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RESEARCH

EVALUATION OF EUSTACHIAN TUBE FUNCTION TESTS AND IMMITANCEMETRIC MEASUREMENTS IN A GERIATRIC GROUP

ABSTRACT

Introduction: Atrophy in the middle ear and degeneration of muscle fibers, fibrous tissue ligament, and bone as well as calcification of Eustachian cartilage occurs with aging. We aimed to evaluate the middle ear system and changes in Eustachian tube functions in a geriatric group.

Materials and Method: Study participants comprised 30 older and 30 younger individuals between the age of 65 and 84 years (74.3±5.4 years) and 18 and 45 years (30.4±4.2 years), respectively. All participants underwent immitancemetric measurements and Eustachian tube function tests after ear, nose, and throat examination. For the immitancemetric measurements, the ear canal volume, compliance, middle ear pressure, and gradient were evaluated. Valsalva and Toynbee maneuvers were used to perform the Eustachian tube function tests.

Results: Non-significant differences were found between the two groups for the ear canal volume and middle ear pressure ($p>0.05$). While no significant difference was found for the left ear compliance values between the two groups ($p>0.05$), a significant difference between the left ear compliance and gradient values for both ears was found ($p<0.05$). Eustachian tube function tests showed no significant differences between the groups, based on the values obtained by Valsalva and Toynbee maneuvers.

Conclusion: Eustachian tube functions in the geriatric group were found to be normal in this study. Bilateral gradient and right ear compliance values were higher in the geriatric group than in the control group indicating that the middle ear system in the geriatric group was more active.

Key Words: Hearing Tests; Aged; Eustachian Tube; Audiometry.

ARAŞTIRMA

GERİATRİK GRUPTA İMMİTANSMETRİK ÖLÇÜM VE ÖSTAKİ TÜP FONKSİYON TESTLERİNİN DEĞERLENDİRİLMESİ

ÖZ

Giriş: Yaşa bağlı orta kulakta atrofi, kas liflerinin, fibroz doku ligamentlerinin, kemik gelişiminin dejenerasyonu ve östaki tüpünün kıkırdaksı kısmında kireçlenmeler gözlenmektedir. Bu çalışmanın amacı; geriatrik grupta orta kulak sistemi ve östaki tüp fonksiyonlarında meydana gelen değişimleri değerlendirmektir.

Gereç ve Yöntem: Bu çalışmaya 65–84 yaş arasında (74,3±5,4) 30 yaşlı birey ile 18–45 yaş arasında (30,4±4,2) 30 birey katılmıştır. Katılımcılara Kulak Burun Boğaz muayenesinden sonra immitansmetrik ölçüm ve östaki tüp fonksiyon testleri yapılmıştır. İmmitansmetrik ölçümlerde kulak kanal volümü, komplians, orta kulak basıncı ve gradient değerlendirilmiştir. Östaki tüp fonksiyonları ise Valsalva ve Toynbee manevraları ile incelenmiştir.

Bulgular: İmmitansmetrik ölçümlerde geriatrik ve kontrol grubu arasında kulak kanal volümü ve orta kulak basıncı arasında istatistiksel olarak anlamlı bir fark bulunamamıştır ($p>0,05$). Sol kulak compliance değerleri arasında istatistiksel olarak anlamlı bir fark mevcut değilken ($p>0,05$), sağ kulak compliance ve bilateral gradient değerleri arasında istatistiksel olarak anlamlı bir fark mevcuttur ($p<0,05$). Östaki tüp fonksiyonları Valsalva ve Toynbee manevraları ile değerlendirilmiş, gruplar arasında istatistiksel olarak anlamlı bir fark bulunamamıştır (p?0,05).

Sonuç: Elde edilen bulgulara göre geriatrik grupta östaki tüp fonksiyonları normal sınırlardadır. Bilateral gradient ve sağ kulak komplians değerleri kontrol grubuna göre yüksek elde edilmiştir. Bu durum geriatrik grupta orta kulak sisteminin daha hareketli olduğunu göstermektedir.

Anahtar Sözcükler: İşitme Testleri; Yaşlı; Östaki Tüpü; Odiometri.

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Introduction

The World Health Organization (WHO) defines older people according to the calendar age as the young old (60–64), middle-old (65–74), old (75–84), and old-old (85+) (1). Although aging exhibits individual differences, it is influenced by life style and chronic diseases, as well as by physiological, genetic, and environmental factors. Physiological changes encountered during old age often occur in single or multiple organs (2).

In the geriatric group, certain age-dependent changes are observed in the middle ear. These changes are seen in the tympanic membrane; ossicular chain; middle ear joints; and cartilages in the joint surfaces, middle ear muscles, and fibrous tissue ligaments. Previous middle ear structural and histological studies have reported many old age-related changes. Other age-related changes include atrophy and degeneration of bone as well as fibrous tissue bands in the middle ear muscle fibers (3,4). It has been reported that the cartilaginous support of the Eustachian tube gets calcified and there is muscle fiber atrophy. Age-related reduction of muscle functions may present problems in opening the Eustachian tube, especially while gulping (2). Although the middle ear goes through some age-related anatomical changes, the effects of ageing on the physiological and behavioral tests of the middle ear are very low (5).

The most detailed information concerning the middle ear system is obtained by immitancemetric measurements. According to the definition adopted by the American National Standards Institute (ANSI) in 1987, tympanometry is the process of acoustic immitance as a function of the air pressure in the outer ear canal (6).

Currently, all measuring instruments measure admittance. Impedance is the resistance shown by the middle ear system to the flow of the acoustic energy; conversely, admittance is the permeability of the middle ear system to the flow of acoustic energy (7). Immitancemetric measurements are performed with tympanometric instruments. Tympanometry involves a probe that is placed outside the outer ear. This probe has three main components: 1) a speaker that gives sinusoidal signals at known frequencies, 2) a microphone that collects signals coming back from the tympanic membrane, and 3) a manometer that can change the pressure that exists between the probe and the tympanic membrane. A tympanogram is a graph that shows values estimated from tympanometry.

For immitancemetric measurements, a probe that is placed in the outer ear track applies pressure between +200 daPa and -400 daPa. A tympanogram is drawn between the changing pressure levels. The peak of the tympanogram graph in the normal middle ear is the pressure near 0 daPa. Thus, this is the condition with highest acoustic energy passage. As the pressure moves toward positive or negative pressure, the tympanic membrane and the middle ear system hardens, which means that the acoustic admittance decreases indicating that more energy is reflected toward the middle ear track. In the cases, where the pressure is either highly positive or negative, the middle ear assumes a stiffness, and the admittance is at the lowest level. As the pressure decreases from +200 daPa to -400 daPa, the middle ear pressure where maximum passage occurs is determined (8). The parameters for immitancemetric measurements are the outer ear volume, compliance, middle ear pressure, and pressure gradient (9,10).

The Eustachian tube plays an important role during the assessment of the middle ear function. It balances the pressure in the middle ear with the atmospheric pressure. Improper functioning of the Eustachian tube leads to problems in the middle ear. Valsalva and Toynbee maneuvers are used to measure the functions of the Eustachian tube. The Valsalva test is based on increasing the middle ear pressure. The mouth and nose of the patient are closed to ensure passage of air into the middle ear. However, the Toynbee test is a maneuver which decreases the pressure in the middle ear. By gulping or drinking water, air exiting from the patient's middle ear is ensured. The patient is asked to clamp her/his nose and to gulp. After the test, the tympanogram is taken. The aim of this study was to evaluate the geriatric groups' middle ear systems as well as Eustachian tube functions.

Materials and Method

The present study was carried out at the Audiology Tertiary Referral Center and Speech Disorders Clinic. Ethical approval was given by the University Medical School, Non-Medication Clinical Researches Ethical Board by its meeting decision dated 26/09/2014 and No. 30. All study participants signed an informed consent form.

Participants comprised 30 old individuals between the age of 65–84 years (mean 74.3±5.4 years) and 30 individuals between the age of 18–45 years (mean 30.4±4.2 years). After the otolaryngology [ear, nose, and throat (ENT)] examinations, each participant underwent pure tone audiometry (Interacoustics AC 40 Audiometer Assens, Denmark), an immitancemetric examination and Eustachian tube function tests (ETF (Interacoustics AZ26 tympanometer Assens, Denmark))

Following were the inclusion criteria of the study: 1) individuals with normal routine ENT examinations, 2) individuals without otological problems, 3) individuals whose average hearing thresholds were ≤25 dB (hearing loss of high frequency were ignored), and 4) individuals who had a maximum of 5 dB difference in air and bone track hearing thresholds.

Following were the exclusion criteria of the study: 1) individuals who had undergone ear surgery, 2) use of a hearing device, 3) outer and middle ear problems (such as ear infections), 4) perforated tympanic membrane, 5) exposure to noise, 6) ototoxicity, 7) otological trauma history, and 8) systemic diseases.

For immitancemetric measurements, the outer ear canal was plugged with a probe suitable to the ear canal, and the measurements were made automatically. Pressure was applied between +200 daPa and -400 daPa, and with a probe tone of 226 Hz and 85 dBSPL sound pressure level, the ear canal volume, compliance, middle ear pressure, and pressure gradient were measured. For the ETF test, the normal tympanogram (P1) was drawn without removing the probe. The study subject was then asked to perform the Toynbee maneuver (gulping) and another tympanogram (P2) was drawn. After the Toynbee maneuver, the patient was asked to perform the Valsalva maneuver (pumping air into the ear by inflating the mouth and the cheeks), and the third tympanogram (P3) was drawn, which concluded the test.

Statistical Analysis

Statistical analyses were performed using SPSS for Windows 20.0 (SPSS Inc., Chicago, IL, USA). Kolmogorov Smirnov test was performed to see if there was normal distribution between the normal and the geriatric groups. A paired t-test was used for groups that showed normal distribution in the right and left ear evaluations, and the Wilcoxon test was performed to evaluate the groups who did not show a normal range of distribution. For ETFs, differences between the values in P1, P2, and P3 group (P1-P2, P1-P3, and P2-P3) for right and left ears were evaluated with the independent two-sample t-tests.

RESULTS

Non-significant differences were found for the immitancemetric measurements in the intra- and intergroup ear canal volumes between the control and geriatric group ($p>0.05$). Values are shown in Table 1.

Geriatric and control group compliance values are shown in Table 2.

Significant differences were found in the right ear compliance values ($p<0.05$), while there were no significant differences for the left ear compliance values ($p>0.05$) between the control and geriatric group.

Middle ear pressure values for geriatric and control groups are shown in Table 3.

Table 1— Values of Right and Left Ear Canal Volume

	Control Group				Geriatric Group				
	Min.	Max.	Mean	sd	Min.	Max.	Mean	sd	p
Right	0.16	0.96	0.52	0.218	0.27	1.23	0.54	0.212	p?0.05
Left	0.22	0.92	0.47	0.190	0.22	1.01	0.54	0.213	p?0.05

SD: Standart Deviation

Table 2— Right and Left Ear Compliance Values

	Control Group				Geriatric Group				
	Min.	Max.	Mean	sd	Min.	Max.	Mean	sd	p
Right	0.22	1.11	0.43	0.191	0.11	1.89	0.50	0.334	p<0.05
Left	0.24	0.82	0.45	0.152	0.19	1.63	0.50	0.288	p>0.05

SD: Standart Deviation

Table 3— Right and Left Ear Middle Ear Pressure Values

	Control Group				Geriatric Group				
	Min.	Max.	Mean	sd	Min.	Max.	Mean	sd	p
Right	-64.00	48.00	-28.66	22.775	-60.00	-4.00	-33.46	14.873	p>0.05
Left	-64.00	-12.00	-33.46	12.272	-64.00	24.00	-25.46	18.834	p>0.05

SD: Standart Deviation

Table 4— Right and Left Ear Gradient Values

	Control Group				Geriatric Group				
	Min.	Max.	Mean	sd	Min.	Max.	Mean	sd	p
Right	0.15	0.75	0.27	0.113	0.17	1.33	0.33	0.220	p>0.05
Left	0.16	0.49	0.26	0.829	0.17	1.24	0.33	0.197	p>0.05

SD: Standart Deviation

No significant differences were found (p>0.05) for the intra- and intergroup middle ear pressures between the control and geriatric group.

Pressure gradient values of geriatric and control groups are shown in Table 4.

Significant differences were found (p>0.05), for the intergroup pressure gradient values between the control and geriatric group.

The Eustachian functions of the geriatric group were evaluated based on the Toynbee and Valsalva maneuvers. Decrease in ear pressure along with the Toynbee maneuver delays the increase in ear pressure as well as the ability to perform the Valsalva maneuver. Non-significant differences were found between the geriatric and control group (p>0.05) based upon the maneuver values obtained.

Discussion

Acoustic immitancemetric measurements are made with a tympanometer and have been routinely used in the clinical practice since 1970s. Compliance and ear pressure values are of utmost importance in such measurements. In addition, the ear canal volume shows tympanic membrane perforations, while the pressure gradient shows middle ear effusion (11).

Although there are anatomical differences among older individuals, ear canal volume differences up to 2.00 ml are considered normal. Ear canal volumes above normal value show tympanic membrane perforations. Values obtained from immitancemetric measurements play an important role in diagnosing small ear tympanic membrane perforations.

Jerger et al. (1972) demonstrated that normal compliance values are between 0.3 ml and 1.6 ml. Brooks et al. (1968) reported that the compliance values are between 0.35 ml and 1.4 ml, and that the middle ear pressure is between -100 daPa and +50 daPa. They stated that in a normal otoscopic examination, the middle ear pressure up to -150 daPa is acceptable (12,13).

In the present study, significant differences between compliance values of the geriatric and control groups were present. This shows that in the geriatric group, the middle ear admittance values are higher for the right ear, which means that their middle ear systems are more active compared with those of the control group. Middle ear pressure showed meaningful differences between the groups. These results are similar to those of the studies conducted by Jerger et al. and Brooks et al. (3,7).

In addition, pressure gradient values included in the immitancemetric measurements also provide information on the middle ear functions. In some cases, the fact that the gradient value was low, even if the middle ear pressure was within normal limits, suggests middle ear fluid effusion or accumulation. Brooks et al. stated that a gradient value of <0.15 ml suggests considerable middle ear fluid effusion or accumulation (3). In the present study, high gradient values were obtained from the control group. These values agreed with compliance values found in the right ear. No statistically meaningful va-

lues were found for the left ear compliance values, although the values were high among the geriatric group.

Bernstein stated that a change of 10 daPa in the Eustachian tube measured by the Valsalva maneuver is a normal Eustachian tube function (2). In addition, Bernstein emphasized that a difference of 15 daPa between the maximum and minimum limits of the normal values is to be considered as normal function (14).

In this study, the lowest pressure change in ETFs both in the geriatric and control groups was 4 daPa. This value is 6 daPa lower than the value found by Bernstein (1992). According to the outcomes of the present study, in order to state that the Eustachian tube has a normal function, a pressure change of at least 4 daPa must be obtained by the Valsalva and Toynbee maneuvers.

Immitancemetric measurements are routinely used in audiology clinics, while the Eustachian tube function tests are sparingly used. Availability of literature that examines the use of these tests in the geriatric group is very limited. Even though immitancemetric measurements and the ETF tests play an important role in audiological testing, they do not possess much clinical value. These tests play an important role in the geriatric group where it is difficult to interpret in some cases whether the abnormal values are due to age or due to pathological changes. This explains why these tests play an important diagnostic role in the geriatric group (15-17). Newman and Spitzer (1981) suggested that ETF is valuable in geriatric group as it could possibly explain the hypofunction of the aged Eustachian tube (18). Results of our study are also very important as they present ET hypofunction in geriatric group.

Smith et al. (2016) emphasises that The Eustachian tube is a complex structure. In their review on ET imaging, they claimed that best method for ET imaging can be achieved by Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) (19). However, same results could also be gained by ETF tests that are conducted in audiological clinics. Thus, ETF tests should primariliy be prefered as MRI and CT are expensive methods.

Llewellyn et al. (2014) reported that future studies are needed to define Eustachian tube dysfunction (ETD) in adults, broader middle ear ventilation problems and differential diagnose criteria as well to provide consensus on differential diagnose on ETD (20).

As a result, high values for right ear compliance and bilateral pressure gradient clearly show that probe tone sound in the geriatric group passed more easily at 226 Hz. Increase in the compliance and gradient value ratios are in proportion with each other. Both compliance and gradient values are in agreement as they both have high values. Thus, the activity of the middle ear systems of the geriatric group gives rise to the concept that aging could lead to system atrophy along with the degeneration of the middle ear muscle fibers, fibrous tissue ligaments, and middle ear ossicles. No significant ETF differences were found between the geriatric and control group. These results give important diagnostic information about abnormal Eustachian test results. A pressure change of 4 daPa obtained with the Valsalva and Toynbee maneuvers should be accepted as normal.

REFERENCES

1. Arun O. The Adventure of Elderly in Turkey: Scenarios on the Quality Ageing. GÜ Sos Bil D 2008;7(2):313-30.
2. Bernstein JM. The role of Ig E-mediated hypersensitivity in the development of otitis media with effusion. Otolaryngol Clin North Am 1992;25(1):197-211. (PMID:1549382).
3. Brooks DN. An objective method of determining fluid in the middle ear. Int Audiol 1968;7:280-86.
4. Covell WP. Histologic changes in the aging cochlea. J Gerontol 1952;7(2):173-77. (PMID:14927897).
5. Etholm B, Belal A. Senile changes in the middle ear joints. Ann Otol Rhinol Laryngol 1964;83(1):49-54. (PMID:4130015).
6. Gelfand SA. Acoustic Immitance Assessment. In: Gelfand SA (Ed). Essentials of Audiology. 3rd Edition. Thieme Medical Publishers, New York, USA 2001, pp 226-36.
7. Jerger J, Jerger S, Mauldin L. Studies in impedance audiometry. I. Normal and sensorineural ears. Arch Otolaryngol 1972;96(6):513-23. (PMID:4621039).
8. Jerger J. Clinical experience with impedance audiometry. Arch Otolaryngol 1970;92(4):311-24. (PMID:5455571).
9. Hunter LL, Sanford CA. Tympanometry and Wideband Acoustic Immittance. In: Katz J (Ed.) Handbook of Clinical Audiology. 7th Edition, PA 19103 Philadelphia, USA 2015, pp 137-65.
10. Nozza RJ, Bluestone CD, Kardatzke D, Bachman R. Identification of middle ear effusion by aural acoustic admittance and otoscopy. Ear Hear 1994;15(4):310-23. (PMID: 7958530).
11. Rosenwasser H. Otitic problems in the aged. Geriatrics 1964;19:11-17. (PMID:14117917).
12. Shahnaz N, Polka L. Standard and multifrequency tympanometry in normal and otosclerotic ears. Ear Hearing 1997;18(4): 326-41. (PMID:9288478).
13. Son EJ, Park YA, Kim JH, et al. Classification of Trace patterns of 226 and 1000 Hz tympanometry in healthy neonates. Auris Nasus Larynx 2012;39(5):455-60. (PMID:22055507).

14. Silman S, Silverman CA. Audiotory Diagnosis. Thime Medical Publishers, San Diego: Academic Press; USA 1991, pp 11-14.
15. Weinstein BE. The Aging Auditory System. In: Weinstein BE (Ed). Geriatric Audiology. 2nd Edition, Thieme Medical Publishers, New York, USA 2013, pp 65-80.
16. Wiley TL, Cruickshanks KJ, Nondahl DM, Tweed TS. Self-Reported Hearing Handicap and Audiometric Measures in Older Adults. J Am Academy Audiol 2000;11(2):67-75. (PMID:10685672).
17. Jerger J, Northern J. Clinical Impedance Audiometry. In: Jerger J, Northern J. (Eds). 2nd Edition. Thieme Medical Publishers, New York, USA 1970, pp 18-64.
18. Newman CW, Spitzer JB. Eustachian tube efficiency of geriatric subjects. Ear Hear 1981;2(3):103-7. (PMID:725055).
19. Smith ME, Scoffings DJ, Tysome JR. Imaging of the Eustachian tube and its function: a systematic review. Neuroradiology 2016. DOI 10.1007/s00234-016-1663-4. (PMID:26922743).
20. Llewellyn A, Norman G, Harden M, et. al. Interventions for adult Eustachian tube dysfunction: a systematic review. Health Technol Assess 2014;18(6):1-180. (PMID:25029951).