Insert earphones: application to avoid collapse of the external auditory canal

Fones de inserção: aplicação no colabamento de meato acústico externo

Andréa Tortosa Marangoni[1], Renata Coelho Scharlach[2], Marcela Rosana Maia da Silveira[1], Lucila Leal Calais[3], Daniela Gil[4]

ABSTRACT

Purpose: To determine the efficacy of insert earphones in cases of collapsed external auditory canals. **Methods:** Twenty-one elderly individuals with air-bone gaps greater than 10 dBHL at frequencies of 3 kHz and/or 4 kHz underwent anamnesis, pure tone audiometry, speech audiometry, and immittance test. Pure tone audiometry and speech audiometry were performed with both supra-aural and insert earphones. **Results:** Air conduction thresholds were lower with insert earphones at all frequencies except 1 kHz. The magnitude of the air-bone gap was also lower with the insert earphones, and there was a air-bone coupling with this transducer. **Conclusion:** Insert earphones ER-3A allowed significant improvement in air conduction hearing thresholds in elderly individuals, reducing or even eliminating the air-bone gap in cases of collapsed external auditory canals, especially at higher frequencies.

Keywords: Hearing; Audiometry; Auditory threshold; Ear canal; Elderly

INTRODUCTION

Supra-aural earphones, conventional in clinical audiology, may cause the occlusion of the external auditory canal due to the pressure exerted on the pinna, which hinders the passage of sound from the outer ear to the inner ear and determines false conductive hearing loss at high frequencies. This effect is known as collapse of the external auditory canal.

Such a collapse can occur at any age, but approximately one third of patients are elderly (aged 65 years or older)[1], due to the fact that ageing causes anatomic changes in the middle and outer ear[2].

In the outer ear, the pinna often increases in size due to the reduction in skin elasticity and muscle tone. The loss of elasticity in the cartilaginous portion of the external auditory canal can lead to its collapse, that is, narrowing or closure of this region due to the pressure exerted by headphones during audiometry[3].

The ER-3A insert earphones were developed to reproduce the electroacousitc characteristics of TDH-39 supra-aural earphones. A number of authors have highlighted the advantages of this type of transducer, such as: greater comfort for the patient, greater reliability of the exam, greater attenuation of background noise, reduction in the occlusion effect during testing of the bone pathway, and significant reduction in the risk of collapse of the external auditory canal, among others[4-7]. It should be emphasized that the manufacturer recommends employing correction factors when using insert earphones with equipment calibrated for supra-aural earphones.

Studies involving individuals with a collapsed external auditory canal during the testing of pure tone thresholds using supra-aural earphones report an improvement of 15 to 30 dB in air-conduction thresholds following the insertion of plastic tubes in the external auditory canal[8-10], especially at a frequency of 4 kHz[11], thereby indicating the need for another type of transducer or a change in the presentation of the stimulus in such patients[12,13]. However, despite recommendations for the use of another type of earphones in such cases and the proclaimed advantages of insert earphones regarding a reduced risk of ear canal collapse, no studies were found in the literature proving the efficacy of insertion ear phones in this population.

Study carried out at the Department of Speech-Language Pathology and Audiology, Universidade Federal de São Paulo – UNIFESP – São Paulo (SP), Brazil.
(1) Graduate Program (Masters degree) in Human Communication Disorders, Universidade Federal de São Paulo – UNIFESP – São Paulo (SP), Brazil.
(2) Hearing Disorders Sector, Universidade Federal de São Paulo – UNIFESP – São Paulo (SP), Brazil.
(3) Graduate Program (Doctorate degree) in Human Communication Disorders, Universidade Federal de São Paulo – UNIFESP – São Paulo (SP), Brazil.
(4) Department of Speech-Language Pathology and Audiology, Universidade Federal de São Paulo – UNIFESP – São Paulo (SP), Brazil.
Correspondence address: Andréa Tortosa Marangoni. R. Nicarágua, 140, Jardim das Nações, Taubaté (SP), Brasil, CEP: 12030-500. E-mail: andreatortosa@hotmail.com
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The aim of the present study was to determine the efficacy of insert earphones regarding air-conduction tone and voice audiometry in cases of collapse of the external auditory canal among elderly individuals.

METHODS

The present cross-sectional study received approval from the Research Ethics Committee of the *Universidade Federal de São Paulo* (Brazil) under process number 0568/09. All participants were informed about the procedures to be carried out and signed a free and informed consent term authorizing their participation, in compliance with Resolution 196/96 of the Brazilian National Health Council.

The sample was selected from and evaluated at the audiology clinic of the Department of Speech-Language Pathology and Audiology of the *Universidade Federal de São Paulo* (UNIFESP). Twenty-one elderly individuals (42 ears) from both genders were evaluated after fulfilling the following eligibility criteria: age 60 years or older; pure tone audiometry with air-bone gap greater than 10 dBNA at frequencies of 3 kHz and/or 4 kHz; type A tympanometric curve; contralateral acoustic reflexes; and absence of evident neurological and/or cognitive impairment.

The pre-existence of diagnosed otological diseases, such as otosclerosis, cholesteatoma, otitis media, and other conditions that include the air-bone gap among the signs and/or symptoms was the exclusion criterion for this study.

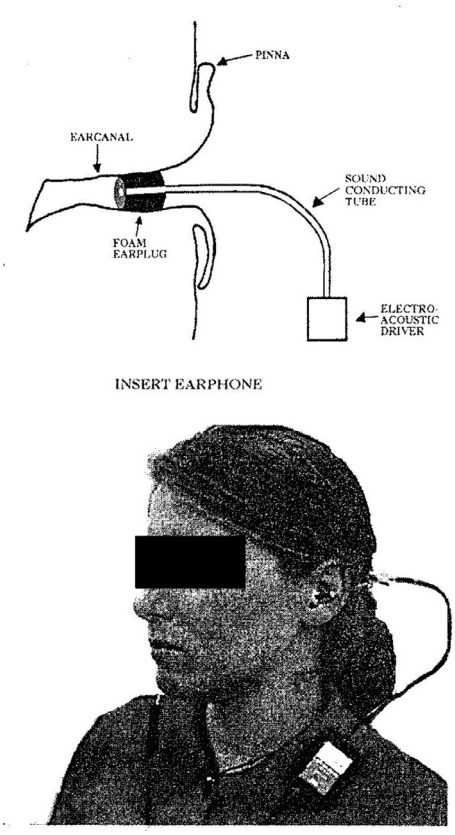
Patient histories were taken and all individuals underwent inspection of the external auditory canal, pure tone threshold audiometry, speech audiometry (SRT – speech reception threshold and SRR – speech recognition rate), and acoustic immittance measures (tympanometry and contralateral acoustic reflex threshold).

Pure tone threshold audiometry and speech audiometry were performed in a sound booth using a Maico® audiometer (model MA-41) calibrated based on the ANSI 1969 standard. Both procedures were performed using TDH-39 supra-aural earphones, followed by ER-3A insert earphones. Due to the need to prove the existence of collapse of the external auditory canal, it was not possible to carry out these procedures in an order other than first with the supra-aural earphones and then with the insert earphones. The procedures were carried out on a single day, but with an interval between sessions, at which time the acoustic immittance measures and/or complementation of the patient history were carried out.

For the use of the ER-3A insert earphones with the same testing equipment, the following correction factors recommended by the manufacturer were added to the threshold values obtained (Etymotic Research, 1985): 250 Hz = 5 dB; 500 Hz = 0 dB; 1 kHz = 5 dB; 2 kHz = 5 dB; 3 kHz = 5 dB; 4 kHz = 0 dB; 6 kHz = -10 dB; and 8 kHz = -10 dB.

Also according to the manufacturer's recommendation, the plugs were inserted at a depth of 2 to 3 mm for ideal performance, thereby ensuring a total insertion of approximately 16 mm into the external auditory canal measuring from the concha[14-16] (Figure 1).

The descending-ascending method was used to determine the thresholds with both transducers.



Source: Roeser RJ, Buckely KA, Stickney GS. Pure tone tests. In: Roeser RJ, Valente M, Hosford-Dunn H, editors. Audiology – Diagnosis. New York: Thieme Medical Publishers; 2000. p. 227-51.

Figure 1. Image demonstrating the position of ER-3A insertion earphone

For the SRT, the individuals were instructed to repeat the recorded words presented as they understood them and the intensity at which the subject repeated 50% of the words (two out of four words) correctly was recorded.

For the SRR, an intensity of 40 dBNS was used, considering the mean of the pure tone thresholds at frequencies of 500 Hz, 1 and 2 kHz. A list of 25 recorded monosyllabic words was presented, with 4% attributed each time a word was correctly recognized.

Tympanometry and the determination of contralateral acoustic reflexes at frequencies of 500 Hz, 1, 2 and 4 kHz were performed with the AZ-7 immittance meter (Interacoustics®) and the individuals were instructed to remain quiet without moving or speaking.

Statistical analysis used the non-parametric Wilcoxon test. Descriptive statistics involved frequency measures and mean values of all frequencies analyzed (cited in the tables as the general term). Ninety-five percent confidence intervals were determined and the level of significance was set at 5% ($p<0.05$).

RESULTS

Twenty-one elderly individuals (42 ears) were evaluated. Eleven were female and 10 were male, with ages ranging from 60 to 84 years (mean = 70 years) and 60 to 82 years (mean = 74.4 years), respectively.

In the comparison between transducers, hearing thresholds were lower (better) with the ER-3A earphones, with significant differences at all frequencies except 1 kHz (Table 1).

The air-bone gap was smaller with the ER-3A earphones in comparison to the TDH-39 earphones at all frequencies, with significant differences at frequencies of 500 Hz, 3 kHz and 4 kHz (Table 2).

Moreover, significantly lower SRT values and higher SRR values were achieved with the insert earphones in comparison to the supra-aural earphones (Table 3).

DISCUSSION

The section offers a critical analysis of the results of the present study on the use of insert earphones in elderly individuals with collapse of the external auditory canal in relation

Table 1. Descriptive values (mean, median and standard deviation) of hearing thresholds (dB) obtained with TDH-39 supra-aural earphones and ER-3A insert earphones in 21 elderly individuals

AP		Mean	Median	SD	Q1	Q3	n	CI	p-value
250 Hz	TDH-39	25.36	25	10.67	20	30	42	3.23	0.007*
	ER-3A	20.24	20	12.09	10	30	42	3.66	
500 Hz	TDH-39	27.74	28	11.80	20	35	42	3.57	0.001*
	ER-3A	23.21	20	12.92	15	35	42	3.91	
1 kHz	TDH-39	32.62	33	14.02	20	44	42	4.24	0.183
	ER-3A	31.43	33	14.66	20	40	42	4.43	
2 kHz	TDH-39	40.71	43	15.99	26	50	42	4.83	0.001*
	ER-3A	37.14	40	15.07	20	50	42	4.56	
3 kHz	TDH-39	47.26	50	20.13	35	55	42	6.09	0.003*
	ER-3A	43.45	45	17.41	30	55	42	5.26	
4 kHz	TDH-39	55.00	55	18.51	50	65	42	5.60	<0.001*
	ER-3A	43.57	45	15.86	35	55	42	4.80	
6 kHz	TDH-39	63.33	65	16.48	56	70	42	4.98	<0.001*
	ER-3A	53.93	55	15.99	45	60	42	4.83	
8 kHz	TDH-39	66.55	70	17.62	55	79	42	5.33	0.005*
	ER-3A	59.64	65	17.16	50	70	42	5.19	
General	TDH-39	44.82	45	21.68	25	60	336	2.32	<0.001*
	ER-3A	39.08	40	19.93	24	55	336	2.13	

* Significant values (p<0.05) – Wilcoxon test

Note: AP = air pathway; SD = standard deviation

Table 2. Descriptive values (mean, median and standard deviation) of air-bone gap (dB) obtained with TDH-39 supra-aural earphones and ER-3A insert earphones in 21 elderly individuals

Gap		Mean	Median	SD	Q1	Q3	n	CI	p-value
500 Hz	TDH-39	1.67	0	3.25	0	0	42	0.98	0.006*
	ER-3A	0.12	0	0.77	0	0	42	0.23	
1 kHz	TDH-39	2.02	0	3.50	0	5	42	1.06	0.071#
	ER-3A	1.19	0	2.16	0	0	42	0.65	
2 kHz	TDH-39	1.90	0	4.12	0	0	42	1.25	0.083#
	ER-3A	0.71	0	1.77	0	0	42	0.54	
3 kHz	TDH-39	7.86	5	9.70	0	10	42	2.93	<0.001*
	ER-3A	3.33	0	4.37	0	5	42	1.32	
4 kHz	TDH-39	15.71	15	9.41	10	20	42	2.85	<0.001*
	ER-3A	4.17	5	5.05	0	5	42	1.53	
General	TDH-39	5.83	0	8.58	0	10	210	1.16	<0.001*
	ER-3A	1.90	0	3.59	0	5	210	0.49	

* Significant values (p<0.05) – Wilcoxon test

Values close to significance level

Note: SD = standard deviation

Tabela 3. Descriptive values (mean, median and standard deviation) of speech reception threshold (dB) and speech recognition rate (%) obtained with TDH-39 supra-aural earphones and ER-3A insert earphones in 21 elderly individuals

SRT and SRR	SRT		SRR	
	TDH39 (dB)	ER-3A (dB)	TDH-39 (%)	ER-3A (%)
Mean	37.62	32.98	78.2	86.0
Median	37.5	35	88.0	88.0
SD	12.79	11.85	22.7	12.3
Q1	25	25	69.0	80.0
Q3	45	40	92.0	96.0
CI	3.87	3.58	6.9	3.7
p-value	<0.001*		0.001*	

* Significant values (p<0.05) – Wilcoxon test

Note: SD = standard deviation; SRT = speech reception threshold; SRR = speech recognition rate

to findings described in the specialized literature. It should be pointed out that no recent studies addressing this topic were found.

The hearing thresholds were lower (better) with the insert earphones in comparison to the supra-aural earphones (Table 1). This improved performance cannot be explained by test--retest variability in the acquisition of hearing thresholds, as previous studies have found no significant test-retest differences in hearing thresholds with different transducers (insertion, circum-aural or supra-aural earphones), with the threshold variability within 5 dB in 90 to 99% of individuals[17,18].

The improvement in the hearing threshold at lower frequencies (250 Hz and 500 Hz) may be explained by the fact that the insert earphones enhanced the attenuation of background noise[4-7], thereby contributing toward a better perception of low-frequency pure tones. At higher frequencies, the improved hearing threshold with the insert earphones may be explained by the reduction in or even the elimination of the collapse of the external auditory canal[4-7], as the collapse of the canal due to the pressure of supra-aural earphones against the pinna generates false conduction hearing loss at higher frequencies[3].

A number of studies have used plastic tubes inserted into the external auditory canal and report a 15 to 30 dB improvement in air conduction thresholds, especially at a frequency of 4 kHz[8-10]. Therefore, some authors suggest the use of a transducer other than supra-aural earphones on this population[11-13], as corroborated by the data of the present study.

The use of insert earphones reduced or even eliminated the collapse of the external auditory canal caused by supra--aural earphones (Table 2). This corroborates findings described in studies that report a significant reduction in the risk of collapse of the hearing canal as one of the advantages of insert earphones[4-7], although no previous studies have been carried out to prove this advantage scientifically. Moreover, the reduction in or elimination of the air-bone gap in the elderly individuals in the present study provided a more compatible result, as the subjects exhibited normal acoustic immittance measures, with type A tympanometric curves and the presence of acoustic reflexes, indicating the adequate functioning of the eardrum system.

SRT and SRR values were better with the insert earphones (Table 3), which is in agreement with the pure tone audiometry findings, as the SRT was compatible with the tritonal means at frequencies of 500 Hz, 1 kHz and 2 kHz obtained with each type of transducer. The insertion phones led to greater attenuation of background noise, thereby providing greater speech recognition, as reported in previous studies[4-7].

CONCLUSION

Based on the findings of the present study, ER-3A insert earphones enable a significant improvement in air-conduction hearing thresholds in elderly individuals by reducing or even eliminating the air-bone gap, especially at higher frequencies. Moreover, insert earphones are effective for cases of collapse of the external auditory canal and provide improved speech audiometry, as demonstrated by the lower speech reception threshold and greater speech recognition rate.

RESUMO

Objetivo: Determinar a eficácia dos fones de inserção em casos de suspeita de colabamento de meato acústico externo. **Métodos:** Vinte e um idosos com intervalo aéreo-ósseo superior a 10 dBNA nas frequências de 3 kHz e/ou 4 kHz foram submetidos à anamnese, audiometria tonal liminar, logoaudiometria e imitanciometria. A audiometria tonal e a logoaudiometria foram realizadas com os fones supra-aurais e com fones de inserção. **Resultados:** Verificou-se que os limiares auditivos por via aérea obtidos com os fones de inserção foram menores em todas as frequências com exceção de 1 kHz. O intervalo aéreo-ósseo também foi menor com o fone de inserção, havendo um acoplamento aéreo-ósseo com este transdutor. **Conclusão:** Os fones de inserção ER-3A possibilitam melhora significativa nos limiares de audibilidade por via aérea em idosos, diminuindo ou até eliminando o intervalo aéreo-ósseo, sobretudo nas frequências altas, nos casos de colabamento do meato acústico externo.

Descritores: Audição; Audiometria; Limiar auditivo; Meato acústico externo; Idoso

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