Otoacoustic Emissions in Otitis Media with Effusion: Do They Carry any Clinical Significance?

J. S. Thakur · Ishan Chauhan · N. K. Mohindroo · D. R. Sharma ·
R. K. Azad · M. S. Vasanthalakshmi

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Abstract Otoacoustic emissions have been advocated in the management of otitis media with effusion. However, otoacoustic emissions cannot differentiate different types of hearing loss. This study was conducted to find factor that can differentiate otitis media with effusion from other common causes of hearing loss in children. Children were enrolled in the study and divided in four groups consisting of 25 ears each after pure tone and impedance audiometry: (1) Otitis media with effusion group, (2) Normal ear group, (3) Sensory-neural hearing loss group, (4) Chronic suppurative otitis media group. Otoacoustic emissions were recorded and results were analyzed statistically. The normal hearing group had significant difference from other groups but total band reproducibility of transient evoked otoacoustic emissions did not show any statistical difference in the cases groups. In distortion product otoacoustic emissions, group 1 showed significant difference from group 3 and group 1 had significant difference from all other groups at 4 kHz. The study did not find any factor that differentiates otitis media with effusion from other diseases. Although, distortion product otoacoustic emissions can indicate otitis media with effusion but impedance audiometry should be the main tool in the management of otitis media with effusion.

Keywords Otoacoustic emission · Otitis media · Effusion · Hearing loss

Introduction

Otoacoustic emissions were described by Kemp in 1978 [1]. They are detected by a hand-held tool (commonly known as OAE) that provides objective test of hearing. Otoacoustic emissions have advantages of objectivity, noninvasiveness and specificity to record the mechanical activity of outer hair cells present in the organ of corti [2]. These characteristics have made OAE extremely useful in neonatal and school-age children screening programs [3].

Otitis media with effusion (OME) is the commonest cause of hearing loss in children [4]. As otoacoustic emissions represent normal outer hair cells, middle ear effusion (MEE) can impair the transmission of these emissions. Recently, number of publication appeared in literature recommending OAE in the management of OME [5–11].

It has been well established that otoacoustic emissions are absent in hearing loss above 30 dB [12]; and hence this hearing loss can be easily detected on OAE. However, OAE cannot detect the type of hearing loss or disease responsible for this hearing loss. In operative patients, hearing status can be influenced by other factors (e.g. eustachian tube blockade, drug induced toxicity) moreover, hearing improvement cannot be quantified which can lead to legal issues. It is therefore; this prospective and randomized study was conducted to find factor(s) that can differentiate otitis media with effusion from other common causes of hearing loss in children.

J. S. Thakur (✉) · I. Chauhan · N. K. Mohindroo ·
D. R. Sharma · R. K. Azad
Department of Otolaryngology-Head and Neck Surgery,
Indira Gandhi Medical College, Shimla 171001, HP, India
e-mail: anujagdeep@yahoo.co.in

M. S. Vasanthalakshmi
Department of Speech, Language and Pathology,
All India Institute of Speech and Hearing, Mysore 570 006,
Karnataka, India

Materials and Methods

This prospective, randomized study consisted of children in the age group of 6–18 years. The subjects were enrolled in the study after IRB approval and informed consent.

All subjects had detailed history evaluation and clinical examination. They were subjected to audiological evaluation in the sound proof room situated in the department. Pure tone audiometry was done with AC 40 Clinical Audiometer (Inter Acoustics A/S, Assens, Denmark). Tympanometry was performed using the Interacoustics DK-5610 impedance tympanometer (Interacoustics A/S, Assens, Denmark). A frequency of 226 Hz was used, at 85 dB SPL with pressure recording from −400 to +200 dapa. The modified Jerger classification for type A, B and C tympanograms was used.

Based on the clinical examination and audiometry, the subjects were divided into four groups consisting of 25 ears each and none of the group had any common subject.

Group 1 consisted of 25 ears diagnosed as OME on impedance audiometry. This group had 16 subjects with mean age of 11.16 years, and mean hearing threshold of 34.96 dB on PTA. Ten ears had ‘B’ type graph and other had ‘C’ type graph on impedance audiometry.

Group 2 consisted of 25 ears with normal ear as control. It consisted of 15 subjects with mean age of 11.92 years, and mean hearing threshold of 15.64 dB on PTA. All ears had ‘A’ type graph on impedance audiometry.

Group 3 consisted of 25 ears with sensory-neural hearing loss (SNHL). This group had 14 subjects with mean age of 10.9 years, and mean hearing threshold of 63.2 dB on PTA. All cases had ‘A’ type graph on impedance audiometry.

Group 4 consisted of 25 ears suffering with chronic suppurative otitis media (CSOM) with conductive hearing loss only. Subjects of CSOM with mixed hearing loss were excluded from this group. This group had 15 subjects with mean age of 11.4 years, and mean hearing threshold of 39.7 dB on PTA.

Subjects with any history known for causing hearing loss were excluded from group 1 and 2.

After assigning the group to a subject, otoacoustic emission testing was done with a GSI audioscreener+ (VIASYS NeuroCare, Madison, USA) to assess distortion product otoacoustic emissions (DPOAEs) and transient evoked otoacoustic emissions (TEOAEs). Total Band Reproducibility (TBR) in TEOAEs and Signal Noise Ratio (SNR) in DPOAEs were considered to analyze the results. A pass or refer result for each frequency band is based first on the presence or absence of a DPOAEs and TEOAEs and second on the absolute level of the DPOAEs and TEOAEs in dB SPL.

Statistical Analysis

The data was analyzed separately for TBR and SNR in the following stages and $p < 0.05$ was considered significant.

1. Mixed ANOVA (Repeated Measure ANOVA for comparison of frequencies with group as independent factor) to study the overall effect of group, frequency and interaction between groups and frequencies
2. MANOVA to find out the effect of group within each frequency
3. Repeated MANOVA for the comparison of frequencies within each group

Results

TEOAEs

TEOAEs were found absent in 24 ears in group 1 while they were absent in all ears in group 3 and 4. TEOAEs were also found absent in 5 ears in group 2. Descriptive comparison of groups at various frequencies is provided in Fig. 1.

TBR (Table 1) In all groups, TBR decreased at 4 kHz as compared to 2 kHz. Mixed ANOVA showed no significant difference between frequencies ($p > 0.05$), and interaction between groups and frequencies ($p > 0.05$). There was significant difference between groups ($p < 0.001$) but Duncan’s post hoc test did not find any significant difference in OME cases from other diseased groups. Groups 1, 3 and 4 were found significantly different ($p < 0.05$) from group 2 (group 2 had higher TBR) on Duncan’s post hoc test.

MANOVA was administered to see the difference between groups within each frequency. It showed significant effect of group at each frequency level ($p < 0.001$). Duncan’s post hoc test showed that group 1, 3 and 4 were significantly different from group 2 ($p < 0.05$).

Fig. 1 Chart showing comparison of absent TEOAE at different frequencies in groups

Table 1 Descriptive statistics of total band reproducibility of TEOAE in groups

Frequency	Groups	Mean	Std. deviation	N
TBR2K	1	34.9480	28.19272	25
	2	74.8440	26.45377	25
	3	28.4920	18.72024	25
	4	29.6800	19.54299	25
TBR3K	1	36.8520	29.28138	25
	2	79.5200	25.12681	25
	3	25.8040	20.93505	25
	4	28.1280	21.73938	25
TBR4K	1	24.7680	20.12639	25
	2	69.7920	25.09271	25
	3	29.3360	15.98361	25
	4	23.6040	18.13899	25

Repeated Measure ANOVA showed no significant difference between frequencies in each group.

DPOAEs

DPOAEs were found absent in 20 ears in group 1 while they were absent in 21 ears in group 3 and 4. DPOAE were also found absent in one ear in group 2. Descriptive comparison of groups at various frequencies is provided in Fig. 2.

SNR (Table 2) Mixed ANOVA showed significant difference between frequencies ($p < 0.01$), interaction between groups and frequencies ($p < 0.01$), and significant difference between groups ($p < 0.001$). Bonferroni's multiple comparison test found significance ($p < 0.01$) at 3 and 4 kHz in all group pairs. Duncan's post hoc test showed that group 1, 3 and 4 were significantly different from group 2 ($p < 0.05$), and significant difference also existed between group 1 and group 3 ($p < 0.05$).

MANOVA was administered to see the difference between groups within each frequency. It showed significant

Table 2 Descriptive statistics of signal noise ratio of DPOAE in four groups

Frequency	Groups	Mean	Std. deviation	N
2K	1	3.3520	6.97365	25
	2	20.7160	8.55330	25
	3	1.5040	4.54152	25
	4	0.9600	5.21696	25
3K	1	2.0000	7.70682	25
	2	20.8240	7.71218	25
	3	−0.7840	6.35162	25
	4	0.7800	5.28126	25
4K	1	5.5760	11.43953	25
	2	27.2720	9.09233	25
	3	−0.6080	3.63993	25
	4	1.0696	5.21468	25

effect of group at each frequency level ($p < 0.001$). Duncan's post hoc test showed that group 1, 3 and 4 were significantly different ($p < 0.05$) from group 2 at 2 and 3 kHz. There was no significant difference between group 3 and group 4 but other group pairs were significantly different ($p < 0.05$) at 4 kHz.

Repeated Measure ANOVA to study the effect of frequency within each group found no significant difference between frequencies in group 1, 3 and 4 but it showed significant effect of frequency in group 2. Bonferroni's multiple comparison test showed significant difference between (2 and 4 kHz) and (3 and 4 kHz) in group 2 ($p < 0.01$).

Discussion

Otoacoustic emissions are generated by outer hair cells in the cochlea and represent normal physiological functions of the outer hair cells. These have been divided into spontaneous and evoked otoacoustic emissions. Spontaneous otoacoustic emissions are present in half of the normal individuals while evoked otoacoustic emissions are detected in almost all normal hearing individuals [12]. Few authors stated that the middle ear effusion acting as shield reduces the transmission [9, 13, 14] although this is still debatable. It has been found that positive and negative middle ear pressures significantly attenuate the amplitude of evoked emissions below 2 kHz, whereas high frequency emissions remain stable [14–17]. In our opinion, perforation of tympanic membrane should also increase the transmission of emission through middle ear. Ueda et al. [18] conducted an animal experimental study to know the effect of fluid in the middle ear and tympanic perforation on otoacoustic emissions. They concluded that otoacoustic

Fig. 2 Chart showing comparison of absent DPOAE at different frequencies in study groups

emissions are affected only if more than half of middle ear space is filled with fluid and the size of tympanic perforation directly influence the otoacoustic emissions. Le-Bourgeois et al. [19] found similar results in another animal experimental study. In the present study, we did not evaluate effect of size of tympanic membrane perforation on the otoacoustic emissions. We found that although tympanic membrane perforation had significant difference from the normal ear but there was no statistical significant difference from OME and SNHL cases.

In this study, all diseased groups had statistical difference between them on TEOAEs but Duncan post hoc test did not confirm this statistical significance although, these groups were significantly different from normal cases even on Duncan post hoc test. Similarly, all group had statistical difference in all frequencies but Bonferroni's multiple comparison test found statistical significance ($p < 0.01$) at 3 and 4 kHz only. Duncan post hoc test showed that OME group was significantly different ($p < 0.05$) from SNHL and normal hearing groups only. The OME group showed statistical significant difference ($p < 0.05$) from all other groups at 4 kHz on DPOAEs.

In the present study, TEOAE did not show any statistical significant difference of SNHL group from OME and CSOM but OME group had statistical significant difference from other groups on DPOAEs at 4 kHz. It means DPOAEs can differentiate OME from other diseases of hearing loss. This interpretation supports a study by Tas et al. [7] who evaluated DPOAEs in pre-operative and post-operative cases of MEE and advocated DPOAEs in the management MEE. Dragicovic et al. [11] conducted a similar study of TEOAE in pre-operative and post-operative cases of OME, and advocated use of TEOAEs in such cases. Chang et al. [5] evaluated the effect of OME on TEOAEs, and they suggested that TEOAEs could indicate OME if band reproducibility and echo amplitude on spectral analysis are analyzed. The present study did not find any TEOAE factor differentiating OME from other common childhood hearing diseases.

On reviewing the literature, we found that all studies have evaluated either TEOAEs or DPOAEs in OME, and none studied them simultaneously. Review of these studies resulted confusion rather than defining the investigation of choice (TEOAEs or DPOAEs) in OME. TEOAEs has been studied enormously and found clinical significance with limited role of DPOAEs [12]. In the present study, DPOAEs appeared better than TEOAEs in differentiating OME from other diseases. Probst [20] compared TEOAEs with DPOAEs in 83 subjects and found that DPOAEs were present more often than TEOAEs when hearing levels across the frequency were greater than 30 dB hearing level which was comparative to our study.

There are number of publications on the role of OAE in OME in the last decade and researchers have advocated the use of OAE in the OME. Our study showed that hearing impaired groups had statistically significant difference from normal hearing group in both TEOAEs and DPOAEs however; OME group had no significant difference from SNHL or CSOM group (except at 4 kHz on DPOAEs). Therefore, OAE cannot differentiate the type of hearing loss, and this contradicts earlier publication advocating the role of TEOAE in OME. Plinkert et al. [16] also stated that reduction of late OAE responses (low frequencies) could be due either to a frequency-dependent alteration of the middle ear transfer function or an inner ear hearing loss. Therefore, impedance audiometry should be performed to differentiate between these two different disorders.

Conclusion

OAE has indispensable role in hearing screening but exact characterization of hearing loss needs other audiological tests. In this study, Signal noise ratio of DPOAE in OME had statistical significant difference at 4 kHz. Further research analyzing all the parameters (TBR, SNR and amplitude) of TEOAEs and DPOAEs, is needed to find the exact role of OAE in OME

Conflict of interest None

Financial Disclosure None

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