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The Effect of Chronic Otitis Media on Cochlear Function

Kronik Otitis Medianın Koklear Fonksiyon Üzerine Etkisi

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ABSTRACT Objective: The relationship between chronic otitis media (COM) and inner ear function is a contentious issue in current research. The purpose of this study is to add to the existing knowledge on the subject by analyzing bone conduction hearing levels in a large series of cases involving patients with unilateral COM. **Material and Methods:** Bone conduction levels at frequencies of 500 Hz to 4 kHz in pure tone audiometry of all patients were recorded separately for the affected ear and the normal ear, and the results of both ears were compared. **Results:** The study included 514 patients who underwent surgery for COM pathologies, including cholesteatoma in 94 (18.2%) cases, adhesive otitis in 87 (16.9%) cases, dry perforation in 325 (63.2%) cases, and tympanosclerosis in 8 (1.5%) cases. The mean four-frequency bone conduction was 15.8 dB±13.8 in the total of 514 operated ears, and 11.0 dB±11.0 in the contralateral ear with a normal ear membrane. There was found to be a statistically significant difference between the average frequency values on the COM side and the frequency values on the normal side. The mean bone conduction four-frequency values in cholesteatoma were significantly worse than those of all the other groups ($p<0.001$). **Conclusion:** This study provides evidence that COM can cause not only conductive hearing loss but also affect the inner ear. Cholesteatoma was found to cause the most profound bone conduction hearing loss among these pathologies. These findings underscore the importance of considering inner ear involvement in evaluating and managing patients with COM.

Keywords: Otitis media; cholesteatoma; sensorineural hearing loss; audiometry

ÖZET Amaç: Kronik otitis medianın (KOM) iç kulak fonksiyonu üzerindeki etkisi literatürde tartışmalıdır. Bu çalışmanın amacı, tek taraflı KOM hastalarında kemik iletim işitme seviyelerinin değerlendirilmesi yoluyla geniş bir vaka serisi ile bu konuya katkıda bulunmaktır. **Gereç ve Yöntemler:** Tüm hastaların 500 Hz ile 4 kHz frekanslarındaki kemik iletim seviyeleri ayrı ayrı kaydedilerek etkilenen kulağın ve kontralateral normal kulağın sonuçları karşılaştırıldı. **Bulgular:** Çalışmaya, KOM patolojileri nedeniyle opere edilen 514 hasta dahil edildi. Bu hastalar arasında, 94 (%18.2) vakada kolesteatom, 87 (%16.9) vakada adeziv otit, 325 (%63.2) vakada kuru perforasyon ve 8 (%1.5) vakada timpanoskleroz tespit edildi. Toplam 514 opere kulakta, dört frekanslı kemik iletim ortalaması 15,8 dB±13,8, normal timpanik membran olan karşı taraf kulakta 11,0 dB±11,0 idi. KOM tarafındaki ortalama frekans değerleri ile normal taraftaki frekans değerleri arasında istatistiksel olarak anlamlı bir fark bulundu. Kolesteatomdaki dört frekanslı kemik iletim değerleri, tüm diğer gruplarınkinden anlamlı olarak daha kötüydü ($p<0,001$). **Sonuç:** Bu çalışma, KOM nedeniyle ortaya çıkan işitme kaybının sadece iletim tipi değil, aynı zamanda iç kulakta da etkilenmenin olabileceğine dair kanıtlar sunmaktadır. Kolesteatomun bu patolojiler arasında en derin kemik iletimi işitme kaybına neden olduğu belirlenmiştir. Bu bulgular, KOM hastalarının değerlendirilmesi ve yönetilmesinde iç kulağın tutulumunun dikkate alınmasının önemini vurgulamaktadır.

Anahtar Kelimeler: Otitis media; kolesteatom; sensörinöral işitme kaybı; odyometri

Chronic otitis media (COM) is a polymicrobial infection of the middle ear and mastoid cavity, which lasts longer than 3 months and progresses with ear discharge and tympanic membrane perforation. In developing countries, it is a frequent cause of illness and hearing impairment.[1] The two most important findings are ear discharge and conductive hearing loss (CHL) because of middle ear pathologies. In addition, some studies which have examined this patient group have determined sensorineural effects in audiometric measurements. However, this subject is controversial in literature as different results have been presented related to the long-term effect of COM on the inner ear.[1,2]

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COM may present in the form of different pathologies such as dry perforation, cholesteatoma, tympanosclerosis, and adhesive otitis. The most aggressive of these is cholesteatoma, which can cause bone destruction with the release of proteolytic enzymes expressed from granulation tissue rich in macrophages. A study that aimed to compare ears with cholesteatoma with the contralateral normal ears determined greater sensorineural hearing loss (SNHL) in the ears with cholesteatoma.[3] There is a scarcity of studies in the literature that have compared the cochlear function between cases of COM with and without cholesteatoma.[4,5] Therefore, it is still not fully understood whether the cause of SNHL in COM is chronic inflammation or cholesteatoma. Moreover, the number of cases is low in studies related to the effects on the cochlear function of other middle ear pathologies such as adhesive otitis and tympanosclerosis.[4] This study aimed to determine if the effect on bone conduction hearing levels differs based on the specific pathology present, by evaluating various types of COM.

The effect of perforation size is a subject with conflicting results in studies that have investigated cochlear damage in COM. In a previous study on this subject, it was shown that the greater SNHL in large and subtotal perforations than in other perforations could be related to greater exposure of the round window to inflammatory mediators.[1] Therefore, it was also aimed in the current study to examine the effect of perforation size.

MATERIAL AND METHODS

This study was conducted at Necmettin Erbakan University Meram School of Medicine, Department of Otorhinolaryngology in Konya, Türkiye, and it was approved by Necmettin Erbakan University Ethics Committee (date: November 4, 2022, no: 2022/4035). The study was conducted in compliance with the principles outlined in the Declaration of Helsinki. The study included patients diagnosed with unilateral COM between January 2012 and January 2022. A retrospective examination was made of the preoperative findings and operating records. A control group was formed of the contralateral ears to eliminate the effects on hearing of systemic diseases such as diabetes mellitus, environmental factors such as smoking, metabolic disorders affecting both ears and age-related effects such as presbyacusis.

Patients were excluded from the study if they had bilateral COM, acoustic trauma, sudden hearing loss, traumatic tympanic membrane perforation, or a history of ear surgery, and patients with cholesteatoma who were determined with labyrinth destruction during the operation. The control ears were confirmed as healthy on examination of temporal computed tomography and the otoscopic examination in the preoperative records. Demographic data (age, gender) and information about the operated side, tympanic membrane status, pathologies, and perforation size were obtained from the patient files.

The patients included in the study were only those who underwent preoperative pure tone audiometry at our institution. The audiometry tests were performed by three audiometrists with similar training and experience in this field. Bone conduction thresholds were measured for both ears at frequencies of 500, 1000, 2000, and 4000 Hz, and the mean values for these frequencies were calculated. As the study was retrospective, all the data were obtained from patient records.

The COM patients were classified as COM with dry perforation, tympanosclerosis, adhesive otitis, and cholesteatoma. The dry perforation patients were defined as those with a tympanic membrane perforation and no discharge in the last 3 months. Tympanosclerosis patients were identified as individuals who had a CHL of at least 20 dB with no perforation in the tympanic membrane, as well as those who were diagnosed with tympanosclerosis during surgery. The adhesive otitis patients were defined as patients with a retraction pouch of varying size and tympanic membrane location with no perforation of the tympanic membrane. The cholesteatoma group included patients with the presence of epithelial clusters/saccules accompanying the retraction pouch and perforation in the tympanic membrane, who were histopathologically diagnosed with cholesteatoma. Cases in the dry perforation group were separated into 3 subgroups according to perforation size as

cases with small, moderate, or total perforation. Small perforations were defined as a perforation up to 25% of the tympanic membrane, moderate as those between 25% and 75%, and total as those >75%.

STATISTICAL ANALYSIS

The data analysis in this study was performed using SPSS version 22 software (SPSS, Chicago, IL, USA). Descriptive statistics were used to summarize the data, with parametric continuous variables presented as mean±standard deviation, non-parametric continuous variables as median and interquartile range, and categorical variables as number and percentage. Student's t-test was used to compare the mean values of the 4 frequencies and bone conduction thresholds at 500, 1000, 2000, and 4000 Hz frequencies between the ears with COM and the control group ears. The One-Way ANOVA test was used to compare pathology and perforation size groups. To compare multiple groups, the One-Way ANOVA test was followed by the post hoc Tukey's test. A statistically significant result was defined as having a p-value less than 0.05.

RESULTS

A total of 514 patients were evaluated in this study, with 259 (50.3%) males and 255 (49.6%) females, and a mean age of 36.3±14.8 years (range, 9-77 years). The patients were divided into four groups based on the reason for the operation, with 94 (18.2%) in Group 1 (COM with cholesteatoma), 87 (16.9%) in Group 2 (adhesive otitis), 325 (63.2%) in Group 3 (dry perforation), and 8 (1.5%) in Group 4 (tympanosclerosis). The average age of the patients in the four groups was 39.0±16.0 (9-77), 36.2±14.3 (11-68), 35.6±14.5 (10-73), and 36.2±14.3 (11-68) years, respectively. There was no statistically significant difference in the mean age of the groups (p=0.266).

The mean 4 frequency bone conduction was 15.8 dB±13.8 in the total 514 operated ears, and 11.0 dB±11.0 in the contralateral ear with normal ear membrane. A statistically significant difference was determined between the mean bone conduction frequency values of the COM side and the normal side (p=0.001).

The mean 4 frequency bone conduction according to the separate pathologies in the ear were determined to be 22.9 dB±2.0 for cholesteatoma, 14.9 dB±1.0 for adhesive otitis, 13.9 dB±0.6 for dry perforation, and 18.5 dB±5.6 for tympanosclerosis. The mean bone conduction 4 frequency values in the cholesteatoma group were determined to be significantly worse than those of all the other groups (p<0.001). The mean bone conduction 4 frequency values were seen to be similar in the cholesteatoma and tympanosclerosis groups (p=0.786).

Of the patients in the dry perforation group, a small perforation was observed in 51 (9.9%) patients, a moderate perforation in 212 (41.2%), and total or almost total perforation in 62 (12.0%). The bone conduction 4 frequency mean values of these subgroups were determined to be 12.4 dB±10.8, 14.3 dB±12.2, and 14.0 dB±11.7, respectively. The effect of the perforation sizes on SNHL was seen to be similar (p=0.576).

The threshold values at varying frequencies of each pathology and the bone conduction threshold values of the contralateral normal ears are shown in Table 1. A statistically significant difference was determined at each frequency in the cholesteatoma and dry perforation groups compared to the normal ears (p<0.05). As the frequency increased, an increase in the difference compared to normal ears was observed in the cholesteatoma group, while in the dry perforation group, an increase was observed independently of the frequency increase. In the adhesive otitis group, a significant difference was found at 1000 and 2000 Hz compared to the normal ears, and in the tympanosclerosis group, a significant difference was determined only at 1000 Hz (p<0.05).

When comparisons were made within the pathology groups at each frequency (Figure 1), it was determined that the cholesteatoma group was more affected at all the frequencies than the adhesive otitis group and the dry perforation group (p<0.05). The tympanosclerosis group was seen to be affected at a similar level to the cholesteatoma group at all 4 frequencies (p>0.05).

TABLE 1: The threshold values at varying frequencies of each pathology and the bone conduction threshold values of the contralateral normal ears.

Group	500 Hz	1000 Hz	2000 Hz	4000 Hz
Cholesteatoma (n=94)	18.6 dB±16.6	20.2 dB±20.6	23.8 dB±21.7	28.9 dB±24.1
Contralateral normal ear (n=94)	10.9 dB±12.0	11.0 dB±13.1	13.1 dB±15.9	17.2 dB±18.3
	(p=0.000)	(p=0.000)	(p=0.000)	(p=0.000)
Adhesive otitis (n=87)	12.0 dB±9.1	12.5 dB±10.5	16.0 dB±12.3	19.0 dB±15.4
Contralateral normal ear (n=87)	9.4 dB±9.1	9.1 dB±9.6	10.6 dB±10.5	15.5 dB±15.4
	(p=0.063)	(p=0.028)	(p=0.002)	(p=0.136)
Dry perforation (n=325)	11.9 dB±10.8	11.5 dB±11.0	14.9 dB±13.6	17.5 dB±17.0
Contralateral normal ear (n=325)	8.8 dB±9.3	8.7 dB±9.8	10.6 dB±11.9	13.9 dB±15.7
	(p=0.000)	(p=0.001)	(p=0.000)	(p=0.006)
Tympanosclerosis (n=8)	16.2 dB±13.2	17.5 dB±13.8	19.3 dB±15.4	21.2 dB±24.4
Contralateral normal ear (n=8)	8.1 dB±7.5	6.2 dB±4.4	8.7 dB±6.4	11.2 dB±15.9
	(p=0.155)	(p=0.047)	(p=0.094)	(p=0.349)
Total (n=514)	13.2 dB±12.1	13.4 dB±13.6	16.7 dB±15.6	19.9 dB±18.8

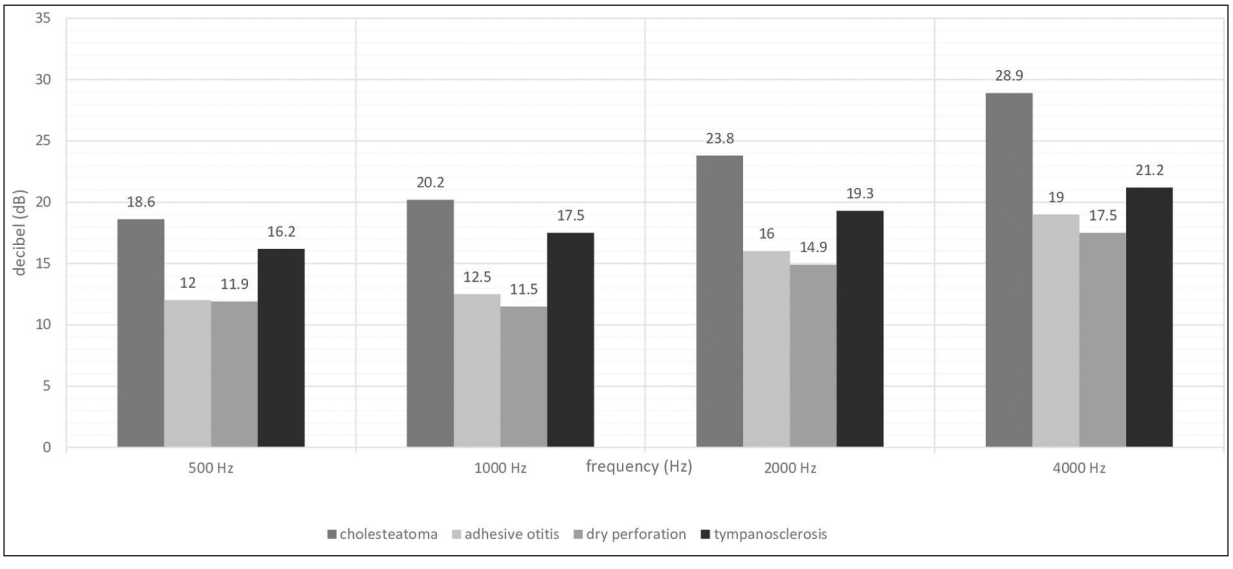

FIGURE 1: Comparison between pathology groups at each frequency.

DISCUSSION

COM is a frequently encountered cause of hearing loss in developing countries. Previous studies have reported that mixed-type hearing loss can be caused by delayed treatment of COM, lack of education, poor hygiene, and insufficient follow-up.[6] The mechanisms causing CHL can be simply explained by COM pathologies damaging the middle ear conduction pathway. Many studies have examined the relationship between COM and SNHL and no consensus has been reached. With the large case series of the current study, it was aimed to contribute to this subject. The results of the study demonstrated that COM has an effect on cochlear functions, and of the pathology subgroups, cholesteatoma was determined to have the most profound effect on the bone conduction pathway.

There are studies in the literature about COM and the sensorineural effect, and conflicting results have been presented. In a study of pediatric patients by Kaplan et al., which included a total of 127 ears with COM, 40 of which were bilateral, COM was shown to have very little effect on cochlear function.[7] Dumich et al. evaluated 200 unilateral COM patients and reported that SNHL was not at a level that was reflected clinically in patients with COM.[8] In a study conducted by Singer et al. on 200 patients, it was found that 10% of the patients with COM had SNHL, and this result was in line with the findings of a study by Blakley and Kim which had a sample size of 123 patients.[1,9] The results of our study were in the same direction and caused sensorineural involvement independent of the clinical presentation of chronic otitis.

The main physiopathology blamed for the effect on the inner ear is inflammatory mediators populating the inner ear through the round window, and therefore it has been claimed that the inner ear remains defenseless in COM.[10] In other studies in the literature, it has been reported that the negative effect of COM is more profound at high frequencies.[6,11] Similarly in the current study, the effect was seen to be greater at high frequencies than at low frequencies, with the greatest effect at 2000 Hz and 4000 Hz. These data can be explained by studies that have revealed that COM causes loss in inner and outer hair cells and stria vascularis areas, especially in the basal rotation of the cochlea.[2,10,12,13] According to the same theory, it can be thought that the significant sensorineural effect at 1000 and 2000 Hz in the adhesive otitis ears in our study is associated with chronic otitis with effusion secondary to eustachian dysfunction.

Few studies have separately examined the effect of COM subgroups on the cochlea. In a study of 158 patients by Dobrianskyj et al., patients with chronic ear discharge were compared with patients with dry perforation, and it was stated that dry perforation did not affect sensorineural thresholds, and the basis of SNHL could originate from suppuration.[5] da Costa et al. examined 150 patients with and without cholesteatoma, and a significant difference was determined in the sensorineural hearing thresholds only at 500 Hz.[14] In studies by Amali et al., MacAndie and O'Reilly, and de Azevedo et al., the presence of cholesteatoma was not associated with SNHL.[11,15,16] In contrast, in a retrospective study of 159 patients by Gulustan et al., a sensorineural effect was seen in ears with cholesteatoma compared to the normal contralateral ears, but the cholesteatoma group was not compared with other chronic otitis subgroups.[3] In the current study, the ears of the patients with cholesteatoma were determined to be affected more at all frequencies compared to the dry perforation group, and this effect increased towards higher frequencies.

Of the very few studies conducted related to tympanosclerosis, Jesic et al. determined that tymanosclerosis affected SNHL only at 1000 Hz when accompanied by a retracted tympanic membrane, and the findings of the tympanosclerosis group in the current study were consistent with this.[4] At this point, it should be considered that SNHL may be pseudoperceptive deafness of middle ear conduction origin.[17,18] However, as with the present study, the number of patients in previous studies was also limited, making it difficult to draw a definitive conclusion. Therefore, there is a necessity for further research on this specific topic with larger sample size.

In studies that have compared patients with chronic otitis dry perforation according to the size of the perforation, it has been shown that wide and subtotal tympanic membrane perforations cause higher losses, especially at higher frequencies. These studies have supported a correlation between the sensorineural effect and perforation size.[1,4] To compare the change in perforation size in the current study, the data of 325 patients with dry perforation were used, and in this context, the amount of data was much greater than in other studies. The results of the current study showed that perforation size created no difference in the cochlear effect.

The strength of this study was that in contrast to studies that have generally compared COM or COM with cholesteatoma with the normal ear, four different middle ear pathologies were compared with the normal ear. The limitations of the study include its retrospective design, the unknown duration of infection, and the inclusion of only operated patients, re-

sulting in a small number of patients with adhesive otitis and tympanosclerosis.

CONCLUSION

COM not only leads to hearing loss in the middle ear but also affects the inner ear. Among the different types of COM, cholesteatoma results in the most severe bone conduction hearing loss, followed by adhesive otitis and dry perforation. Tympanosclerosis can sometimes cause a false sensorineural loss due to resonance.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

***Idea/Concept:** Hamdi Arbağ, Mehmet Akif Eryılmaz, Fakih Cihat Eravcı; **Design:** Mitat Arıcıgil, Mehmet Akif Dündar, Miyase Orhan; **Control/Supervision:** Hamdi Arbağ, Fakih Cihat Eravcı; **Data Collection and/or Processing:** Mehmet Akif Dündar, Miyase Orhan; **Analysis and/or Interpretation:** Mehmet Akif Eryılmaz, Mitat Arıcıgil; **Literature Review:** Mehmet Akif Dündar, Miyase Orhan; **Writing the Article:** Fakih Cihat Eravcı, Miyase Orhan; **Critical Review:** Hamdi Arbağ, Mehmet Akif Eryılmaz; **References and Fundings:** Fakih Cihat Eravcı, Miyase Orhan; **Materials:** Mitat Arıcıgil, Mehmet Akif Dündar.*

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