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ORIGINAL ARTICLE

Correlation Between Video-Otoendoscopy and Tympanograms of Patients with Acute Middle Ear Infections

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Abstract The tympanic membrane (TM) undergoes a number of pathological changes in middle ear disease which can be detected by a video-otoendoscope. Middle ear disease is also accompanied by changes in middle ear pressure which can be assessed by tympanometry. The objectives of this study were to find the correlation between video-otoendoscopy and tympanometry in acute middle ear infections and to deduce which of the two is more efficient and reliable for early diagnosis. 75 patients with AOM or OME were included over 1 year where each patient was followed for 21 days. Detailed history and clinical examination with videootoendoscope and tympanometry was done on each visit. Each TM was graded using OMGRADE scale. Symptoms and clinical findings consistent with acute otitis media were given a clinical score (CO Score). The results were collected and correlation between video-otoendoscopy and tympanometry was determined and their individual sensitivity, specificity and diagnostic accuracy was calculated. The sensitivity, specificity and diagnostic accuracy for tympanometry and video-otoendoscopy was calculated individually for each of the 4 visits and positive correlation between the 2 was found. Our study showed that tympanometry had a higher overall sensitivity than video-otoendoscopy. While, video-otoendoscopy showed a higher specificity than Tympanometry. Otoendoscopy is good for ruling out AOM/OME but cannot rule out persisting Middle Ear Effusion and Tympanometry is a better tool for detecting MEE but cannot differentiate well between AOM and OME. We found that tympanometry plus otoendoscopy together greatly increase the chances of detecting AOM and OME thus improving diagnostic accuracy, reducing financial costs associated with over or mis-diagnosis.

Keywords Acute Otitis Media · Tympanometry · OM grade · Video-otoendoscopy · Otitis Media with effusion

Introduction

Acute Otitis Media (AOM) is a common ailment and a prominent cause of health care visits and antibiotic prescription. Otitis Media with effusion (OME) may occur spontaneously because of poor Eustachian tube function or as an inflammatory response following AOM. Early diagnosis of acute middle ear infection is important for early initiation of treatment and thus preventing future complications and cost implications.

Visualization of the tympanic membrane with identification of the presence of an middle ear effusion (MEE) and inflammatory changes is necessary to establish diagnosis of AOM or OME with certainty. Tympanometry provides a general view of the pressure condition in the middle ear and when the presence of middle ear fluid is difficult to determine, tympanometry can be helpful.

Video-otoendscopy uses endoscopic technology to project the image of the tympanic membrane (TM) onto a monitor visible to both the physician and the patient. It produces a larger, clearer, well-focused image of the TM which allows for analysis of the image any time after image acquisition. This allows for better monitoring the progression of the disease process.

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In AOM, the characteristics of TM and MEE are different than those in OME and these may not be easily distinguishable.

A type B tympanogram with flat curve and normal canal volume is considered diagnostic of OME. Compared with all other types of tympanograms it has a high sensitivity and specificity in detecting OME confirmed surgically [1].

Methods

This prospective study was conducted in a tertiary health care centre in North India from September 2019 to 2020. 75 patients were examined who were selected from the population visiting the ENT Outpatient Department. Patients included were between the age of 5–18 years, with signs (redness, bulging of TM) and symptoms (fever, tugging, irritability or pain) corresponding with AOM or OME without any complications and no history of ear trauma or ear surgery. Detailed clinical history was taken and examination was done using video-otoendoscopy followed by tympanometry.

Each patient found having AOM or OME was put on a treatment of Amoxycillin + clavulanic acid along with an antihistaminic, analgesic and nasal decongestant for 1 week. Patients were followed up after 3 days of the 1st visit and then weekly for 2 weeks. Every patient underwent video-otoendoscopy using Karl Storz Telepack 0° endoscope and the images were graded on the basis of an image-based grading scale developed by Lundberg et al. [2] known as the OMGRADE scale, tympanometry was done using Impedance Audiometer GSI Tympanostar Pro and the tympanograms were classified into 5 types according to the modification given by Jerger, with Feldman [3] and was given a clinical score based on the Clinical Score developed by Dagan et al. [4] on each visit. It included categories of fever, irritability, tugging, redness and bulging were classified as absent, mild, moderate or severe. If the eardrum was perforated at the time of the second visit and pus was draining, this was scored by definition as "severe bulging." Maximum score was 15 while minimum score was 0 (Figs. 1, 2).

Omgrade	Sub-division	Description
0	0	Transparent TM, normal position
1	1R	Transparent TM, slightly retracted
	1F	Transparent TM, normal position, fluid level or fluid filled ME
	1RF	Transparent TM, retracted with fluid level or fluid filled ME
2	2OF	Transparent TM with opaque fluid level, w/wo retraction
3	3	Opaque appearance of TM in a fairly normal position
4	4	Opaque appearance of TM and bulging
5	5B	Opaque appearance of TM with bullous formations
	5C	Contourless TM with a wet appearance and swollen keratin patches, w/wo pulsating pus from small perforation
Temporary subgrade 6	6	TM perforation, retraction pocket or cholesteatoma w/wo purulent discharge, previous ear surgery and TM grommets

Results

A total of 75 patients (22 females, 53 males) were included in this study aged between 5 and 18 years. 4 out of these 75 patients were lost to follow-up. The mean age was 13.65 ± 3.59 years. Each patient who had signs and symptoms of AOM or OME and were given a CO score.

Irritability was present in majority of patients (98.67%) on the 1st visit followed by redness (93.33%). On the 2nd visit redness was present in majority of patients (72.22%) followed by tugging (62.50%). Tugging was present in majority (38.03%) of patients on 3rd visit followed by redness (22.54%). On the 4th visit Tugging was present in 8.45% patients while none had fever, irritability, redness and bulging (Table 1).

Moderate agreement exists between tympanogrmas and video-otoendoscopy on each visit with kappa value 0.472 on the 1st, 0.452 on the 2nd, 0.380 on the 3rd and 0.516 on the 4th visit. Significant correlation was seen in the distribution of tympanongrams and video-otoendoscopic images on each visit (p value < 0.5) (Table 4).

Tympanogram at 1st visit was A in 50% of patients in 1R, 0% of patients in 1RF, 0% of patients in 2OF, 0% of patients in 3, 5% of patients in 4, 3.33% of patients in 5B and 0% of patients in 5C. Tympanogram at 1st visit was B in 100% of patients in 5C, 100% of patients in 2OF, 100% of patients in 3 and 96.67% of patients in 5B, 50% of patients in 1R, 92.86% of patients in 1RF and 95% of patients in 4. Tympanogram at 1st visit was C in 7.14% of patients in 1RF, 0% of patients in 1R, 0% of patients in 2OF, 0% of patients in 3, 0% of patients in 4, 0% of patients in 5B and 0% of patients in 5C (Fig. 3).

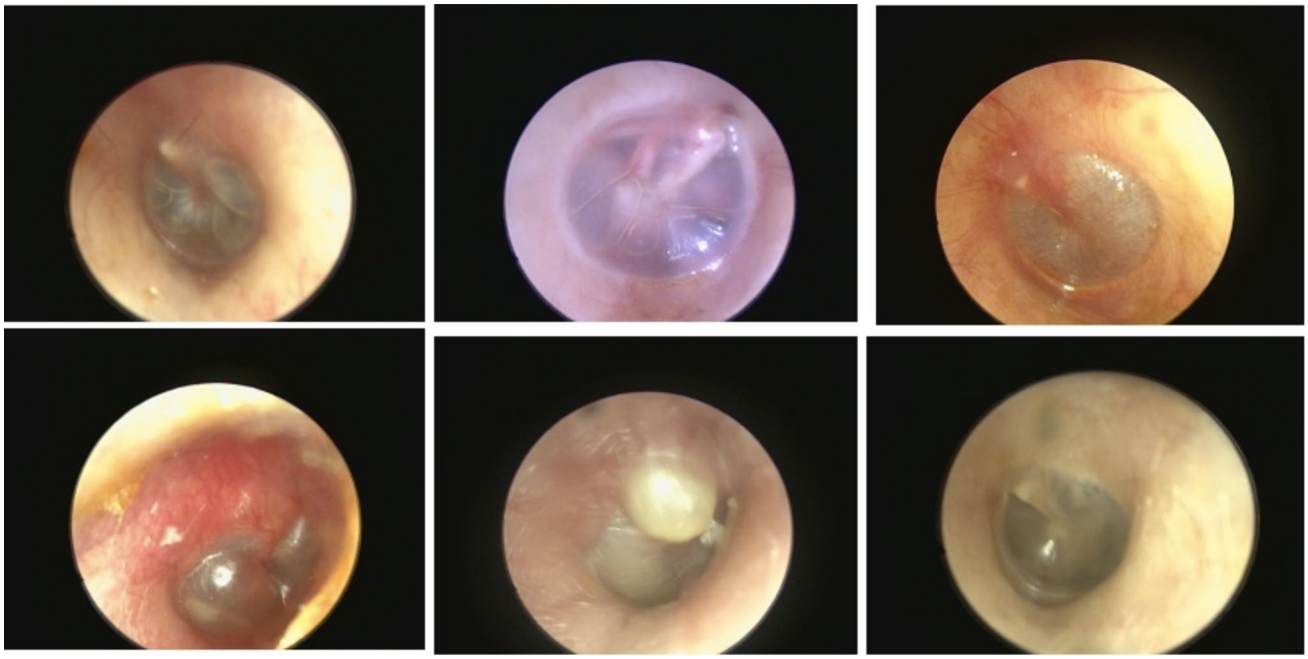

Fig. 1 OM Grade of video-otoendoscopic images. Upper row left to right Grade 2OF, Grade 1RF, Grade 4. Lower row left to right: Grade 5B, Grade 5B, Grade 0

Tympanogram at 2nd visit was A in 42.11% of patients in 1R, 6.90% of patients in 1RF, 0% of patients in 2OF, 0% of patients in 3, 0% of patients in 4, 0% of patients in 5B and 0% of patients in 5C. Tympanogram at 2nd visit was B in 100% of patients in 5C, 100% of patients in 2OF, 100% of patients in 3, 100% of patients in 4 and 100% of patients in 5B and 93.10% of patients in 1RF, 52.63% of patients in 1R. Tympanogram at 2nd visit was C in 5.26% of patients in 1R.

Tympanogram at 3rd visit was A in 100% of patients in 0, 58.82% of patients in 1R, 0% of patients in 1RF, 0% of patients in 3 and 0% of patients in 4. Tympanogram at 3rd visit was B in 100% of patients in 4, 100% of patients in 1RF and 100% of patients in 3, 0% of patients in 0 and 39.22% of patients in 1R. Tympanogram at 3rd visit was C in 1.96% of patients in 1R.

Tympanogram at 4th visit was A in 100% of patients in 0, 54.55% of patients in 1R, 0% of patients in 1RF and 0% of patients in 4. Tympanogram at 4th visit was B in 100% of patients in 4 and 100% of patients in 1RF, 0% of patients in 0 and 45.45% of patients in 1R.

Univariate logistic regression was performed taking OM grade at 1st visit as independent variable to predict tympanogram finding at 2nd visit, 3rd visit and 4th visit. Patients categorized as diseased by OM grade at 1st visit had significantly higher chances of tympanogram B/C at 2nd visit with odds ratio of 19.139. No significant relation was seen between OM grade at 1st visit and tympanogram finding at 3rd visit and 4th visit (p value > 0.05). On taking tympanogram at 1st visit as independent variable to predict OM grade finding at 2nd visit, 3rd visit and 4th visit. No significant relation was seen between tympanogram at 1st visit and OM grade at 2nd visit, 3rd visit and 4th visit (p value > 0.05) (Table 5).

Discussion

We used both tympanometry as well as video-otoendoscopy to the assess the tympanic membrane and the condition of the middle ear and used a Clinical Score for diagnosing AOM or OME as standard.

Pain /irritability was the most common presenting complaint followed by tugging and fever. This correlated well with studies performed by Niemela et al. and Rothman et al. [5, 6] according to whom earache was present in majority of the patients of AOM and also the most useful symptom for diagnosis. The most common sign among the patients was redness of the TM followed by bulging of the TM. However Karma et al. and McCormick et al. [7, 8] found bulging of the TM had higher specificity (97%) while redness of the TM only correlated with the presence of AOM.

In our study TM's were graded on the basis of OM Grade using an otoendoscope which showed a sensitivity of 94.67% and PPV 100% on the 1st visit. A sensitivity of 92.31%,specificity of 48.48%, PPV 67.92% and NPV 84.21% on the 2nd visit. On the 3rd visit we found

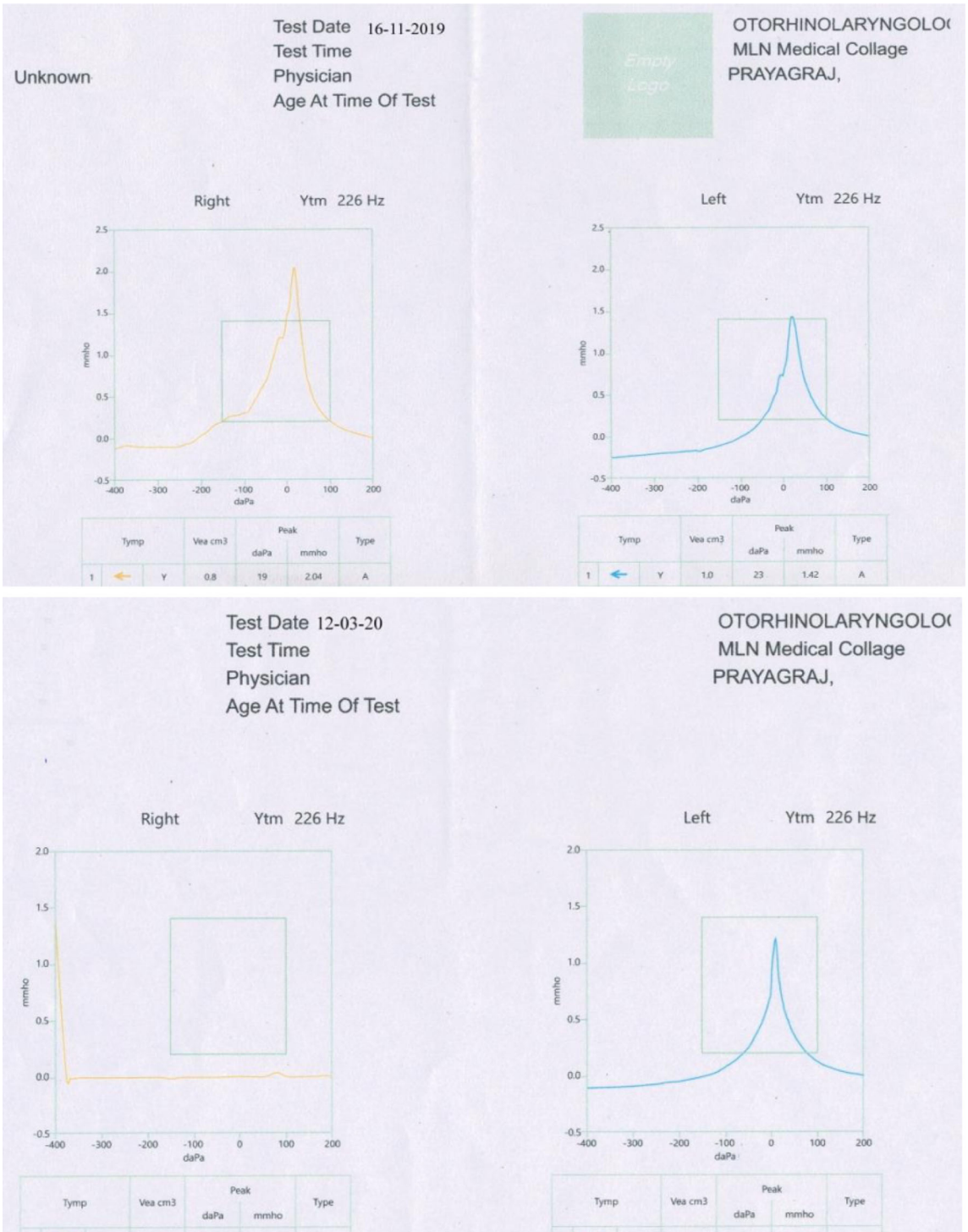

Fig. 2 Tympanograms upper: right-type A, left-type A; lower: right-type B, left-Type A

sensitivity of 66.67%,specificity of 85.29%, PPV 16.67% and NPV 98.31%. On the 4th visit we found that OM grade had a specificity of 95.77% and a NPV of 100% (Table 2). Our findings correlated well with a study by Takata et al. [9] who found that the sensitivity of pneumatic otoscopy was 94%, Lee and Yeo [10] who found that the sensitivity of pneumatic otoscopy was 97.2% and a specificity 38% while poor correlation was found with a study by Rogers et al. [11] who found that pneumatic otoscopy had a sensitivity of 67.9%, specificity of 81.4% while Binocular microscopy performed by staff paediatric otolaryngologist

Table 1 Distribution of frequency (percentage) of signs/symptoms of study subjects

	Fever	Irritability/pain	Tugging	Redness	Bulging
1st visit (n = 75)	42 (56.00%)	74 (98.67%)	57 (76.00%)	70 (93.33%)	60 (80.00%)
2nd visit (n = 72)	3 (4.17%)	39 (54.17%)	45 (62.50%)	52 (72.22%)	35 (48.61%)
3rd visit (n = 71)	0 (0.00%)	10 (14.08%)	27 (38.03%)	16 (22.54%)	2 (2.82%)
4th visit (n = 71)	0 (0.00%)	0 (0.00%)	6 (8.45%)	0 (0.00%)	0 (0.00%)

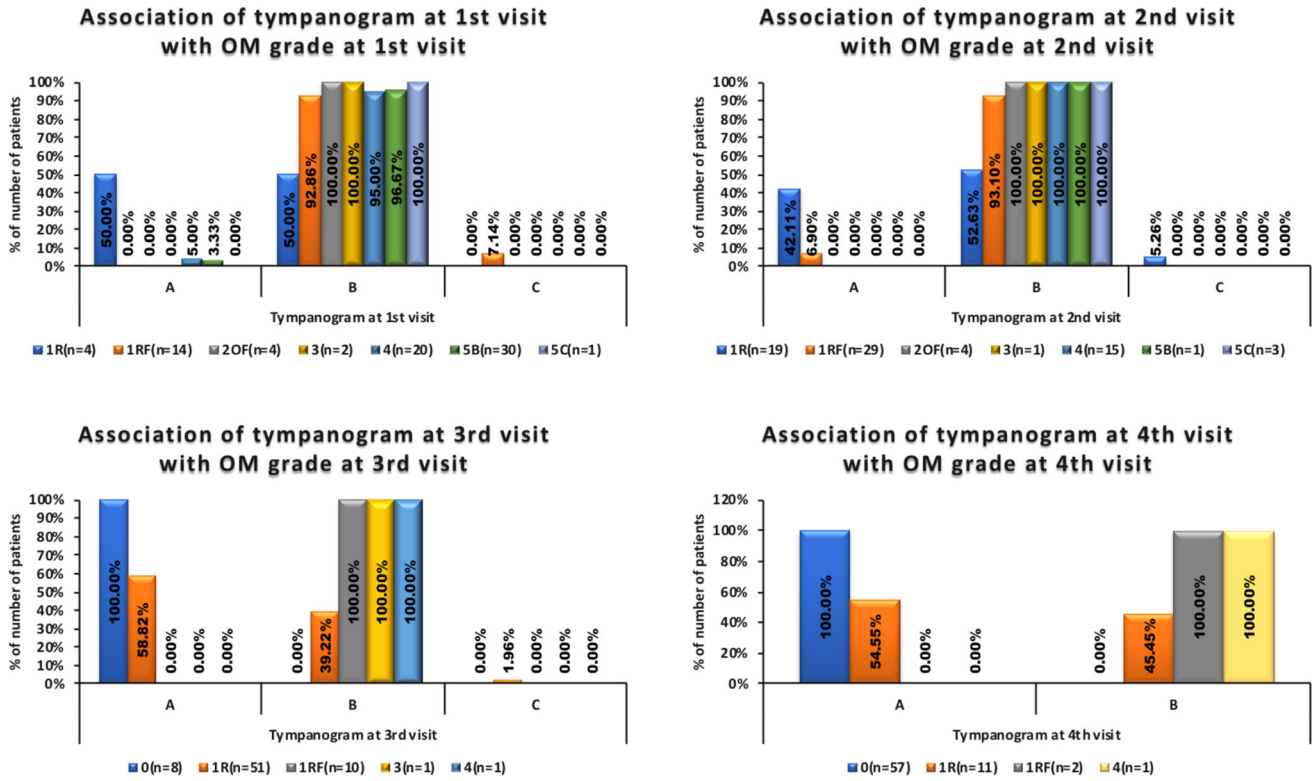

Fig. 3 Association of tympanogram on various visits with OM Grade

Table 2 Sensitivity, specificity, NPV, PPV and diagnostic accuracy of OM grade taking CO score as standard

	OM grade				
	Sensitvity	Specificity	NPV	PPV	Diagnostic accuracy
1st visit (n = 75)	94.67% (86.90–98.53%)	–	–	100% (94.94–100.00%)	–
2nd visit (n = 72)	92.31% (79.13–98.38%)	48.48% (30.80–66.46%)	84.21% (60.42–96.62%)	67.92% (53.68–80.08%)	72.22%
3rd visit (n = 71)	66.67% (9.43–99.16%)	85.29%. (74.61–92.72%)	98.31% (90.91–99.96%)	16.67% (2.09–48.41%)	84.51%
4th visit (n = 71)	–	95.77%. (88.14–99.12%)	100.00% (94.72–100.00%)	–	–

Table 3 Sensitivity, specificity, NPV, PPV and diagnostic accuracy of tympanometry taking CO score as standard

	Tympanometry				
	Sensitvity	Specificity	NPV	PPV	Diagnostic Accuracy
1st visit (n = 75)	94.67% (86.90–98.53%)	–	–	100% (94.94–100.00%)	–
2nd visit (n = 72)	97.44% (86.52–99.94%)	27.27% (13.30–45.52%)	90.00% (55.50–99.75%)	61.29% (48.07–73.40%)	65.28%
3rd visit (n = 71)	100.00% (29.24–100.0%)	55.88% (43.32–67.92%)	100.00% (90.75–100.00%)	9.09% (1.92–24.33%)	57.75%
4th visit (n = 71)	–	88.73% (79.0–95.01%)	100.00% (94.31–100.00%)	–	–

Table 4 Correlation of tympanogram with video-otoendoscopy (OM grade) at each visit

Tympanogram at 1st visit	OM grade at 1st visit		*P* value	Kappa
	Normal(n = 4)	Disease(n = 71)		
Normal	2 (50%)	2 (2.82%)	0.013	0.472
Disease	2 (50%)	69 (97.18%)		
Tympanogram at 2nd visit	OM grade at 2nd visit		*P* value	Kappa
	Normal (n = 19)	Disease(n = 53)		
Normal	8 (42.11%)	2 (3.77%)	0.0002	0.452
Disease	11 (57.89%)	51 (96.23%)		
Tympanogram at 3rd visit	OM grade at 3rd visit		*P* value	Kappa
	Normal (n = 59)	Disease(n = 12)		
Normal	38 (64.41%)	0 (0%)	< .0001	0.380
Disease	21 (35.59%)	12 (100%)		
Tympanogram at 4th visit	OM grade at 4th visit		*P* value	Kappa
	Normal (n = 68)	Disease(n = 3)		
Normal	63 (92.65%)	0 (0%)	0.001	0.516
Disease	5 (7.35%)	3 (100%)		

showed the best sensitivity, 88.0%, and best specificity, 89%.

We found that Tympanogram was type B in 93.33% of patients in first visit and type A in 5.33% of patients in first visit. This correlated well with the study done by Groothius et al. [12] who found that at the time of diagnosis of AOM, 87% of tympanograms were type B.

Renko et al. [13] found normal tympanograms after a median time of 7.5 days (range 1–58 days) among 75 successfully monitored patients. This correlated well with our study where we found normal tympanograms in 53.52% patients after 10 days and in 88.73% patients after 17–21 days.

We found tympanometry to have a sensitivity of 94.67% and PPV 100% on the 1st visit. Tympanometry had a sensitivity of 97.44%, specificity of 27.27%, PPV 61.29%, NPV 90% on the 2nd visit and a sensitivity of 100%, specificity of 55.88%, PPV 9.09%, NPV 100% on the 3rd visit. While,the specificity on the 4th visit was 88.73% along with NPV 100% (Tables 3, 4).

The tympanic membranes categorized as diseased by OM grade at 1st visit had significantly higher chances of tympanogram B/C at 2nd visit (Table 5).

Table 5 Univariate logistic regression to find out the relationship of OM grade at 1st visit with findings of tympanogram at 2nd visit, 3rd visit and 4th visit and the relationship of tympanogram at 1st visit with findings of OM grade at 2nd visit, 3rd visit and 4th visit

Variable	*P* value	Odds ratio
OM grade at 1st visit with findings of tympanogram at 2nd visit		
Normal		1.000
Diseased	0.011	19.139
OM grade at 1st visit with findings of tympanogram at 3rd visit		
Normal		1.000
Diseased	0.497	2.136
OM grade at 1st visit with findings of tympanogram at 4th visit		
Normal		1.000
Diseased	0.883	1.286
Tympanogram at 1st visit with findings of OM grade at 2nd visit		
Type A		1.000
Type B	0.298	2.943
Tympanogram at 1st visit with findings of OM grade at 3rd visit		
Type A		1.000
Type B	0.677	2.027
Tympanogram at 1st visit with findings of OM grade at 4th visit		
Type A		1.000
Type B	0.683	0.488

According to the p values we can draw the conclusion that changes due to AOM or OME in tympanometry as well as video-otoendoscopy are most evident on the 1st and 2nd visit.

This implies that otoendoscopy detects AOM/OME before tympanometry and can therefore diagnose it earlier. Thus, if there is an abnormal otoendoscopic image on the 1st visit then there are high chances that the tympanogram obtained on the next visit will be abnormal as well. Whereas, a normal tympanogram could not completely rule out the presence of effusion.

Our findings correlate well with the studies done by Bluestone, Beery and Paradise [14] who found that in 59 ears with type B tympanograms effusions were found in 49 ears (83%), Fiellau-Nikolajsen et al. [15] who found a nearly 100% correlation between a flat tympanogram and the presence of MEE as well as Groothuis et al. [12] who found that Type A tympanograms correlated well with normal otoscopic findings in 92% cases and Type B tympanograms were associated with abnormal otoscopic findings in 93% of cases. Smith et al. [16] found MEE in 80.2% patients with Type B tympanograms. Helenius et al. [17] found that Flat (type B) tympanogram was related to otitis media with effusion in 44% and to acute otitis media in 56% of examinations, respectively.

We found that tympanometry had a higher overall Sensitivity than video- otoendoscopy. While, video-otoendoscopy showed a higher specificity than Tympanometry. Thus, tympanometry is good for catching actual cases of OME but it also comes with a fairly high rate of false positives. Whereas, Otoendoscopy is superior at early diagnosis of AOM/OME but cannot rule out persisting MEE. This shows that while tympanometry is a good tool for detecting residual or persisting MEE but it cannot differentiate between AOM and OME. Also, tympanometry alone cannot determine the presence or absence of acute middle ear infections.

Conclusion

Our study found that there is good correlation between tympanometry and video-otoendoscopy. Otoendoscopy remains superior to tympanometry in detecting AOM. On the other hand, tympanometry is more precise in detecting the presence or absence of MEE.

It also shows that tympanometry plus otoendoscopy together greatly increase the chances of detecting AOM and OME. Using both these modalities together:

1. Reduces overdiagnosis and unnecessary treatment. Increases the probability of correct diagnosis of other conditions with symptoms that otherwise could be attributed to AOM.
2. Improve diagnostic accuracy
3. Reduces financial costs associated with misdiagnosis
4. Promote consistency in diagnosis

5. Helps in monitoring and documentation of the progression of the disease process for patients being considered for surgical treatment.

Thus we can conclude that instead of using only otoscopy for diagnosing AOM or OME, we should utilize both otoendoscopy as well as tympanometry at the first visit itself for early diagnosis of AOM and early detection of MEE before development of any sequalae which can be missed if these modalities are not used.

Our study had certain limitations such as a small sample size because of the limited OPD operations due to COVID-19 pandemic as well as a higher faith in alternative medicine which leads to several drop-outs.

Declarations

Conflict of interest There are no conflicts of interest.

Ethical Approval The study was approved by the Institutional Ethics Committee.

References

1. Johansen EC, Lildholdt T, Damsbo N, Eriksen EW (2000) Tympanometry for diagnosis and treatment of otitis media in general practice. Fam Pract 17(4):317–322
2. Lundberg T, Biagio L, Laurent C, Sandström H, Swanepoel DW (2014) Remote evaluation of video-otoscopy recordings in an unselected pediatric population with an otitis media scale. Int J Pediatr Otorhinolaryngol 78(9):1489–1495
3. Feldman AS (1976) Tympanometry: application and interpretation. Ann Otol Rhinol Laryngol 85:202–208
4. Dagan R D, Leibovitz E, Greenberg D (1998) Early eradication of pathogens from middle ear fluid during antibiotic treatment of acute otitis media is associated with improved clinical outcome. Pediatr Infect Dis J
5. Niemela M, Uhari M, Jounio-Ervasti K, Luotonen J, Alho OP, Vierimaa E (1994) Lack of specific symptomatology in children with acute otitis media. Pediatr Infect Dis J 13(9):765–768
6. Rothman R, Owens T, Simel DL (2003) Does this child have acute otitis media? JAMA 290(12):1633–1640
7. Karma PH, Penttilä MA, Sipilä MM (1989) Otoscopic diagnosis of middle ear effusion in acute and non-acute otitis media. I. The value of different otoscopic findings. Int J Pediatric Otorhinolaryngol 17(1):37–49
8. McCormick DP, Elizabeth L-M, Kokab S (2000) Otitis media: can clinical findings predict bacterial or viral etiology? Pediatric Infect Dis J 19(3):256–258
9. Takata GS, Chan LS, Morphew T, Mangione-Smith R, Morton SC, Shekelle P (2003) Evidence assessment of the accuracy of methods of diagnosing middle ear effusion in children with otitis media with effusion. Pediatrics 112(6 Pt 1):1379–1387
10. Lee D-H, Yeo S-W (2004) Clinical diagnostic accuracy of otitis media with effusion in children, and significance of myringotomy: diagnostic or therapeutic? J Korean Med Sci 19(5):739–743
11. Rogers DJ, Boseley ME, Adams MT, Makowski RL, Hohman MH (2010) Prospective comparison of handheld pneumatic otoscopy, binocular microscopy, and tympanometry in identifying middle ear effusions in children. Int J Pediatr Otorhinolaryngol 74(10):1140–1143
12. Groothuis JR, Sell SH, Wright PF, Thompson JM, Altemeier WA (1979) Otitis media in infancy: tympanometric findings. Pediatrics 63(3):435–442
13. Renko M, Kontiokari T, Jounio-Ervasti K, Rantala H, Uhari M (2006) Disappearance of middle ear effusion in acute otitis media monitored daily with tympanometry. Acta Paediatr 95(3):359–363
14. Bluestone CD, Beery QC, Paradise JL (1973) Audiometry and tympanometry in relation to middle ear effusions in children. Laryngoscope 83(4):594–604
15. Fiellau-Nikolajsen M (1983) Tympanometric prediction of the magnitude of hearing loss in preschool-children with secretory otitis media. Scand Audiol Suppl 17:68–72
16. Smith CG, Paradise JL, Sabo DL, Rockette HE, Kurs-Lasky M, Bernard BS et al (2006) Tympanometric findings and the probability of middle-ear effusion in 3686 infants and young children. Pediatrics 118(1):1–13
17. Helenius KK, Laine MK, Tähtinen PA, Lahti E, Ruohola A (2012) Tympanometry for discrimination of otoscopic diagnoses in young ambulatory children. Pediatric Infect Dis J 31(10):1003–1006