ISSN- O: 2458 - 868X, ISSN–P: 2458 – 8687
National Library of Medicine - ID: 101731606

International Journal of Medical Science and Innovative Research (IJMSIR)
IJMSIR : A Medical Publication Hub
Available Online at: www.ijmsir.com
Volume – 11, Issue – 3, June – 2026, Page No. : 19 – 28

Tympanometric Evaluation in Children Pre and Post-Adenoidectomy

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Citation this Article: Dr. Riya Chatterjee, Dr. Piyush Kant Singh, Dr. Aanieq Moghal, "Tympanometric Evaluation in Children Pre and Post-Adenoidectomy", IJMSIR – June – 2026, Vol – 11, Issue – 3, P. No. 19 – 28.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Introduction: Hearing is a critical sensory function for a child's speech development, cognitive growth, and academic performance, and middle ear disorders like Otitis Media with Effusion (OME) are common causes of reversible impairment. Adenoid hypertrophy can mechanically obstruct the Eustachian tube and act as a reservoir for infection, leading to negative middle ear pressure and conductive hearing loss. This study utilizes tympanometry as a non-invasive, objective tool to evaluate these middle ear changes before and after surgical intervention.

Objective: The primary aim of this study is to investigate the effect of adenoid hypertrophy on middle ear function by comparing tympanometry results in children before and after they undergo an adenoidectomy. It also aims to evaluate the common clinical symptoms associated with enlarged adenoids and to observe how surgical removal helps in restoring normal middle ear ventilation and pressure.

Methods: This prospective study involved 45 children diagnosed with Grade III and Grade IV adenoid hypertrophy who were selected for surgery. Each patient underwent a detailed preoperative clinical examination and diagnostic testing, specifically tympanometry, to establish a baseline of their middle ear health. Following the adenoidectomy, the patients were monitored through postoperative follow-ups at intervals of one week, one month, and three months to track the progress of their recovery.

Result: The preoperative data showed that 86.7% of the patients had abnormal tympanograms, specifically Type B or Type C. While only a small percentage showed normalization at the one-week follow-up due to temporary postoperative swelling, significant improvement was observed over time. By the three-month mark, the majority of the children had achieved normal Type A tympanograms, a change that was found to be statistically highly significant with a p-value of less than 0.001.

Conclusion: The study concludes that adenoid hypertrophy significantly impairs middle ear function by causing Eustachian tube dysfunction, and adenoidectomy is an effective treatment for reversing these issues.

Because the restoration of middle ear ventilation is a gradual process, extended postoperative follow-up is necessary to confirm full recovery. Timely surgical intervention is essential to prevent long-term hearing complications and to improve the overall quality of life for the affected children.

Keywords: Adenoid hypertrophy, Adenoidectomy, Tympanometry, Middle ear function, Eustachian tube dysfunction, and Otitis media with effusion.

Introduction

Adenoid hypertrophy is one of the most prevalent conditions encountered in paediatric otolaryngology and has a well-established association with middle ear disease. The adenoids are lymphoid tissues located in the roof and posterior wall of the nasopharynx, forming an integral component of Waldeyer's ring. During early childhood they contribute to immune defence; however, recurrent upper respiratory tract infections and chronic inflammation may lead to pathological enlargement, commonly presenting with nasal obstruction, mouth breathing, snoring, sleep disturbances, and middle ear dysfunction.[5],[6]

The relationship between adenoid hypertrophy and middle ear disease is multifactorial. Enlarged adenoids mechanically obstruct the pharyngeal opening of the Eustachian tube, impairing ventilation, while chronically infected adenoid tissue acts as a reservoir of pathogenic microorganisms and biofilms that perpetuate nasopharyngeal inflammation.[7] This dual insult produces Eustachian tube oedema and dysfunction, resulting in negative middle ear pressure, fluid transudation, reduced tympanic membrane mobility, and conductive hearing loss.[8]

Children are especially vulnerable owing to their shorter, wider, and more horizontally oriented Eustachian tube with incompletely developed neuromuscular control, predisposing them to recurrent middle ear effusion — a fluctuating condition whose episodic improvement often leads caregivers to underestimate its severity.[7],[8] Over time, cumulative auditory deprivation during critical periods of language development may give rise to delayed speech, articulation difficulties, reduced attention span, and impaired academic performance.[8],[9]

Clinical assessment of middle ear status in children is challenging, as otoscopic findings may be subtle and behavioural audiometry unreliable in young or uncooperative patients. Tympanometry offers a simple, non-invasive, and objective solution: by measuring tympanic membrane compliance across a range of air pressures, it provides reproducible characterisation of middle ear pressure, membrane mobility, and effusion, making it particularly well suited to paediatric practice and to serial pre- and postoperative evaluation.[10],[11]

Adenoidectomy is one of the most commonly performed surgical procedures in children, indicated for nasal obstruction, recurrent upper respiratory tract infections, sleep-disorder , mouth breathing, and chronic otitis media with effusion.[12] Beyond relieving nasal symptoms, adenoidectomy is believed to improve Eustachian tube function by removing mechanical obstruction, reducing nasopharyngeal inflammation, and eliminating a potential source of infection. Restoration of normal middle ear ventilation following adenoidectomy can lead to resolution of effusion and improvement in hearing.[12],[13] However, the degree and timing of improvement in middle ear function following adenoidectomy may vary among individuals. Clinical improvement in nasal symptoms does not always correlate with normalisation of middle ear mechanics. Objective assessment is therefore essential to accurately evaluate surgical outcomes.[14]

Tympanometric evaluation before and after adenoidectomy allows for systematic documentation of changes in middle ear function and helps identify children with persistent dysfunction who may require further management, such as medical therapy or additional surgical intervention.[15] Serial tympanometric assessment also provides insight into both immediate and long-term effects of adenoidectomy, distinguishing transient changes due to mucosal oedema from true restoration of Eustachian tube function, and assists in counselling parents regarding expected outcomes and the importance of postoperative follow-up.[16],[17] In the Indian paediatric population, where overcrowding, limited health awareness, and delayed access to specialised care frequently allow middle ear pathology to remain underdiagnosed alongside nasal symptoms, routine perioperative tympanometric assessment is of particular importance. The present study was therefore undertaken to evaluate tympanometric findings in children undergoing adenoidectomy and to objectively document the impact of surgery on middle ear function across defined postoperative intervals.

Aim and Objectives

Aim: To study the effect of adenoid hypertrophy on tympanometry in children before and after adenoidectomy.

Objectives:

- To study the clinical symptoms associated with adenoid hypertrophy in children.
- To assess the alteration in middle ear function.
- To observe the changes in tympanometry outcome after adenoidectomy.

Material and Methods

This prospective interventional study was conducted in the Department of Otorhinolaryngology (ENT), K.D. Medical College, Hospital and Research Centre, Mathura, Uttar Pradesh, for 18 months (May 2024 to November 2025) after obtaining Institutional Ethics Committee approval and written informed consent from parents/guardians.

Inclusion Criteria

- Children aged between 5 to 15 years.
- Children with more than 50% obstruction of the nasopharyngeal airway on X-ray nasopharynx lateral view.
- Children having ≥3 symptoms: mouth breathing, snoring, nasal obstruction, hyponasal speech, decreased attention, or recurrent URTIs.

Exclusion Criteria

- Patients with acute upper respiratory tract infection.
- Patients with tympanic membrane perforation.
- Patients with craniofacial anomalies.

Sample Size

$n = Z^2 \times p \times q / e^2 = (1.96)^2 \times 3 \times 97 / (5)^2 \approx 45$ patients

A total of 45 children fulfilling the inclusion criteria were enrolled consecutively from the ENT OPD to minimise selection bias.

Preoperative Evaluation

All patients underwent detailed clinical history, general physical examination, and comprehensive ENT examination. Investigations included lateral X-ray nasopharynx, diagnostic nasal endoscopy, and baseline tympanometry. Adenoid hypertrophy was graded endoscopically: Grade III (50–75% obstruction) and Grade IV (>75% obstruction).

Surgical Procedure

All patients underwent endoscopic microdebrider-assisted adenoidectomy under general anaesthesia. The primary surgical objective was relief of obstruction at the Eustachian tube opening to improve middle ear ventilation.

Tympanometry

Tympanometry evaluates middle ear function by assessing tympanic membrane compliance based on the principle of acoustic impedance/admittance. Tympanograms were classified as:

Type A — Normal compliance at atmospheric pressure; normal middle ear function.

Type B — Flat curve, no identifiable peak; middle ear effusion.

Type C — Peak shifted towards negative pressure; Eustachian tube dysfunction.

Conversion from Type B/C to Type A was considered a favourable outcome. The same calibrated tympanometer was used throughout; both ears were tested at every visit.

Follow-up Protocol

- 1 Week — early postoperative period
- 1 Month — intermediate assessment
- 3 Months — final outcome assessment

Statistical Analysis

Data were entered in Microsoft Excel and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequency and percentage. Preoperative and postoperative tympanometric findings were compared using the chi-square test. A p-value of <0.05 was considered statistically significant.

Results

The present study included 45 children with Grade III and Grade IV adenoid hypertrophy who underwent adenoidectomy. Tympanometric assessment was performed preoperatively and at 1 week, 1 month, and 3 months postoperatively.

Table 1: Age-group Distribution

Age Group (years)	Number (n)	Percentage (%)
5 – 7	5	11.11
8 – 10	18	40.00
11 – 13	13	28.89
14 – 15	9	20.00
Total	45	100

*n = number of patients; % = Percentage shown in parentheses.

The majority of children belonged to the 8–10 years age group (40%), followed by 11–13 years (28.89%), 14–15 years (20%), and 5–7 years (11.11%), suggesting peak occurrence in middle childhood.

Table 2: Gender Distribution

Gender	Number (n)	Percentage (%)
Female	23	51.11
Male	22	48.89
Total	45	100

Females (51.11%) slightly outnumbered males (48.89%), indicating near-equal gender distribution with no strong gender predilection.

Table 3: Adenoid Grade Distribution

Adenoid Grade	Number (n)	Percentage (%)
Grade III	21	46.67
Grade IV	24	53.33
Total	45	100

Grade IV adenoids were slightly more common (53.33%), indicating late presentation and significant nasopharyngeal obstruction in the majority.

Table 4: Distribution of Chief Complaints

Symptom	n	%
Mouth breathing	44	97.78
Snoring	43	95.56

Symptom	n	%
Nasal obstruction	42	93.33
Ear fullness/blockage	28	62.22
Hearing difficulty	25	55.56
Recurrent ear discharge	10	22.22
Cold & cough	5	11.11
Ear pain	4	8.89
Sneezing	4	8.89
Hyponasal speech	3	6.67
Sore throat	3	6.67
Dysphagia	2	4.44
Nasal discharge	1	2.22

Obstructive nasal symptoms predominated. Mouth breathing (97.78%), snoring (95.56%), and nasal obstruction (93.33%) were present in almost all patients. A significant proportion also had otological complaints — ear fullness (62.22%) and hearing difficulty (55.56%) — reflecting Eustachian tube dysfunction.

Table 5: Pre-operative Tympanogram (n = 90 ears)

Type	Right Ear (R)	Left Ear (L)
Type A – Normal	9 (20.0%)	6 (13.3%)
Type B – Effusion	20 (44.4%)	17 (37.8%)
Type C – ET Dysfunction	16 (35.6%)	22 (48.9%)

Most ears showed abnormal tympanograms pre-operatively (86.7% Type B or C; only 13.3% Type A). The left ear showed a higher Type C pattern, reflecting Eustachian tube blockage secondary to adenoid hypertrophy.

Table 6: Adenoid Grade vs Pre-operative Tympanogram

Grade	Type A	Type B	Type C	Total
Grade III (21)	11	12	17	42
Grade IV (24)	4	25	21	48
Total (45)	15	37	38	90

Grade IV adenoids showed a higher proportion of Type B tympanograms (50%) vs Grade III (30%), demonstrating worsening middle ear dysfunction with increasing adenoid size.

Table 7: Allergy History vs Pre-operative Tympanogram

Allergy	Type A	Type B	Type C	Total
Present	5	16	11	32
Absent	10	21	27	58
Total	15	37	38	90

Abnormal tympanograms were observed in both allergic and non-allergic children, suggesting that mechanical Eustachian tube obstruction plays a greater role than allergy alone.

Table 8: 1-Week Post-operative Tympanogram

Ear-wise	Type A	Type B	Type C	Total
Right Ear	10	14	21	45
Left Ear	9	15	21	45
Total	19	29	42	90

p-value = 0.612 (Not Significant)

At one week, 42 ears continued to show Type C tympanograms. Improvement was minimal and statistically insignificant (p = 0.612), consistent with transient mucosal oedema and Eustachian tube inflammation during the early healing phase.

Table 9: 1-Month Post-operative Tympanogram

Ear wise	Type A	Type B	Type C	Total
Right Ear	23	12	10	45
Left Ear	25	8	12	45
Total	48	20	22	90

p-value = 0.048 (Significant*)

At one month, significant improvement was observed (p = 0.048). Over half of all ears achieved normal tympanograms. However, some ears continued to show Type B and Type C curves, indicating persistent effusion and negative middle ear pressure.

Table 10: 3-Month Post-operative Tympanogram

Ear wise	Type A	Type B	Type C	Total
Right Ear	37	4	4	45
Left Ear	39	3	3	45
Total	78	7	7	90

p-value < 0.001 (Highly Significant**)

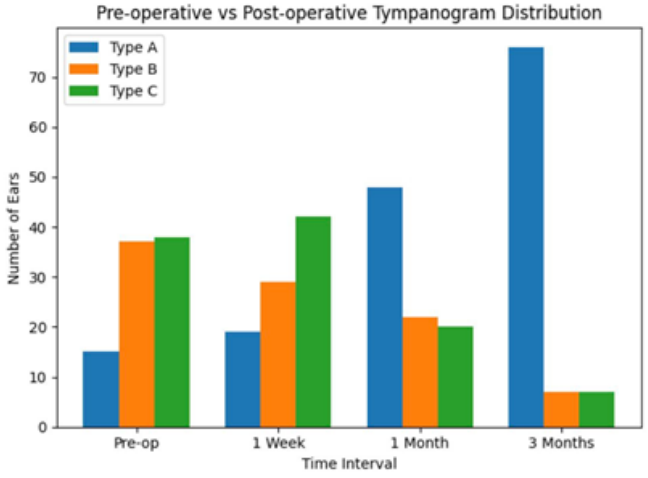
At three months, 78 showed Type A tympanograms (p < 0.001). A small proportion continued to demonstrate Type B and Type C curves, suggesting persistent but resolving Eustachian tube dysfunction.

Table 11: Pre-operative vs Post-operative Tympanogram — All Ears (n = 90)

Time Interval	Type A n (%)	Type B n (%)	Type C n (%)	p-value
Pre-operative	15 (16.7)	37 (41.1)	38 (42.2)	—
1 Week	19 (21.1)	29 (32.2)	42 (46.7)	0.612
1 Month	48 (53.3)	22 (24.4)	20 (22.2)	0.048*
3 Months	76 (84.4)	7 (7.8)	7 (7.8)	<0.001**

* p<0.05; ** p<0.001 (chi-square, vs. preoperative baseline)

A progressive shift from abnormal to normal tympanogram pattern was seen over time. Minimal improvement at one week, significant improvement by one month, and marked recovery by three months.



Discussion

The present study evaluated tympanometric changes in 45 children diagnosed with Grade III and Grade IV adenoid hypertrophy undergoing adenoidectomy. A prominent preoperative finding was the high prevalence of middle ear dysfunction, with 86.7% of patients demonstrating abnormal tympanograms (Type B or Type C). This proportion is higher than previously reported series, including St Y et al.[53] who documented Type B curves in 72.9% of ears, and Nguyen et al.[48] who reported 33% Type A curves preoperatively. The elevated abnormality rate is attributable to the uniform inclusion of advanced adenoid grades (III and IV), capturing children with more pronounced nasopharyngeal obstruction and prolonged Eustachian tube compromise.

The age distribution in our study differed from patterns observed in earlier investigations. While Nguyen et al.[48] and Turaki et al.[58] described peak prevalence among younger children aged 2–6 years, the majority of our patients were between 8 and 10 years. This older age predominance may reflect delayed referral, prolonged symptom tolerance, or limited access to specialised otolaryngological care in the Indian paediatric population.

The relationship between adenoid grade and tympanometric pattern supports a dose–response

association. Grade IV hypertrophy demonstrated a higher frequency of Type B curves (50%) compared to Grade III (30%), consistent with Singhal et al.[50] and Turaki et al.[61] who demonstrated statistically significant relationships between adenoid–nasopharyngeal ratio and middle ear dysfunction.

In the immediate postoperative period, tympanometric improvement was limited ($p = 0.612$ at one week). This aligns with Unlu et al.[46] and Awad et al.[56] who described transient postoperative middle ear pressure changes attributable to surgical oedema and temporary Eustachian tube dysregulation. Early postoperative tympanometric findings should not be considered definitive indicators of surgical success.

By one month, significant improvement was evident ($p = 0.048$), consistent with Agaman et al.[51] and Rahman et al.[55] At three months, 84.4% of ears showed Type A tympanograms ($p < 0.001$). Literature consistently reports normalisation rates of 80–88% at comparable follow-up intervals, including Nguyen et al. (83.4%)[48], Turaki et al. (82.1%)[58], and Vasudha et al. (88%)[59]. This staged recovery pattern reflects gradual mucosal oedema resolution, effusion clearance, and restoration of ciliary and neuromuscular function within the middle ear, documented similarly by Somayaji et al.[49] and Sharma et al.[60]

A minority of patients (15.6%) continued to demonstrate abnormal tympanograms at three months, reflecting possible intrinsic Eustachian tube dysfunction, chronic mucosal remodelling, or incomplete peritubal lymphoid tissue clearance, as reported by Capaccio et al.[47] and Shenoy et al.[57] Additionally, the presence of abnormal tympanograms in children without overt hearing impairment — as noted by Gunel et al.[41] — underscores the importance of routine objective tympanometric assessment in all children with significant adenoid hypertrophy.

Conclusion

The present study conclusively demonstrates that adenoid hypertrophy has a significant and measurable impact on middle ear function. A substantial majority (86.7%) exhibited abnormal preoperative tympanometric findings (predominantly Type B and Type C), confirming that enlarged adenoids contribute directly to Eustachian tube obstruction and impaired middle ear ventilation. The study establishes a clear relationship between adenoid grade and degree of middle ear dysfunction.

Adenoidectomy leads to progressive tympanometric normalisation — minimal at one week ($p = 0.612$), significant at one month ($p = 0.048$), and highly significant at three months (84.4% Type A, $p < 0.001$). A residual 15.6% of ears with persistent dysfunction at three months warrants additional follow-up, medical management, or further otological intervention.

Routine tympanometric evaluation should be incorporated into the management of all children with significant adenoid hypertrophy, with postoperative follow-up extending beyond the immediate period. Timely adenoidectomy can prevent chronic middle ear disease, reduce the risk of conductive hearing loss, and improve speech development, academic performance, and overall quality of life.

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