

The role of multifrequency tympanometry in otitis media

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ABSTRACT

Objectives: To evaluate the diagnostic value of multifrequency tympanometry in otitis media with effusion and adhesive otitis media.

Methods: We selected 50 patients with long standing or recurrent attacks of otitis media with effusion from the outpatient clinic of the Ears, Nose and Throat (ENT) Department, Sohag Medical School, Egypt between May 2002 and December 2002. A control group was also selected, consisting of 25 patients with normal hearing levels and with no history of ENT problems. We conducted full audiological investigations in the form of pure tone audiometry, speech audiometry and immittanceometry. Immittanceometry included low probe tone frequency and multifrequency tympanometry. Each subject in the study

group had undergone myringotomy and examination under microscope to decide if the case had either otitis media with effusion or adhesive otitis media.

Results: Resonant frequency proved to have the best performance in reflecting middle ear pathology. It was lowest in otitis media with effusion with a mean value of 428 ± 159 Hz and it was highest in adhesive otitis media with a mean of 1336 ± 230 Hz.

Conclusion: Multifrequency tympanometry has an efficacy of 100% in the diagnosis of otitis media with effusion and 70% in the diagnosis of adhesive otitis media.

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Tympanometry has become a routine in otological evaluation since early 1970s.¹ It has been used in detecting middle ear diseases by the measurements of the aural acoustic immittance at the tympanic membrane as a function of the ear canal pressure within the external auditory meatus. Most of the commercial instruments offer a single low probe tone (226 Hz) for evaluating the acoustic immittance of the ear. At this low frequency probe tone (226 Hz), the compliance or stiffness elements are the main contributors to the admittance measured in the ear canal.² Previous study by Lilly³ states that low frequency tympanometry could provide useful diagnostic information for patients with disorders of the tympanum (effusion), for patients with disorders of the tympanic membrane

(atrophic scarring, retraction or perforation), and for patients with eustachian tube dysfunction. However, it is relatively insensitive to many lesions that affect the tympano-ossicular system. Moreover, it gives the same tympanometric pattern for different pathologies. Middle ear effusion, malleus fixation, and tympanic membrane perforation sealed with cholesteatoma give similar flat tympanograms. Conversely, the same middle ear pathology may give different tympanometric patterns. For example, middle ear effusion gives a flat tympanogram, but it may produce a broadly notched tympanogram.

To overcome this problem, several studies have discussed the possible advantage of using probe tone frequencies closer to the resonance of the tympanic

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membrane and middle ear.⁴ Shanks and Shelton² reported that the higher frequency probe tone, closer to the resonant frequency of the middle ear, the higher sensitivity in the diagnosis of middle ear pathologies and therefore could be more beneficial than the 226 Hz tone in evaluating the middle ear transmission system. Colletti⁵ was the first who stated that the multifrequency tympanometric investigation is superior to mono frequency tympanometric investigation in detecting small changes in the transmission characteristics of the tympano-ossicular system. A tympanogram measured at the resonance frequency will often show the characteristic deep notch around peak pressure.

Margolis and Goycoolea⁶ considered that the most potentially useful measure that could be extracted from multifrequency tympanometry is the resonant frequency of the middle ear. Resonance occurs at the frequency at which stiffness and mass elements of the ear are in balance or at which the phase angle of the middle ear admittance is 0 degree.

The predictive value of tympanometry is well established in otitis media with effusion.^{7,8} Otitis media is a world wide child health problem, particularly among infants and young children. It is characterized by collection of non purulent fluid in the middle ear cavity.⁹ The most frequent complications are adhesive otitis media, tympanosclerosis and cholesteatoma. Conductive hearing loss is an important audiological complication. In some cases, sensorineural hearing was also reported,^{10,11} leading to delayed speech and language development and scholastic under achievement.¹²

We designed this study to evaluate the diagnostic value of multifrequency tympanometry in otitis media with effusion and adhesive otitis media.

Methods. Fifty patients with long standing or recurrent attacks of otitis media with effusion were selected from the outpatient clinic of Ears, Nose and Throat (ENT) Department, Sohag Medical School, Egypt between May 2002 and December 2002. They had no history of aural discharge. A control group, 25 relatives of the patients, was selected with normal hearing levels and with no history of ENT problems.

Equipment used were otoscope with Siegle pump (Welch Allyn), sound-treated room, computerized 2 channel pure tone audiometer (Madsen model, Orbter 922) and digital impedancemeter virtual model, 310 (Multifrequency tympanometer).

A full medical history was taken from all patients and controls included trauma to the ear (physical or acoustic), aural discharge, intake of ototoxic drugs,

ear operations, diabetes, hypertension and family history of hearing loss.

A full ENT examination was carried out with emphasis in otological examination. Full audiological investigations were conducted in the form of pure tone audiometry, speech audiometry and immittancemetry. Immittancemetry included low probe tone frequency and multifrequency tympanometry.

The low probe tone frequency of 226 Hz was performed under the following parameters: 1. Sweep pressure from negative to positive (-300 to +250 da pa). 2. Fast sweep rate at 125 da pa per second. Multifrequency tympanograms was performed from 250 - 2000 Hz with 1/6 octave increments.

The first curve, which showed W notching was provided an estimate of resonant frequency. Acoustic reflex thresholds using pure tones at frequencies 500,1000 and 4000 Hz were also estimated.

Each subject in the study group had undergone myringotomy and examination under microscope to decide if the case had either otitis media with effusion or adhesive otitis media.

Statistics used for evaluation was the Statistical Package for Social Sciences under windows, t-test, correlation coefficient and calculation of mean and standard deviation

Results. The 25 patients in the control group, have normal hearing levels. Their age ranged between 2.5 and 45 years with a mean age of 19 years. According to Jerger's system, 44 ears had type A tympanogram and 6 ears had type As tympanogram and all of them had normal acoustic reflex thresholds. **Table 1** shows the values of their resonant frequency, which ranged from 710 - 1250 Hz. The mean of their resonant frequency was 948 Hz and their standard deviation was 120 Hz.

In the 50 patients previously selected, 94 ears with middle ear pathology was subdivided according to history, otological examination and operative findings under 2 subgroups. In subgroup A, 71 ears had otitis media with effusion. All 71 ears in this subgroup had type B flat tympanogram. The range of resonant frequency was 350 - 700 Hz with a mean of 428 Hz and standard deviation of 159 Hz. There was a highly statistical significant difference between the resonant frequency of the control group and subgroup A.

In subgroup B, 23 ears had adhesive otitis media, in which 16 of these ears had type B tympanogram and 7 ears had type As tympanogram. **Table 2** shows the values of resonant frequency in this subgroup. The range of resonant frequency was between 950 - 1800 Hz with a mean of 1336 Hz and a standard deviation

Table 1 - Values of resonant frequency of control group.

Case	Resonant frequency		Case	Resonant frequency	
	Right Ear	Left Ear		Right Ear	Left Ear
1	1000	1120	14	1000	800
2	1000	1120	15	900	1000
3	710	800	16	900	1000
4	900	1250	17	1000	1100
5	750	810	18	850	900
6	910	1000	19	950	850
7	1000	1100	20	710	800
8	800	850	21	950	1000
9	1120	1200	22	850	900
10	900	850	23	1000	1050
11	900	910	24	950	1020
12	1000	950	25	850	950
13	1000	1120			

Table 2 - Values of resonant frequency of subgroup B.

Case	RF	Case	RF	Case	RF
1	900	9	1400	17	1400
2	1000	10	1300	18	1300
3	1400	11	1300	19	1300
4	1500	12	1400	20	1500
5	1400	13	1250	21	1100
6	1200	14	1800	22	950
7	1120	15	1800	23	1400
8	1400	16	1600		
RF - resonant frequency					

Table 3 - Percentage of overlap in resonant frequency between control group and subgroup B.

Variables	RF
Range of resonant frequency in control group	710-1250 Hz
Subgroup B cases which their RF lies in control range	7 cases
Percentage of overlap	30.5%
Efficacy of multifrequency tympanometry in the diagnosis of adhesive OM	70%
RF - resonant frequency, OM - otitis media	

of 230 Hz. There was a highly statistical significant difference between the resonant frequency of the control group and subgroup B. **Table 3** shows the percentage of overlap in resonant frequency between control group and subgroup B.

Discussion. Tympanometry is used routinely in audiological practice for assessment of middle ear disorders. Most of the available tympanometric data have been generated with instruments that measure immittance magnitude at single low frequency probe tone 226 Hz. This instrument is relatively insensitive to many lesions that affect the tympano-ossicular system. In a study about the effect of otitis media on middle ear mechanics on 70 children, Vlachou et al¹³ found abnormal values of multifrequency tympanogram despite the normal findings of conventional tympanogram. A normal-appearing tympanic membrane does not exclude the possibility of middle ear pathology and multifrequency tympanometry can help in these cases.¹⁴ Multi-frequency tympanometry detects some middle ear pathologies that are not detected by conventional 226 Hz tympanometry.¹⁵ Therefore, we have this study to highlight the ability

of the recent tool of multifrequency tympanometry in adding a more useful diagnostic information about the nature of the pathology of the middle ear for patients with conductive hearing loss.

In the normal control ears, the resonant frequency ranged between 710 - 1250 Hz. This data are agreeing with the results obtained by Colletti et al¹⁶ in 1993 and Colletti^{5,17} in 1975 and 1976. Other studies also reported a narrower range (800 - 1250 Hz).^{2,3,6,18} On the other hand, Valvik et al⁴ reported a wider range from 350 - 1750 Hz.

In our otitis media with effusion cases, the mean of the resonant frequency was 428 Hz. This complements the results reported by many authors.^{2,4,6,7,16,18} Kontrogianni et al¹⁹ found that there is a significant decrease in resonant frequency values in ears with otitis media with effusion. This finding could be attributed to an increase in the mass of the middle ear transmission system with subsequent decrease in middle ear resonant frequency.

In our adhesive otitis media cases, the mean of the resonant frequency was 1336 Hz. This agrees the results reported by Margolis and Goycoolea in 1993.⁶

This finding could be correlated to an increase in stiffness of middle ear with a subsequent increase in its resonant frequency.

Observation of the previous data revealed the extent which multifrequency tympanometry can be relied upon to diagnose otitis media with effusion and adhesive otitis media. The efficacy of multifrequency tympanometry in the diagnosis of otitis media with effusion is 100% and 70% in diagnosis of adhesive otitis media. It also helps in decision making in cases with flat type B tympanogram whether to continue the medical treatment if the resonant frequency increases to approach normal values or to shift to surgical treatment if resonant frequency decreases on follow up or stays far below normal.

In conclusion, multifrequency tympanometry is a reliable and sensitive method for the diagnosis of middle ear disorders. The resonant frequency in otitis media with effusion is lower than normal while that of adhesive otitis media are higher than normal.

References

1. ASHA (American Speech Language Hearing Association): Tympanometry. *J Speech Hear Disord* 1988; 53: 354- 377.
2. Shanks J, Shelton C. Basic principles and clinical applications of tympanometry. *Otolaryngol Clin North Am* 1991; 24: 299-328.
3. Lilly DJ. Multiple frequency, multiple component tympanometry: New approaches to an old diagnostic problem. *Ear Hear* 1984; 5: 300-308.
4. Valvik BR, Johnsen M, Laukli E. Multifrequency tympanometry: preliminary experiences with a commercially available middle – ear analyzer. *Audiology* 1994;33:245-253.
5. Colletti V. Tympanometry from 200 to 2000 Hz probe tone. *Audiology* 1976; 15: 106-119.
6. Margolis RH, Goycoolea HG. Multifrequency tympanometry in normal adults. *Ear Hear* 1993; 14: 408-413.
7. Nozza RJ. Critical issues in acoustic immittance screening for middle ear effusion. *Semin Hear* 1995; 16: 86- 97.
8. Gates G, Avery C, Cooper J, Hearbe EM, Holt G. Predictive value of tympanometry in middle ear effusion. *Ann Otol Rhinol Laryngol* 1986; 95: 46-50.
9. Bluestone CD. Recent advances in otitis media with effusion. *Ann Otol Rhinol Laryngol* 1980; 89: 180-186.
10. Harada T, Yamasoba T, Yagi M. Sensorineural hearing loss associated with otitis media with effusion. *ORL: Journal of Otorhinolaryngology and Related Species* 1992; 54: 61- 65.
11. Tos M, Stangerup SE, Holm-Jensen S, Sorenson CH. Spontaneous course of secretory otitis media and changes of the ear drum. *Arch Otolaryngol Head Neck Surg* 1984; 110: 281- 289.
12. Paparella MM, Goyococlea MV, Meyerhoff WI. Inner ear pathology and otitis media. A review. *Ann Otol Rhinol Laryngol* 1980; 89 (Suppl 68): 249- 253.
13. Vlachou SG, Tsakanikos M, Douniadakis D, Apostolopoulos N. The change in the acoustic admittance phase angle: a study in children suffering from acute otitis media. *Scand Audiol* 2001; 30: 24-25.
14. Jaisinghani VJ, Paparella MM, Schachern PA Le. Tympanic membrane / middle ear pathologic correlates in chronic otitis media. *Laryngoscope* 1999; 109: 712-716.
15. Margolis RH, Schachern PL, Fulton S. Multi-frequency tympanometry and histopathology in Chinchillas with experimentally produced middle ear pathologies. *Acta Otolaryngol* 1998; 118: 216-225.
16. Colletti V, Fiorino G, Sittoni V, Policante Z. Mechanics of the middle ear in otosclerosis and stapedectomy. *Acta Otolaryngol (Stockh)* 1993; 113: 637- 641.
17. Colletti V. Methodologic observation on tympanometry with regard to probe tone frequency. *Acta Otolaryngol (Stockh)* 1975; 80: 54-60.
18. Shanks JE, Lilly DL, Margolis RH, Wiley TL, Wilson R. Tympanometry: A tutorial (ASHA working group on aural acoustic immittance Measurements of the committee on audiologic evaluation). *J Speech Hear Disord* 1988; 53: 354-377.
19. Kontrogianni A, Ferekidis E, Mtouniadakis E, Psarommatis I, Apostolopoulos N, Adamopoulos G. Multi-frequency tympanometry in children with otitis media with effusion. *ORL J Otorhinolaryngol Relat Spec* 1996; 58: 78- 81.