

Research Article

Diagnostic Accuracy of Tympanometry in Pediatric Otitis Media with Effusion Compared to Myringotomy Findings

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ABSTRACT

Background: Otitis media with effusion (OME) is a frequent ear disease in children that may lead to conductive hearing loss and school problems if not detected.

Objective: To assess the diagnostic accuracy of tympanometry for OME in children as compared to the reference standard of myringotomy.

Methods: The study was a prospective diagnostic accuracy study carried out in the Department of ENT, Hayatabad Medical Complex, Peshawar, Pakistan for six months (January, 2026 to June 2026). One hundred children aged 2-12 years, who were clinically suspected of OME and were scheduled for myringotomy, were enrolled using non-probability consecutive sampling. Preoperative tympanometry results were compared to intraoperative myringotomy results using Jerger criteria to determine the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy.

Results: The effusion was confirmed by myringotomy in 62 of 100 children (mean age 6.8 ± 2.7 years, 57% male). The sensitivity, specificity, PPV, NPV, and overall accuracy of tympanometry were 88.7%, 92.1%, 94.8%, 83.3%, and 90.0%, respectively, with a positive likelihood ratio of 11.2 and a negative likelihood ratio of 0.12.

Conclusion: Although there are false-positive and false-negative results, tympanometry is a reliable, non-invasive preoperative test for the detection of pediatric OME, and should be used in conjunction with clinical and intraoperative evaluations.

Keywords: Otitis Media with Effusion, Tympanometry, Myringotomy, Diagnostic Accuracy, Sensitivity and Specificity, Pediatric, Middle-Ear Effusion, Jerger Classification.

INTRODUCTION

Otitis media with effusion (OME) is a very common middle ear disorder among children that is caused by fluid in the middle ear without an acute infection. It can occur after infection, dysfunction of the eustachian tube, or impaired ventilation. Chronic effusion may lead to conductive hearing loss and negatively affect school performance. Since young children might not be able to describe their hearing loss, the objective diagnosis is important. Tympanometry is a quick, non-invasive method of measuring the mechanics of the middle ear and is commonly used in the evaluation of otology in children. This study has been specifically evaluated in Pakistan

regarding its diagnostic value against myringotomy and proved its value in the clinical setting while highlighting the need to validate it against a direct reference standard (1). When myringotomy is performed, there is definitive confirmation of middle-ear effusion if this is performed. Tympanometry is a low-cost, rapid, repeatable, and appropriate assessment method.

In general, Jerger type B and C patterns are considered. Results depend on fluid and middle ear status. A recent study that examined the usefulness of tympanometry in children with OME, using the myringotomy results as the gold standard, found that tympanometry was a useful tool for diagnosis

(2). A further study also assessed the accuracy of tympanometry preoperatively (3). However, traditional tympanometry has its drawbacks. A flat tracing can happen spontaneously, but can also be caused by perforation of the eardrum, patent ventilation tubes, or other abnormal conditions in the middle ear. Negative pressure can be due to Eustachian tube dysfunction and the absence of fluid. Accordingly, wideband tympanometry has been the focus of interest as it assesses acoustic transmission at a number of frequencies and may yield further diagnostic information.

The results of a systematic review of wideband tympanometry in OME were encouraging, with the caveat that the results need to be validated in the clinical setting and need to be interpreted in a standardized manner (4). Tympanometry is still important but needs to be interpreted in the context of clinical and otoscopic findings. Otoscopy is still the basic examination as it permits direct examination of the appearance of the tympanic membrane, which includes retraction, opacity, and air-fluid levels. However, factors such as examiner experience, visualization, cerumen, child cooperation, and anatomical differences can affect diagnostic agreement. The results of the comparison of evidence between otoscopy and tympanometry indicate that these two methods complement each other and that there may be discrepancies between the two methods if used alone (5).

Likewise, the analysis of the comparison between preoperative tympanometry and intraoperative findings shows that tympanometry is useful in predicting the contents of the middle ear, but cannot fully replace the direct confirmation of the middle ear contents (6). Therefore, myringotomy is still a reference standard to assess tympanometry. Newer technologies have been developed due to the demand for accurate noninvasive diagnosis. A recently developed technique, optical coherence tomography, may be able to give structural data of the pediatric middle ear without surgery. Its potential for the detection of effusion has been explored (7). Meanwhile, the reliability of the existing methods is still a must. A study comparing interrater reliability for otoscopic images and wideband tympanometry measurements has demonstrated that consistency of the observers is an important factor in the diagnosis of middle ear disease in children (8). The results confirm the importance of having a

standardized assessment and objective reference standards.

Clinically, it is important to be accurate, as this may affect decisions about the need for ventilation tubes if there is persistent OME. In some children with persistent bilateral effusion, hearing loss or other clinical issues, grommets may be indicated. A Cochrane review underscores the need for careful assessment of the benefits and harms of the use of ventilation tubes, which means reliable diagnosis is relevant in the pre-operative period (9). Wideband tympanometry and absorbance measure sound transmission at several frequencies. A few studies have found that it has potential utility in the diagnosis of middle ear effusion, but more studies are required (10). Simple tympanometry is particularly useful when sophisticated equipment is not available. OME can be asymptomatic and undiagnosed without testing. Studies that have evaluated the prevalence and correlations of otoscopic findings with Jerger tympanograms have demonstrated that tympanometry can provide useful information in pediatric screening and diagnosis (11).

Tympanometric patterns are also applicable to children with hearing impairment who may have both conductive and sensorineural hearing loss. The findings of the tympanograms in hearing-impaired children with OME are consistent with the inclusion of middle-ear assessment in a full hearing evaluation (12). This allows for comparison of tympanometry with a gold standard. The clinical context may affect the interpretation of the diagnosis, especially in children who have adenoid hypertrophy that can affect the functioning of the eustachian tube and cause OME. The diagnosis of OME in children with adenoid hypertrophy has been a subject of research for machine learning models (13). Otoacoustic emissions can be used in conjunction with tympanometry, but they measure cochlear function and are affected by middle-ear transmission. A systematic review has also assessed the use of otoacoustic emissions as a preliminary screening tool for otitis media in children, highlighting the need for their use as a screening tool, not a diagnostic tool (14). It also points to the shortcomings of screening (15).

Wideband tympanometry remains of interest as it offers an acoustic spectrum profile over frequencies and has the potential to enhance the ability to identify abnormalities in the

middle ear. Its clinical potential is supported by research and the need for appropriate parameters and normative data (16). Traditional tympanometry is still available, especially in low-resource areas. A systematic review has also shown that there is an association between OME and adenoid hypertrophy (17). Therefore, the comparison of tympanometric results directly with myringotomy results gives a clinically meaningful appraisal of sensitivity, specificity, predictive values, and overall diagnostic accuracy. This evidence can help to better understand the role of tympanometry in the preoperative setting and guide surgical selection.

Objective: To evaluate the diagnostic accuracy of tympanometry as a tool to diagnose otitis media with effusion (OME) in children, using myringotomy findings as the reference standard, and to evaluate the clinical reliability of tympanometry.

Study Design: A prospective diagnostic accuracy study was performed to assess the diagnostic accuracy of tympanometry for the diagnosis of OME, based on the myringotomy diagnosis.

Study Setting: Department of ENT, Hayatabad Medical Complex, Peshawar, Pakistan.

Study Duration: 6 months, from January, 2026 to June 2026.

Sample Size: A total of 100 pediatric patients with clinically suspected OME who fulfilled the eligibility criteria were included in the study.

Sample Technique: Consecutive sampling technique (non-probability sampling technique) was used. Children who presented during the study period and were eligible for myringotomy were consecutively enrolled until the required sample size was reached.

Inclusion Criteria: Children aged 2–12 years with clinical suspicion of OME who were scheduled for myringotomy and tympanostomy tube placement were included. Children who had been assessed by tympanometry preoperatively and whose middle ear status was subsequently confirmed by direct intraoperative examination or by aspiration during myringotomy were eligible.

Exclusion Criteria: Children who had a history of acute otitis media, chronic suppurative otitis media, active otorrhea, tympanic membrane perforation, previous middle-ear surgery, congenital ear abnormalities, or placement of previous tympanostomy tubes were excluded. Children who had suboptimal tympanometry or had no intraoperative findings were also excluded.

METHODS

Children who met the criteria for eligibility were then assessed in detail before surgery, with regard to their ears. A calibrated tympanometer was used to perform tympanometry in a quiet clinical setting, using the correct size probe to ensure a good seal in the external auditory canal. Tympanograms were assigned to the standard Jerger classification, and a type B pattern was defined as suggestive of middle-ear effusion, whereas a type A and type C pattern were interpreted in the light of the clinical circumstances. The tympanometric results were taken individually for each ear. All children enrolled were then referred for myringotomy under suitable anesthesia as clinically indicated. In the myringotomy, the eardrum was cut, and the presence or absence of fluid in the middle ear was directly observed and recorded. When there was effusion, it was aspirated. Intraoperative findings were used as the reference standard. The tympanometry results were then compared to the myringotomy results to determine sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy. Appropriate statistical methods were used to analyze the data.

RESULTS

There were 100 children with clinically suspected OME who met the inclusion criteria and were included in the final analysis. The mean age of participants was 6.8 ± 2.7 years (range 2–12 years), and the sample comprised 57 (57.0%) males and 43 (43.0%) females. Middle ear effusion was confirmed in 62 (62.0%) children, and no effusion was found in 38 (38.0%) children in the case of intraoperative myringotomy, which served as the reference standard. Fifty-eight children (58.0%) were classified as type B and 42 children (42.0%) were classified as non-type B (types A and C combined) by the preoperative tympanometry. Demographic and clinical

distribution of the cohort and the pattern of tympanometric classification in relation to

confirmed effusion status are shown in Table 1 and Figure 1, respectively.

Table 1. Demographic and Clinical Characteristics of the Study Participants (N = 100)

Variable	n	%
Total participants	100	100.0
Age 2–5 years	31	31.0
Age 6–9 years	45	45.0
Age 10–12 years	24	24.0
Male	57	57.0
Female	43	43.0
Effusion confirmed on myringotomy	62	62.0
No effusion on myringotomy	38	38.0
Type B tympanogram	58	58.0
Non-type B tympanogram	42	42.0

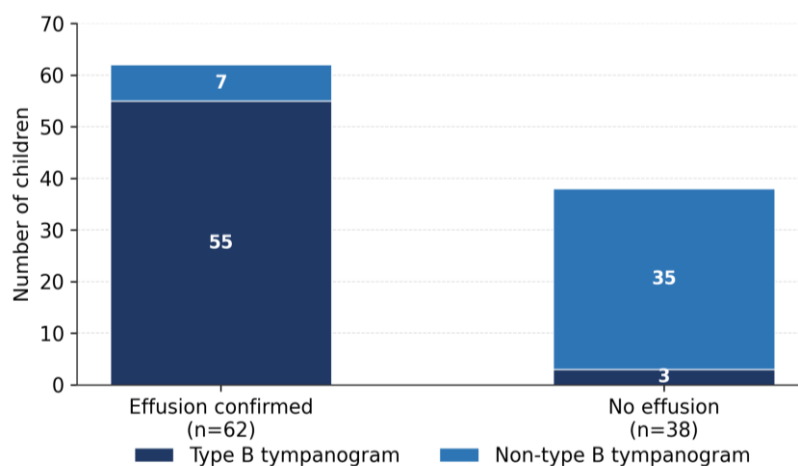


Figure 1 (Below). Tympanometric Pattern by Myringotomy-Confirmed Effusion Status.

Of the 62 children who had surgically confirmed effusion, 55 were correctly identified (true positives), and seven were not identified (false negatives). Of the 38 children

without effusion, 35 were correctly classified as negative (true negatives), and 3 were incorrectly classified as positive (false positives).

Table 2. Cross-Tabulation of Tympanometry Results against Myringotomy Findings

Tympanometry	Myringotomy: Effusion	Myringotomy: No effusion	Total
Positive	55 (TP)	3 (FP)	58
Negative	7 (FN)	35 (TN)	42
Total	62	38	100

This yielded 55 true-positive, 35 true-negative, 3 false-positive, and 7 false-negative results,

as summarised in the cross-tabulation in Table 2 and Figure 2.

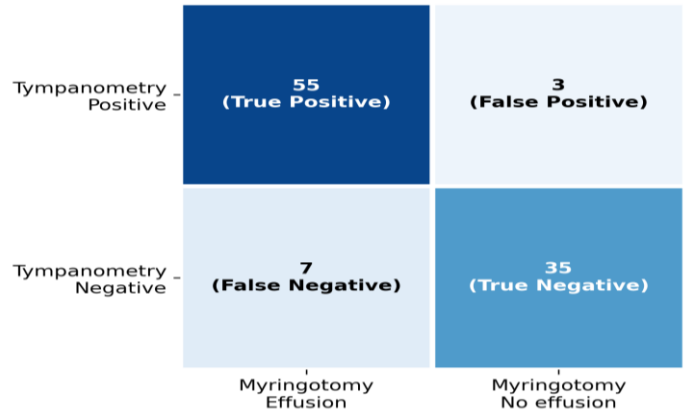


Figure 2 (Below). Confusion Matrix of Tympanometry versus Myringotomy Findings.

Using myringotomy as the reference standard, tympanometry demonstrated a sensitivity of 88.7% (95% CI: 78.5–94.7%) and a specificity of 92.1% (95% CI: 79.2–97.3%). The positive predictive value was 94.8% (95%

CI: 85.9–98.2%), and the negative predictive value was 83.3% (95% CI: 69.4–91.7%), with an overall diagnostic accuracy of 90.0% (95% CI: 82.5–94.6%).

Table 3. Diagnostic Performance of Tympanometry against Myringotomy

Diagnostic measure	Value	95% CI
Sensitivity	88.7%	78.5–94.7%
Specificity	92.1%	79.2–97.3%
Positive predictive value	94.8%	85.9–98.2%
Negative predictive value	83.3%	69.4–91.7%
Diagnostic accuracy	90.0%	82.5–94.6%
Positive likelihood ratio	11.2	—
Negative likelihood ratio	0.12	—

The positive likelihood ratio was 11.2, which meant that the likelihood of effusion increased greatly with a positive result; the negative likelihood ratio was 0.12, meaning that the likelihood of effusion was meaningfully

reduced, but not eliminated, with a negative result. The following diagnostic performance measures are summarised in Table 3 and Figure 3.

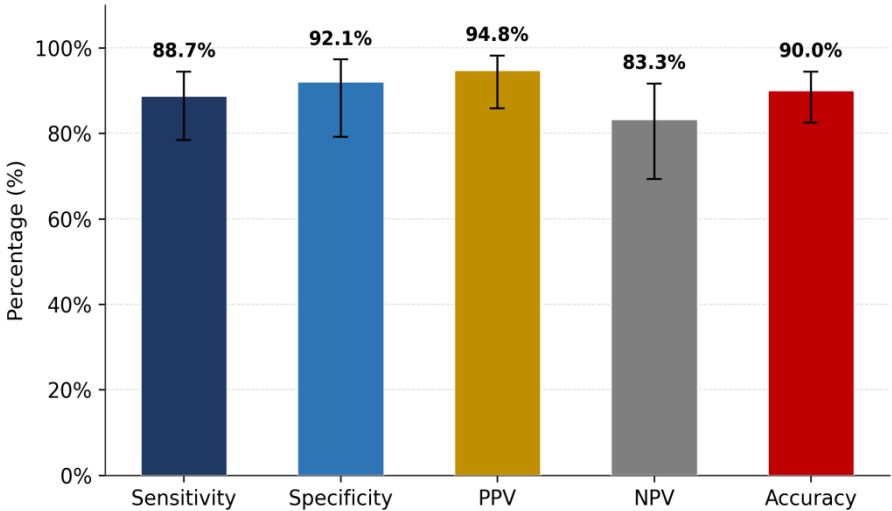


Figure 3 (Below). Diagnostic Performance of Tympanometry With 95% Confidence Intervals.

In general, tympanometry proved to be a good diagnostic tool to detect pediatric OME

compared to direct intra-operative assessment. It has high specificity and positive predictive

value, suggesting that a positive tympanometric result was strongly linked with confirmed middle-ear effusion, and that it is a useful rule-in test. The false-negative results may be related to a small effusion, viscous effusion, or loculated effusion which may not be detected by tympanometric changes, while the false-positive results may be related to other middle-ear pathology that may result in abnormal tympanometric patterns. The results of this study indicate that although tympanometry is a useful non-invasive screening tool, it should not be used alone, especially when clinical suspicion of OME is high, despite the negative result.

CONCLUSION

Tympanometry has been shown to have good diagnostic performance for the detection of otitis media with effusion in children when compared to the results of the myringotomy as the reference standard. The sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of tympanometry in the study suggest that this test is a reliable and practical preoperative middle-ear effusion investigation. This is because it is fast, objective, cost-effective, and suitable for pediatric patients, making it invaluable in everyday otological practice. However, the presence of false-positive and false-negative results indicates that tympanometry should not be considered an absolute replacement for clinical examination or direct intraoperative assessment. Using tympanometry in conjunction with otoscopy and clinical examination can enhance confidence in diagnosis. In summary, tympanometry can be a useful tool in the identification of children with suspected OME and provide assistance in making management decisions, and myringotomy is the gold standard for diagnosing middle-ear effusion when surgery is performed.

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