Kulak Burun Boğaz ve Baş Boyun Cerrahisi Dergisi
Journal of Ear Nose Throat and Head Neck Surgery

ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

DOI: 10.24179/kbbbbc.2023-96790

Evaluation of Mastoid and Tympanic Volumes and Hearing Levels in Male Patients with Tympanic Membrane Perforation

Timpanik Membran Perforasyonu Olan Erkek Hastalarda Mastoid ve Timpanik Hacim ile İşitme Seviyelerinin Değerlendirilmesi

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ABSTRACT Objective: In tympanic membrane perforations, the location and size of the perforation, and the mastoid and tympanic volume can affect the hearing level. The aim of the study is to reveal the level of hearing loss that develops in male patients with tympanic membrane perforation and evaluate the effect of tympanic and mastoid volume on hearing loss. **Material and Methods:** In this retrospective study, we included 35 ears of 28 male patients. The tympanic membrane perforation sizes, localizations, hearing levels, and mastoid and tympanic volumes were noted and compared. **Results:** When the correlation between the 'whole tympanic membrane diameter/perforation diameter' ratio and the air conduction hearing thresholds was analyzed, it was seen that there was a moderate and opposite correlation in all the frequencies and this was statistically significant. When the correlation between the tympanic volume and the air conduction thresholds was analyzed, it was seen that the diference not statistically significant. When the correlation between the mastoid volume and the air conduction thresholds was analyzed, no statistical significance was noted. **Conclusion:** The degree of conductive hearing loss resulting from a tympanic membrane perforation increases when the size of perforation expands, degree of middle ear pneumatization and mastoid pneumatization ratios have no effect on hearing.

Keywords: Conductive hearing loss; tympanic membrane perforation; tympanic volume; mastoid volume

ÖZET Amaç: Kulak zarı perforasyonlarında perforasyonun yeri ve boyutu ile mastoid ve timpanik hacim, işitme düzeyini etkileyebilir. Çalışmanın amacı, kulak zarı perforasyonu olan erkek hastalarda perforasyon lokalizasyonu ve büyüklüğüne bağlı olarak gelişen işitme kaybının düzeyini ortaya koymak ve timpanik ve mastoid hacimlerinin işitme kaybına etkisini değerlendirmektir. **Gereç ve Yöntemler:** Bu retrospektif çalışmaya 28 erkek hastanın 35 kulağı dâhil edildi. Kulak zarı perforasyon boyutları, lokalizasyonları, mastoid ve timpanik hacimleri not edildi ve bu değerler hastaların işitme eşikleri ile karşılaştırıldı. **Bulgular:** "Total kulak zarı çapı/perforasyon çapı" oranı ile havayolu işitme eşikleri arasındaki korelasyon incelendiğinde, tüm frekanslarda orta ve zıt yönde bir korelasyon olduğu ve bunun istatistiksel olarak anlamlı olduğu görüldü. Timpanik hacim ile havayolu eşikleri arasındaki korelasyon incelendiğinde, istatistiksel olarak anlamlı olmadığı görülürken mastoid hacim ile havayolu eşikleri arasındaki korelasyonun da istatistiksel olarak anlamlı olmadığı görüldü. **Sonuç:** Kulak zarı perforasyonundan kaynaklanan iletim tipi işitme kaybının derecesi, perforasyonun boyutu büyüdükçe artar, orta kulak pnömatizasyon derecesi ve mastoid pnömatizasyon oranlarının işitme üzerine etkisi yoktur.

Anahtar Kelimeler: İletim tipi işitme kaybı; timpanik membran perforasyonu; timpanik volüm; mastoid volüm

TO CITE THIS ARTICLE:
Ulus Evecan S, Ak M. Evaluation of Mastoid and Tympanic Volumes and Hearing Levels in Male Patients with Tympanic Membrane Perforation. Journal of Ear Nose Throat and Head Neck Surgery. 2023;31(4):189-93.

Tympanic membrane consists of a membranous partition between the external ear canal and the tympanic space, measuring 9-10 mm vertically and 8-9 mm horizontally.[1] Tympanic membrane perforations can result from an acute or chronic infection or trauma, or be iatrogenic. It is a common finding in

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Peer review under responsibility of Journal of Ear Nose Throat and Head Neck Surgery.

Received: 16 Mar 2023 ***Received in revised form:*** 04 Oct 2023 ***Accepted:*** 04 Oct 2023 ***Available online:*** 06 Oct 2023

our country. According to the studies, conductive hearing loss due to perforation can vary depending on the diameter and location of the perforation. It is known that perforations with intact bone chain can cause up to 50 dB hearing loss but not more.[2] The mastoid cavity contains mastoid cells and they are thought to regulate ear pressure and protect the delicate structures of the area. The tympanic and the mastoid cavity may narrow due to soft tissue often as a result of an unresolved infection or inflammation. Besides, sclerosis can narrow the cavity often in patients with chronic otitis media and less likely in patients with fibro-osseous lesions of the temporal bone. Sometimes, this situation can be seen as congenital. Some studies support that decrease in tympanic and mastoid aeration causes an increase in the severity of the hearing loss.[3,4] Voss et al. assumed in their analog circuit model that the effect of the perforation on the pressure difference across the tympanic membrane can be represented by inclusion of a path for sound coupling through the perforation from the ear canal to the tympanic and the mastoid cavity.[5] However, this statement is contraversial because of the limitations. In this retrospective study, it was planned to reveal how the perforation size and location, mastoid and tympanic aeration affect the hearing levels by evaluating the pure tone audiometry test and temporal bone computed tomography findings.

MATERIAL AND METHODS

This retrospective study includes data of 35 ears of 28 male patients who applied to the hospital between 2015 and 2016, and were scheduled for an operation due to tympanic membrane perforation and Erzurum Regional Training and Research Hospital Clinical Research Ethics Committee approval was obtained (date: June 07, 2016, no: 37732058-53/6455). Each patient file icluded signed informed consent stating that the patients data can be used in any study. All procedures were carried out in accordance with the ethical principles of the Declaration of Helsinki.

These patients did not describe any ear discharge within the last 6 months. The mean age of the subjects was 21.9±1.16 (between 20 and 24) years. Patients with a healthy tympanic mucosa and an intact bone chain observed during surgery were included in the study. Patients with previous ear surgery, ear malformations, additional sensorineural hearing loss, and active ear discharge were excluded. In pure tone audiometry, air conduction hearing thresholds of 500-1000-2000-4000 Hz frequencies were noted in 35 sides (19 right+16 left) of 28 patients. The tympanic membrane is divided into four quadrants as anterosuperior, posterosuperior, anteroinferior, and posteroinferior with an imaginary line that drawn vertically along the malleus handle and extending to the annulus, along with a horizontal line at the umbo (Figure 1). We retrospectively examined the records of patients. All the whole tympanic membrane diameters, localization of perforations according to the quadrants and perforation diameters were noted (Figure 2). Each ear had been operated by the same surgeon and a 90 degree pick hook or similar otologic instrument and 0 degree rigid otoendoscopy equipment had been used to estimate the diameters during the operation.

The tympanic volumes and the mastoid volumes were calculated with Philips Brilliance 64 (Amsterdam, Holland) detector multi-slice computed tomography (Figure 3). The calculation was made by measuring the cross sectional areas in the axial plane from the upper side of the mastoid area to mastoid tip. The slice thickness was 0.6 mm. Each of values were obtained by multiplying of the total area by the distance between the cross sections.

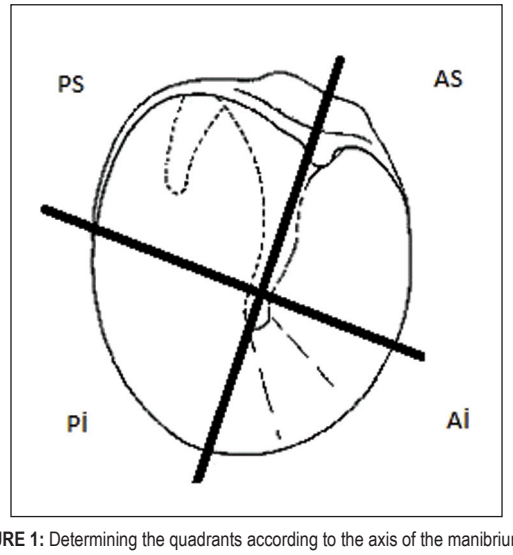

FIGURE 1: Determining the quadrants according to the axis of the manibrium mallei and the axis perpendicular to it.
AS: Anterosuperior; AI: Anteroinferior; PS: Posterosuperior; PI: Posteroinferior.

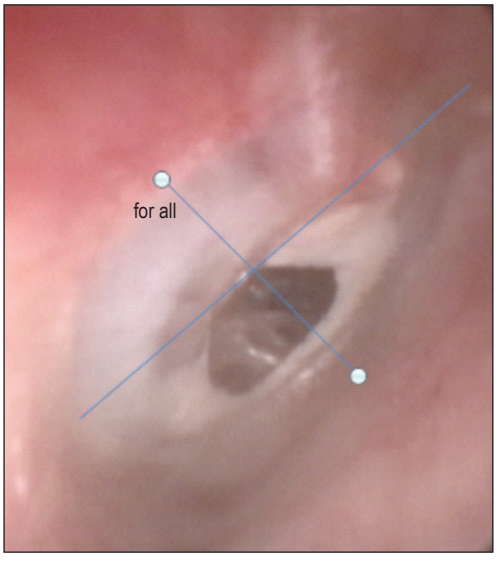

FIGURE 2: Endoscopic view of the whole tympanic membrane with perforation.

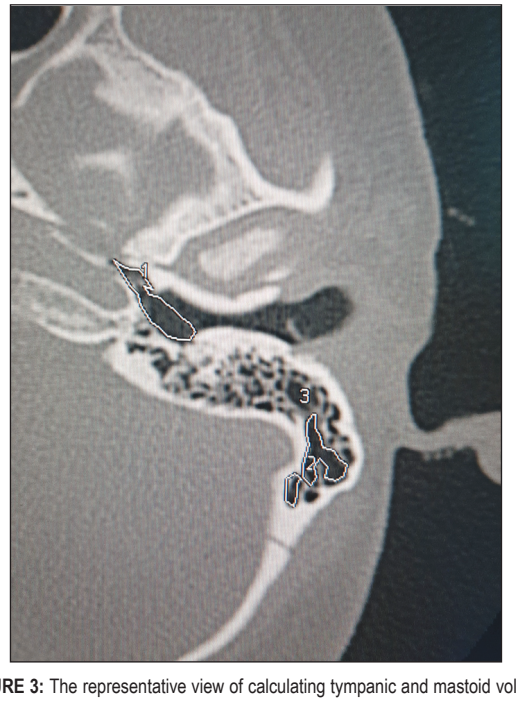

FIGURE 3: The representative view of calculating tympanic and mastoid volume on axial plane of temporal bone computed tomography.

STATISTICAL ANALYSIS

Descriptive statistics were shown as number, percentage, and mean±standard deviation. The relationship between variables was evaluated using the Pearson's correlation analysis. Data were analyzed by SPSS 15.0 (SPSS Inc. Chicago, IL, ABD) program. As the statistical significance limit, a value of $p<0.05$ was accepted.

RESULTS

Of the 35 tympanic membrane perforations, 7 (20%) were localized in one quadrant, 6 (17.1%) in two, 3 (8.5%) in three, and 19 (54.2%) in four (Table 1). The number of perforations located only in the anterior quadrants was 6 (17.1%), for posterior quadrants it was 4 (11.4%). The number of perforations including both anterior and posterior quadrants was 25 (71.4%). All tympanic membrane diameters were measured as 10×9 mm in 32 (91.4%) cases and 9×8 in 3 (8.5%) cases. The smallest perforation diameter was 1×1 mm, while the largest perforation diameter was 6×5 mm.

The mean air conduction tresholds at speech frequencies in 35 ears irrespective to the sizes and the sides of the perforations were: 39 dB at 500 Hz frequency, 30.8 dB at 1000 Hz, 27.4 dB at 2000 Hz, and 37.7 dB at 4000 Hz.

When the correlation between the 'whole tympanic membrane diameter/perforation diameter' ratio and the air conduction hearing thresholds of 500, 1000, 2000, and 4000 Hz, respectively, was analyzed, it was seen that there was a moderate and opposite correlation in all frequencies and this was statistically significant (correlation coefficient: r=0.511 r=0.516 r=0.505 r=0.411, respectively, statistical significance: p=0.005, p=0.005, p=0.006, p=0.030, respectively).

The widest mastoid volume was 8.302 cm^3, while the smallest mastoid volume was 6.93 cm^3. In addition, the widest tympanic volume was measured as 1.126 cm^3, while the narrowest tympanic volume was measured as 8.89 cm^3.

TABLE 1: Number of quadrants with perforation.

Quadrants	n	%
1	7	20
2	6	17.1
3	3	8.5
4	19	54.2
Total	35	

When the correlation between the tympanic volume and the air conduction hearing thresholds of 500, 1000, 2000, 4000 Hz, respectively, was analyzed, it was seen that there was a low degree and a correlation in the same direction, and this was not statistically significant (correlation coefficient: respectively r=0.115 r=0.344 r=0.236 r=0.170, respectively, statistical significance: p>0.005).

When the correlation between mastoid volumes and the air conduction thresholds of 500, 1000, 2000, and 4000 Hz, respectively, was analyzed, it was seen that there was a very low degree and a correlation in the same direction, and this was not statistically significant (p>0.005).

DISCUSSION

It is obvious that the general consensus is bigger tympanic membrane perforations tend to cause more severe hearing loss.[6-8] While some studies traditionally suggest the conductive hearing loss resulting from a tympanic membrane perforation is location-dependent, the others claim that the hearing loss does not vary substantially with the location of the perforation.[3,4,9-11] According to an imaginary vertical line drawn across the manubrium mallei, the vast majority of the perforations (71.4%) are localized to both the anterior and the posterior of the line. Therefore, we did not analyze the perforations according to their localizations.

As in our study, the vast majority of the studies that analyzes the relationship between the perforations and hearing thresholds at speech frequencies conclude that hearing loss is frequency dependent, with most maximum losses seen at the lower frequencies and lowest hearing loss at 2000 Hz.[12-14]

There are some studies stating that hearing loss is affected by tympanic and mastoid volume. While Park et al. calculated this volume by computed tomography, Mehta et al. analyzed this using tympanometry, and they all reported that hearing loss decreased as the tympanic and mastoid cavity air cell volumes increased.[4,15] Aslıer et. al. obtained the best hearing level results in ears with larger middle ear and the mastoid volumes however, this difference was significant at 1000 Hz and lower frequencies.[3] On the contrary, Kim et al. stated that the degree of aeration of the mastoid and tympanic cavity did not affect the severity of conductive hearing loss.[11] Similarly, non significant results were found in our study. The difference of our study is that we did not classify perforations as large or small. Tympanic membrane perforations also ultimately affect hearing values. That's the limitation of our study. But most perforations were subtotal reduces the effect of this limitation. The another difference is that we evaluated the mastoid and tympanic volumes separately. On the other hand, patient selection may affect the results. These volumes may vary by gender. Although studies say that there is no gender difference for tympanic volume, there are opinions that mastoid volume is larger in males. In our study, all the cases were male.[16-18]

The other limitation of the study is the number of patients. Due to device failure, we could not access more patient data. The number of patients included in the study should be increased.

CONCLUSION

The brief overview of the study is,

1) Fundemantal principle is hearing loss increases as the perforation diameter increases.
2) Conductive hearing loss by tympanic membrane perforation occurs primarily at low frequencies.
3) Hearing loss in tympanic membrane perforation is not related to the the degree of middle ear and mastoid pneumatization.

Further studies with more patient participation is required for a more meaningful result.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

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: *Sergül Ulus Evecan;* ***Design:*** *Sergül Ulus Evecan, Mehmet Ak;* ***Control/Supervision:*** *Sergül Ulus Evecan;* ***Data Collection and/or Processing:*** *Sergül Ulus Evecan, Mehmet Ak;* ***Analysis and/or Interpretation:*** *Sergül Ulus Evecan;* ***Literature Review:*** *Sergül Ulus Evecan, Mehmet Ak;* ***Writing the Article:*** *Sergül Ulus Evecan;* ***Critical Review:*** *Sergül Ulus Evecan;* ***References and Fundings:*** *Sergül Ulus Evecan;* ***Materials:*** *Sergül Ulus Evecan.*

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