity. Adenoid facies were more common in Grade IV (16) than Grade III (14) cases ($p=0.04$), and Eustachian tube obstruction was more frequent in Grade IV (18) versus Grade III (12) cases ($p=0.005$), showing a moderate positive correlation (Table 3).

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Table 3: Association of Adenoid Grade with Clinical Parameters (n = 50)

Parameter	Status	Grade III	Grade IV	Total	p-value
Adenoid facies	Present	14	16	30	0.04
	Absent	14	6	20	
Eustachian tube obstruction	Present	12	18	30	0.005
	Absent	16	4	20	

For Adenoid facies: *Chi-square (χ^2) = 4.09; Phi coefficient = 0.29*

For Eustachian tube obstruction: *Chi-square (χ^2) = 7.84; Phi coefficient = 0.40*

Endoscopic evaluation revealed that bilateral inferior turbinate hypertrophy was the most common finding, followed by Eustachian tube obstruction, deviated nasal septum, and inferior meatus congestion, indicating multiple contributing nasal pathologies (Table 4).

Preoperative otoscopic examination revealed that a dull tympanic membrane was the most common (40%), followed by a retracted TM (32%), air-fluid level (16%), and only 12% had normal findings, reflecting middle ear involvement (Table 5).

Table 4: Endoscopic Findings – Right and Left Side

Finding	Right Side (n, %)	Left Side (n, %)
Deviated Septum	12(24%)	14(28%)
Inferior Turbinate Hypertrophy	30(60%)	28(56%)
Eustachian Tube Orifice Edema/ Obstruction	26(52%)	24(48%)
Inferior Meatus Congestion	18(36%)	20(40%)

Table 5: Otoscopic Findings (Preoperative) (n = 50)

Otoscopic Finding	Number (n)	Percentage (%)
Normal TM	6	12
Dull TM	20	40
Retracted TM	16	32
Air-fluid level	8	16
Total	50	100

There was a statistically significant improvement in both hearing threshold and middle ear pressure following adenoidectomy. The mean hearing threshold improved from 28.4±6.2 dB in the preoperative period to 16.8±4.5 dB at 1 month postoperatively ($p<0.001$). Similarly, the mean middle ear pressure showed marked improvement from –178±45 daPa preoperatively to –62±28 daPa at 1 month ($p<0.001$). These findings indicate significant restoration of middle ear function and hearing following surgical intervention (Table 6).

Table 6: Audiological and Middle Ear Pressure Changes (n = 50)

Parameter	Time	Mean±SD	p-value
Hearing Threshold (dB)	Preoperative	28.4±6.2	<0.001
	1 Month Postoperative	16.8±4.5	
Middle Ear Pressure (daPa)	Preoperative	–178±45	<0.001
	1 Month Postoperative	–62±28	

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Tympanometric evaluation showed a progressive improvement following adenoidectomy. The proportion of Type A tympanograms increased from 6 cases preoperatively to 14 cases at 7 days and 32 cases at 1 month postoperatively. Conversely, Type B tympanograms decreased from 26 cases preoperatively to 22 cases at 7 days and 10 cases at 1 month. Similarly, Type C tympanograms decreased from 18 cases preoperatively to 14 at 7 days and 8 at 1 month. This improvement was statistically highly significant ($p<0.001$), indicating effective restoration of middle ear function (Table 7).

Table 7: Tympanometric Findings at Preoperative, 7 Days and 1 Month with Overall Change (n = 50)

Tympanogram Type	Preoperative (n, %)	7 Days Post-op (n, %)	1 Month Post-op (n, %)
Type A	6 (12%)	14 (28%)	32 (64%)
Type B	26 (52%)	22 (44%)	10 (20%)
Type C	18 (36%)	14 (28%)	8 (16%)
Total	50 (100%)	50 (100%)	50 (100%)

Chi-square (χ^2) = 18.72; p-value<0.001
Phi coefficient = 0.61

DISCUSSION

The study evaluated the effect of adenoidectomy on middle ear function in 50 children (5–12 years) with adenoid hypertrophy using tympanometry and audiological assessments. Most participants were aged 7–9 years (44%), followed by 10–12 years (36%) and 5–6 years (20%), indicating that adenoid hypertrophy and related complications are most common in early childhood. This observation is consistent with the physiological growth pattern of adenoid tissue, which typically reaches its maximum size between 3 and 7 years of age. Similar findings were reported by Radhakrishnan *et al.* [7], who found that most children with adenoid hypertrophy and OME were aged 4-8 years. Likewise, Tos [8] demonstrated that otitis media with effusion is most prevalent among children aged 3–7 years, a period of maximum adenoid enlargement.

In the present study, 28 patients (56%) were male, 22 (44%) were female, yielding a male-to-female ratio of 1.27:1, indicating a slight male predominance. Similar gender distribution has been reported in several previous studies. Sarkar *et al.* [9] also reported that adenoid hypertrophy and middle ear disease were slightly more common among male children. However, some studies suggest that gender differences may not be statistically significant, indicating that environmental exposure and recurrent infections may play a greater role than gender in the development of adenoid hypertrophy.

In the present study, mouth breathing was observed in 84% of patients, snoring in 76%, and adenoid facies in 60%. These findings highlight the significant impact of adenoid hypertrophy on upper airway obstruction. Similar observations were reported by Cengel and Akyol [10], who reported a high prevalence of mouth breathing and snoring in children with enlarged adenoids.

Otoscopic examination revealed that a dull tympanic membrane was the most common finding (40%), followed by a retracted tympanic membrane (32%) and an air–fluid level (16%). Similar findings were reported by Bhargava *et al*. [11], who observed that dull and retracted tympanic membranes were common in children with otitis media with effusion.

Endoscopic evaluation showed Grade III adenoid hypertrophy in 56% and Grade IV in 44% of patients, indicating predominantly moderate to severe enlargement. Higher adenoid grades were associated with middle ear effusion and abnormal tympanometry, consistent with findings by Al-Saadi *et al.* [12] and Skoloudik *et al.* [13]. The study found a significant correlation between adenoid grade and Eustachian tube obstruction ($p=0.005$), with Grade IV hypertrophy showing the highest incidence, aligning with Tawab *et al.* [14].

The study found a significant association between adenoid grade and adenoid facies ($p=0.04$). Of 50 children, 30 (60%) showed adenoid facies, more commonly in Grade IV (16/22) than Grade III (14/28) cases, suggesting that severe adenoid enlargement contributes to characteristic facial features from chronic

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mouth breathing. These results align with Cengel and Akyol [15] and Bluestone [16], who reported that persistent adenoid hypertrophy can cause craniofacial changes such as elongated face, open-mouth posture, and high-arched palate, highlighting the importance of early diagnosis and timely surgery to prevent long-term facial abnormalities.

Preoperative tympanometry revealed that Type B tympanogram was the most common pattern (52%), followed by Type C (36%), while Type A was observed in only 12% of patients. This finding indicates that middle ear effusion and Eustachian tube dysfunction were highly prevalent among children with adenoid hypertrophy. Similar observations were reported by Martinez-Cruz *et al.* [17], who found that Type B tympanograms were present in many patients with adenoid hypertrophy before surgery. Likewise, Cengel and Akyol [15] reported a strong association between adenoid enlargement and abnormal tympanometric findings.

Tympanometric evaluation at 7 days after surgery demonstrated early improvement in middle ear function. The proportion of Type A tympanograms increased from 12% to 28%, while Type B decreased to 44% and Type C decreased to 28%. These findings suggest that although early improvement occurs after adenoidectomy, complete normalization of middle ear pressure may take several weeks. Similar findings were reported by Unlu *et al*. [18], who observed that early postoperative tympanometric abnormalities may persist temporarily due to residual middle ear fluid and mucosal edema.

One month after surgery, the present study demonstrated significant improvement in tympanometric findings. The proportion of Type A tympanograms increased to 64%, while Type B and Type C decreased to 20% and 16%, respectively. These findings were statistically significant and indicate that adenoidectomy plays an important role in restoring normal middle ear ventilation. Similar results were reported by Kumar *et al*. [19], who found that more than 70% of ears demonstrated Type A tympanograms after adenoidectomy. Likewise, Maw and Bawden [20] reported progressive normalization of middle ear pressure within 6–12 weeks after surgery.

The present study demonstrated a significant improvement in hearing thresholds following adenoidectomy. The mean hearing threshold improved from 28.4±6.2 dB preoperatively to 16.8±4.5 dB at one month postoperatively, a statistically highly significant difference. Similar findings were reported by Sarin *et al.* [21] who observed a significant reduction in the air–bone gap following adenoidectomy. Likewise, Radhakrishnan *et al.* [7] reported measurable improvement in hearing thresholds after surgical removal of hypertrophied adenoids.

The study confirms that adenoid hypertrophy is a key cause of Eustachian tube dysfunction and otitis media with effusion in children. Adenoidectomy significantly improves middle-ear ventilation, tympanometric patterns, and hearing thresholds, especially within the first month post-surgery. Early detection and surgical management of adenoid hypertrophy can restore normal middle ear function, enhance hearing, and prevent long-term complications in pediatric patients.

CONCLUSIONS

The present study evaluated the effect of adenoidectomy on middle ear function in children with adenoid hypertrophy using tympanometry. The mean age of participants was 8.58 years, corresponding to the period of maximum adenoid growth, with a slight male predominance. Most children presented with symptoms of adenoid hypertrophy, including mouth breathing, snoring, and adenoid facies, indicating upper airway obstruction and craniofacial impact. Preoperative assessment revealed a high prevalence of abnormal tympanograms, with Type B (middle ear effusion) and Type C (negative middle ear pressure) patterns being most common, corroborated by otoscopic findings of dull or retracted tympanic membranes. Following adenoidectomy, progressive improvement in tympanometric patterns and middle-ear pressure was observed, most notably at 1 month postoperatively, along with a significant reduction in hearing thresholds. These results confirm that adenoid hypertrophy contributes to Eustachian tube dysfunction and otitis media with effusion, and that adenoidectomy effectively restores middle ear ventilation, improves hearing, and prevents long-term complications in pediatric patients.

CONTRIBUTION OF AUTHORS

Research concept- Shweta Anand, Antarikhya Borah
Research design- Shweta Anand, Antarikhya Borah
Supervision- Shweta Anand
Materials- Shweta Anand, Antarikhya Borah

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Data analysis and interpretation- Shweta Anand
Literature search- Shweta Anand, Antarikhya Borah
Writing article- Shweta Anand, Antarikhya Borah
Critical review- Shweta Anand
Article editing- Shweta Anand, Antarikhya Borah
Final approval- Shweta Anand

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