Original Article

Evaluation of the Myringosclerotic Tympanic Membrane with Wideband Tympanometry

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Abstract

Objective: The purpose of this study is to evaluate the effects of myringosclerosis (MS) localized to the tympanic membrane (TM) on the mechano-acoustics of hearing using wideband tympanometry (WBT). **Materials and Methods:** In this prospective case-controlled study, 86 ears of 54 patients who were found to have MS localized to the TM were compared to 40 healthy eardrums in 20 patients. Thirty-seven ears which had a MS ratio to the whole TM of <25% were classified as Group 1, 33 ears with a ratio of 25%–50% were classified as Group 2, and 16 ears with a ratio of >50% were classified as Group 3. Peak acoustic compliance, resonant frequency (RF), and frequency-specific absorbance results of WBT were compared among the MS groups and the control group. **Results:** When the amplitudes of peak acoustic compliance of the MS groups and control group were compared, the MS groups were found to have lower amplitudes, and the difference was statistically significant ($P < 0.05$). There was no difference in frequency-specific absorbance values (250, 500, 1000, 2000, 4000, 8000, and 375–2000 Hz averaged absorbance) among the groups ($P > 0.05$). The RF of Groups 1, 2, and 3 were 1062, 1154, and 1166 Hz, respectively, and the RF of the control group was 1077 Hz. There was no significant difference among the groups with regard to resonant frequencies. **Conclusion:** This study showed that although MS localized to the TM decreased the amplitude of peak acoustic compliance of the tympanogram, it did not affect the RF or the wideband acoustic absorbance.

Keywords: Absorbance, acoustic impedance tests, myringosclerosis, tympanometry

Introduction

Myringosclerosis (MS) is characterized as hyaline degeneration and calcification of the tympanic membrane (TM) due to degeneration of collagen in the lamina propria of the TM.

MS formation can develop as a result of otitis media with effusion, chronic middle ear infection, and repeated bouts of acute otitis media, but it also can be secondary to myringotomy treatment and insertion of ventilation tubes.[1,2] Previous studies have shown that hearing loss caused by MS localized to the TM and not involving the middle ear structures is frequently insignificant and can be ignored.[3,4] However, once the foci of sclerosis involve structures of the middle ear and the condition is diagnosed as tympanosclerosis, it then causes conductive type hearing loss.[5]

Wideband tympanometry (WBT) testing was developed to evaluate the external ear canal and middle ear function using wideband frequencies. WBT (which includes absorbance and acoustic admittance) is measured in the external ear canal and enables analysis of the acoustic transfer functions of the ear canal and middle ear. The advantages of WBT include its short duration, a continuous broad frequency response between 0.25 and 8 kHz, the option to measure pressurized or ambient responses, and the ability to measure resonant frequency (RF).[6,7]

The term RF is used to define the frequency at which the stiffness and middle ear admittance are equal. At this frequency, the total susceptance value is equal to zero and the system vibrates at its natural frequency. The resistance is at a minimum at the RF and the entities of mass and compliance start to move at the same phase.[8,9]

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To the best of our knowledge, no other report in the literature has used WBT to study the changes in mechano-acoustics of the TM due to MS. Therefore, our aim was to use WBT to evaluate the effects of MS localized to the TM on the mechano-acoustics of hearing.

Materials and Methods

This study was approved by the local ethics committee (approval number: 2014/61). Written informed consent was obtained from the patients who participated in this study.

Subjects

The MS groups consisted of 86 ears of 54 patients who had MS detected on their TM during a routine ear, nose, and throat examination for any complaint other than otologic in the outpatient clinic and who had normal hearing thresholds in an audiogram. The patients were 25 male and 29 female aged between 14 and 65 years (mean age, 44 years). Patients with MS were divided into three groups according to the proportion of MS in the whole TM: Group 1 included 37 ears with <25% MS, Group 2 included 33 ears with 25%–50% MS, and Group 3 included 16 ears with >50% MS. Patients were excluded from the study if they had perforation, retraction, or atrophy of the TM, hearing loss or findings of chronic otitis media, or otitis media with effusion. The control group included 40 ears of 20 healthy volunteers, 10 men and 10 women, aged 21–58 years (mean age, 43 years). The controls presented at our clinic with no ear or hearing complaints; they had normal otoscopic findings, normal hearing thresholds, and a type A tympanogram.

Instrumentation

Pure tone audiometry tests were performed with an AC40 clinical audiometer (Interacoustics, Assens, Denmark) in a double-walled quiet cabin to evaluate the hearing thresholds of the participants.

All volunteers were evaluated based on the following measurements, obtained using the Titan WBT device (Interacoustics): 226 Hz tympanograms, RF, frequency-specific absorbance, 375–2000 Hz averaged absorbance, and maximum absorbance ratios. OtoAccess ver. 1.2.1 (Interacoustics) data recording software was used to record the data and calculate the outcomes.

Statistical evaluation

For statistical analysis, Statistical Package for Social Sciences (SPSS) for Windows 12.0 software was used (SPSS Inc., Chicago, IL, USA). The one-way ANOVA test was used for intergroup data assessments. The Games-Howell *post hoc* test was used to compare group data. Results were assessed at the 95% confidence level with statistical significance taken as $P < 0.05$.

Results

The groups did not differ significantly in terms of age or sex ($P > 0.05$). At 226 Hz tympanometry, all ears of all participants had a type A tympanogram according to the Jerger classification. The tympanometric evaluations of patients in groups are summarized in Table 1. The amplitudes of peak acoustic compliance indicated significantly lower amplitudes in the MS groups than in the control group ($P < 0.05$). Intergroup comparisons revealed significantly higher amplitudes in Group 1 compared to Groups 2 and 3 although no difference was noted between Groups 2 and 3. Tympanometric peak pressure values did not differ significantly among the groups.

The mean absorbance values of the groups are presented in Table 2. No statistically significant differences were detected among the MS groups or between the MS groups and control group with regard to values of frequency-specific absorbance, 375–2000 averaged absorbance, and maximum absorbance values ($P > 0.05$).

The measurements of the mean RF of the groups are summarized in Table 3. No statistically significant difference was detected between the groups in terms of RF ($P > 0.05$).

Discussion

MS, either localized to one part of the TM or widespread as a white plaque, is thought to form as a consequence of chronic inflammation.[10] The etiology and pathology of MS remain unclear, but the trauma caused by myringotomy and insertion of a tympanostomy tube is the most common cause of MS.[11] Tos *et al*.[2] have shown a rate of development of MS of 48% after insertion of a tympanostomy tube. A meta-analysis by Kay *et al*.[12] reported a MS rate of 32% after insertion of a ventilation tube. The accepted view on this matter is MS has no significant effect on hearing.[4,13] Tos and Stangerup[3] reported that MS due to insertion of a ventilation tube to the TM causes a 0.5–1 dB hearing loss at 250, 1000, and 4000 Hz and this can be ignored. During our search of the literature, we found very few studies that investigated the effect of MS, limited to the TM, on the mechano-acoustics of the middle ear. However, in the last couple of years, an increasing number of studies has focused on attempts to prevent the formation of MS on the TM.[14-19] Kazikdas *et al*.[20] showed a 50% decrease in the maximum admittance values after their experimental formation of MS on the TM. The values in our study are consistent with the results published in that study. In our study, the amplitudes of peak acoustic compliance were lower in the MS groups than in the control group and the difference was statistically significant.

WBT has become a popular diagnostic test in recent years. Many studies have investigated the efficiency of wideband acoustic absorbance in patients with normal and impaired hearing. Several studies have reported that WBT is more sensitive to middle ear dysfunction when compared with 226 Hz tympanometry.[21-23] In our previous study on otitis media with effusion, we reported that 0.375–2 kHz averaged mean absorbance rate obtained by measuring wideband acoustic tympanometry can identify the presence of middle ear effusion with 100% sensitivity and 94% specificity.[24] In the present study, we found no difference in the readings from wideband acoustic absorbance among the MS

Table 1: Comparison of tympanometric values in groups

	Group 1 (*n*=37)	Group 2 (*n*=33)	Group 3 (*n*=16)	Control (*n*=40)	*P*
Peak acoustic compliance (mL)	0.65±0.27 (0.3-1.3)	0.32±0.1 (0.1-0.7)	0.31±0.1 (0.1-0.6)	0.9±0.3 (0.3-2.1)	<0.05
Tympanometric peak pressure (daPa)	−21±20 (−67-24)	−22±24 (−58-32)	−17±19 (-54-16)	−16±20 (-63-44)	>0.05

Values shown as mean±SD (range). SD: Standard deviation

Table 2: Frequency-specific absorbance values according to groups

	Group 1 (*n*=37)	Group 2 (*n*=33)	Group 3 (*n*=16)	Control (*n*=40)	*P*
Absorbance at 250 Hz	7±2.5 (3-14)	7.5±3.0 (0-15)	7.2±3.5 (0-15)	9.7±3.9 (2-24)	>0.05
Absorbance at 500 Hz	24.5±9.7 (10-45)	19.7±7.8 (5-35)	23.8±7.8 (10-40)	25.2±11.9 (2-54)	>0.05
Absorbance at 1000 Hz	59.5±12.8 (35-82)	58.3±11 (40-80)	71.9±11 (45-85)	62.9±17.1 (28-94)	>0.05
Absorbance at 2000 Hz	71±14 (35-95)	73±9.9 (50-90)	72.2±9.6 (50-85)	70±12.5 (32-96)	>0.05
Absorbance at 4000 Hz	61.7±14.8 (30-90)	59.2±16.8 (15-90)	56.9±11.1 (40-80)	60.6±20.4 (8-94)	>0.05
Absorbance at 8000 Hz	23.2±6.5 (10-40)	26.1±9.2 (10-60)	23.9±8.6 (10-42)	24.2±18.1 (10-54)	>0.05
375-2000 Hz averaged absorbance	51.2±9.2 (26-65)	48.9±6.7 (35-65)	50.2±7.4 (40-60)	53±9.5 (38-72)	>0.05
Maximum absorbance value	82.7±8 (65-98)	82.3±6.8 (70-98)	86±8.9 (68-96)	83.4±13.2 (60-98)	>0.05

Values shown as mean±SD (range). SD: Standard deviation

Table 3: Resonant frequency values according to groups

	Group 1 (*n*=37)	Group 2 (*n*=33)	Group 3 (*n*=16)	Control (*n*=40)	*P*
Resonant frequency (Hz)	1062±230 (693-1560)	1154±363 (716-2370)	1166±271 (712-1637)	1077.5±346 (555-2015)	>0.05

Values shown as mean±SD (range). SD: Standard deviation

groups or between the MS and control groups. These results suggest that MS does not affect the transfer of acoustic energy to the middle ear, the absorption of acoustic energy, or its reflection back to the external ear canal.

The RF is another parameter identified by WBT testing, and it can give different results for pathologies which cause a change in stiffness or mass in the middle ear. Otosclerosis, ossicular chain fixation, atelectatic TM, and rheumatoid arthritis are conditions where changes in stiffness are more prominent, and the RF increases in these conditions.[25-27] However, conditions such as otitis media with effusion, which cause a change in mass, decrease the RF.[27,28] The reported normal range of RF values for normal hearing adults varies, but most studies suggest an RF range for the middle ear from 800 to 1200 Hz.[8,9,29] In our previous study of multifrequency tympanometry performed on adults in our country, the RF ranged from 934.6 to 1098 Hz.[30] In the present study, the mean RF in the MS groups was 1127 Hz and did not differ significantly from the control group value. This result suggests that MS does not have a stiffness or mass effect on the middle ear.

The results of our study showed that tympanosclerosis localized to the TM had no significant effect on the mechano-acoustics system of hearing. MS is a common condition observed after surgical procedures such as myringotomy, insertion of a tympanostomy tube, and tympanoplasty. We believe that our study is of clinical importance as it shows that tympanosclerosis is actually not a situation that requires concern.

This study has two limitations. A major limitation could be the exclusion of cases with hearing loss in the MS groups. However, the reason for this was to form purely MS groups which did not have tympanosclerosis or other pathologies forming conductive hearing loss. Another limitation of our study was the unavailability of long-term follow-up of the cases.

Conclusion

This study revealed that MS limited to the TM causes a decrease in the amplitude of peak acoustic compliance of the tympanogram, but it does not change the acoustic absorbance or the RF of WBT. Previous studies have already shown that MS limited to the TM causes no significant hearing loss and can thus be ignored.[3,4,13] Other studies investigating the success rates after tympanoplasty have also shown that MS did not affect the success of tympanoplasty.[31,32] All the outcomes of this study indicate that MS is not a serious condition, and this raises the question whether further experimental studies on its prevention are needed in the future. However, further studies involving long-term follow-up and with larger groups are required before drawing firm conclusions.

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Conflicts of interest

There are no conflicts of interest.

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