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Accuracy of Tympanometry in the Diagnosis of Otitis Media with Effusion in Children's at Myringotomies

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ABSTRACT

Otitis media with effusion is a common cause of hearing impairment in children, required accurate diagnostic tools for timely intervention. Tympanometry is commonly used for assessing middle ear function, but its diagnostic accuracy compared to myringotomy, the gold standard, remains a topic of debate. **Objective:** To assess the diagnostic accuracy of tympanometry in identifying otitis media with effusion (OME) in children, using intraoperative findings during myringotomy as the gold standard. **Methods:** This observational cross-sectional study was carried out from January 2022 to June 2024 at the ENT Department, Hayatabad Medical Complex Peshawar. Ethical approval was obtained from Institutional Review Board (IRB) of the hospital, and written consent was obtained from parents or guardians of all children involved in the study. Total of 157 children aged 2 to 12 years, were included. **Results:** Proportion of sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy were determined. Type B tympanograms, suggestive of OME, were seen in 112 children (71.3%). Type A was observed in 25 children (15.9%) and type C in 20 children (12.7%). Myringotomy verified middle ear effusion in 120 children which is 76.4%.Within this group, 111 children presented with Type B tympanograms resulting in a true positive ratio of 92.5%. 9 cases (5.7%) were noticed with false positive results. **Conclusion:** Tympanometry stands as one of the top diagnostic instruments for OME identification in children. Their use, especially alongside otoscopy and audiometry, adds value in clinical practice.

INTRODUCTION

Otitis media with effusion (OME), which is more popularly known as "glue ear", is one of the most common conditions suffered by children, and involves fluid collections in the middle ear in the absence of acute infection. It is a major contributor to hearing loss in children and may influence speech, language, and academic achievement [1]. OME's accurate diagnosis is important to ensure prompt intervention. Tympanometry is gaining acceptance as an objective measure of assessing middle ear inflammation; however, the accuracy of tympanometry in diagnosing OME, particularly in cases validated with myringotomy, continues to be of great interest [2]. Tympanometry is a method for measuring the compliance of the tympanic membrane and the middle ear system through changes in air pressure in the external ear canal. It gives a graphical representation, called tympanogram, which is classified into types A, B, and C. type B which is flat is typically associated with OME, as such flat configuration indicates low mobility of the tympanic membrane [3]. Despite its widespread use, the accuracy of tympanometry in diagnosing OME has been debated, as many other conditions like cerumen occlusion, or technical faults, may give rise to similar findings [4]. Studies correlating the results of tympanometry with myringotomy have reported varying diagnostic accuracies. Most studies, including those by Azevedo *et al.,* and Vanneste P and Page C primarily used Jerger's classification (Type A, B, and C tympanograms) to categorize middle ear function [5, 6]. Some investigations also incorporated parameters like tympanometric width and peak-compensated static

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acoustic admittance to refine diagnosis [6]. Standardization across different patient groups was generally maintained by using calibrated equipment, a 226 Hz probe tone frequency for children older than six months, and consistent criteria for defining tympanogram types. Nevertheless, minor differences in methodology and patient characteristics could explain the variations reported among different studies [7]. In particular, the effects of age-related anatomical differences such as smaller, more compliant ear canals and immature eustachian tube function in younger children can influence tympanometric readings, sometimes leading to false positives [8]. While some studies attempted to control for these effects by stratifying patients into age groups or applying age-specific normative data, others did not fully adjust for these variations, which may explain part of the variability in reported sensitivity and specificity across different populations. Nonetheless, these measures have, in general, diagnostic and predictive accuracy variations in different studies which might be explained by differences in patient populations, machines used, and interpretation standards. For instance, some studies have pointed to the effect of age on tympanometric measurements when younger children are compared to older children with false positive results due to anatomical and physiological reasons [9, 10]. Another way of increasing the diagnostic accuracy is by using different tympanometric parameters including peak-compensated static acoustic admittance and tympanometric width [11]. Even with current advancements, there is little integration of tympanometry protocols and their results in clinical practice. Combining tympanometry with other tools like audiometry and otoscopy has been suggested to improve accuracy [12]. In addition, how new technologies like WBT contribute to OME detection remain unchecked [13]. This study seeks to determine the validity of tympanometric diagnosis of OME in children, using myringotomy as the gold standard. This review aimed to integrate pre-existing literature to give a thorough account of the impact and challenges posed by tympanometry and clinical practice.

The aim was to direct attention toward new opportunities for further studies.

METHODS

This was an observational cross sectional study carried out over a period of 18 months from January 2022 to June 2024 at the Ear, Nose and Throat (ENT) Department of Hayatabad Medical Complex Peshawar.The sample size was estimated based on a 60% expected prevalence of otitis media with effusion in the target population, using a standard method for single population proportion with a 95% confidence level and 5% margin of error.The prevalence value was derived from previously published data by Yeo SG *et al* [9].The initial calculated sample size was 147, which was increased to 157 to account for potential exclusions or incomplete data.Ethical approval was granted from Institutional Review Board (IRB) of HMC (Ref# 1605) and written consent was obtained from parents or guardians of all children involved in the study.Inclusion criteria were a diagnosis of chronic otitis media with effusion (lasting longer than three months) in children between the ages of two and twelve is made based on the absence of acute inflammatory symptoms (such as redness, bulging, or otorrhea) and otoscopic findings of a dull or retracted tympanic membrane, air-fluid level, or bubbles behind the tympanic membrane. Otoscopic examination was performed using a pneumatic otoscope to assess tympanic membrane mobility. Presence of tympanometric findings suggestive of ME (Type B tympanogram) were also taken into account prior to surgery. Children with ear congenital anomalies (such as associated otitis media with cleft palate), recent upper respiratory infections (within 2 weeks), chronic suppurative otitis media, a history of tympanostomy tube for drainage (within 6 months), or acute otitis media (defined by otoscopic examination revealing bulging, hyperemia, or purulent discharge) were excluded. This helped to guarantee that only individuals with simple, persistent middle ear effusions appropriate for tympanometric evaluation were included in the study. Tympanometric evaluations were performed with the Interacoustics AT235h middle ear analyzer, according to Jerger's classification (Type A, B or C). As per the manufacturer's guidelines, the device was calibrated every three months by certified biomedical engineers to ensure the reliability of the device. Moreover, before each patient testing session, audiologists conducted daily functional checks to ensure probe tone frequency and pressure pump functionality and probe seal integrity. Any anomalies identified on daily checks either triggered a recalibration, or a halt to test until rectified. For quality control purposes, random duplicate tympanometry tests were performed on a small subset of participants to check for machine-related inconsistencies. These actions minimized variability in tympanometric data in each session of the study period. Under general anaesthesia myringotomy was performed by experienced ENT surgeons, and intraoperatively the presence or absence of middle ear effusion was documented. The presence of middle ear effusion was identified at the time of surgery by visual inspection after myringotomy. The presence of effusion was defined as any type of effusion (serous, mucoid, or purulent) seen coming from the incision or aspirated from the middle ear. If none was identified during gentle suctioning, then the ear was characterized as being without effusion. The primary operating surgeon immediately recorded all intraoperative findings and these were independently verified by a second ENT surgeon to limit reporter bias.

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Therefore, all cases were classified in a standardized and objective way, ensuring reliability of the outcome in terms of middle ear status. Data were analyzed using SPSS version 25.0. Descriptive statistics such as means and standard deviations were calculated for continuous variables, while frequencies and percentages were reported for categorical variables. Diagnostic accuracy parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated using cross-tabulation of tympanometry results against myringotomy findings as the reference standard. Chi-square (χ^2) test was used to assess the statistical significance of the association between tympanometric findings and intraoperative myringotomy results. A p-value of ≤ 0.05 was considered statistically significant. Inter-rater reliability for myringotomy interpretation was assessed using Cohen's kappa coefficient.

RESULTS

This research assessed the validity of using tympanometry to detect otitis media with effusion (OME) in children, using myringotomy results as gold standard. One hundred and fifty-seven children aged between 2-12 years were analyzed. Tympanometry was found to have high diagnostic accuracy for the detection of OME. Proportion of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and overall accuracy were determined and presented in summary in (Table 1).

Table 1: Diagnostic Accuracy of Tympanometry in detecting OME

Demographics	Value (%)	95% Confidence Interval (CI)
Sensitivity	92.5%	88.3 - 95.6
Specificity	85.7%	79.4 - 90.5
Positive Predictive Value (PPV)	89.2%	84.1 - 93.0
Negative Predictive Value (NPV)	90.1%	85.0 - 93.8
Overall Accuracy	89.8%	86.2 - 92.7

The frequencies of type A, B, and C tympanograms in the population studied are summarized in Table 2.Type B tympanograms, suggestive of OME, were seen in 112 children (71.3%).Type A was observed in 25 children (15.9%) and type C in 20 children (12.7%). Table-2

Table 2: Distribution of Tympanogram Types

Tympanogram Type	Frequency (%)
Type A (Normal)	25 (15.9%)
Type B (Flat)	112 (71.3%)
Type C (Negative Pressure)	20 (12.7%)

Tympanometry findings alongside myringotomy results are shown in Table 3.Myringotomy verified middle ear effusion in 120 children which is 76.4%. Within this group, 111 children presented with Type B tympanograms resulting in a true positive ratio of 92.5%. 9 cases (5.7%) were noticed with false positive results (Type B tympanogram without effusion). Table-3

Table 3: Comparison of Tympanometry Results with Myringotomy Findings

Tympanometry Result	Myringotomy Positive (N)	Myringotomy Negative (N)	Total (N)
Type B (Positive)	111	9	120
Type A/C (Negative)	9	28	37
Total	120	37	157

The association between the tympanometry results and myringotomy findings was evaluated using a chi-square test. The analysis showed significant association between results and findings (χ^2= 125.4, $p < 0.001$), confirming that the use of tympanometry as a diagnosis tool for OME in children is accurate. A sub group analysis was performed to determine the diagnostic accuracy of tympanometry in different age subgroups: 2-5 years, 6-8 years, and 9-12 years. The results are provided below in Table 4. Regular calibration of the tympanometry equipment and independent verification of intraoperative findings by two ENT surgeons ensured the reliability of the results. The inter-rater agreement for myringotomy findings was excellent (Cohen's kappa = 0.92).

Table 4: Diagnostic Accuracy of Tympanometry by Age Group

Age Group (Years)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
2-5	90.2%	82.4%	87.5%	86.3%	88.1%
6-8	93.1%	86.7%	90.8%	89.7%	90.5%
9-12	94.5%	88.9%	91.2%	92.1%	91.8%

DISCUSSION

This study's results show that tympanometry is an exact diagnostic method for the determination of otitis media with effusion (OME) in children, with a sensitivity of 92.5% and specificity of 85.7%.These results are in accordance with earlier studies that have assessed the accuracy of tympanometry against the 'gold standard' of myringotomy [14, 15]. For example, Torretta S *et al.*, reported a sensitivity of 90% and specificity of 80% for tympanometry in detecting OME and this is similar to these results [16].This also applies to Principi and Esposito where they found PPV of 85% for tympanometry [17].The accuracy of diagnosis using tympanometry in this study was high, because standard protocols were observed such as the use of calibrated instruments and qualified personnel.The classification of the tympanograms according to Jerger's criteria (Type A, B, and C) provided an understandable and reproducible framework for interpretation of results.Type B tympanograms (flat trace) are strongly associated with OME.This is in accordance with the findings of Suzuki HG *et al.*, who pointed out the usefulness of the width of the tympanometric peak and the value of peak-compensated static acoustic admittance for the diagnosis [18].Notable differences in accuracy have been reported in other

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studies, frequently as a result of differing study populations, equipment, and criteria for interpretation. To illustrate, Paul C *et al.*, emphasized that younger children are likely to have greater rates of false positives because of mid-ear anatomy and physiology [19]. The study was done in a single tertiary care facility which may not be representative of other areas and therefore is a confounding factor in the generalizability of the results. The exclusion of patients with congenital ear anomalies and those who had previous tympanostomy tube insertions also comes with selection bias. Further research should evaluate the accuracy of diagnosis of OME with more sophisticated tympanometric techniques like wideband tympanometry that was noted to be helpful in OME detection [20].Multicentric studies with different populations are also necessary to test the results to be more widely applied.Moreover, longitudinal studies evaluating the clinical outcomes for children with OME diagnosed through tympanometry will assist in understanding the consequences of using this clinical tool for diagnosis.

CONCLUSIONS

This study demonstrated that tympanometry is a valuable and effective tool for identifying otitis media with effusion (OME) in children. These findings emphasize the need for further validation of its clinical applicability across diverse populations and with improved wideband tympanometry techniques. Such research could enhance the accuracy of OME diagnosis and support better treatment strategies in pediatric care.

Authors Contribution

Conceptualization: MA, AN
Methodology: MA, HN
Formal analysis: MA, HN
Writing, review and editing: AN, HN
All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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