# Influência do tipo de transdutor na deficiência auditiva de grau profundo***

## Influence of the type of transducer in profound hearing loss

Andréa Tortosa Marangoni*
Daniela Gil**

*Fonoaudióloga. Especializanda em Audiologia pela Universidade Federal de São Paulo. Endereço para correspondência: Rua Nicarágua, 140 - São Paulo - SP - CEP 12030-500 (andreatortosa@hotmail.com).

**Fonoaudióloga. Doutora em Distúrbios da Comunicação Humana pela Universidade Federal de São Paulo. Professor Adjunto do Departamento de Fonoaudiologia da Universidade Federal de São Paulo.

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**Abstract**

Background: individuals with profound hearing loss may present vibrotactile responses when tested with supra-aural earphones due to the large skull area exposed to vibration in these transducers. Aim: to verify the influence of the type of transducer when assessing air conducted pure tone thresholds in individuals with profound sensorineural hearing loss. Method: 50 individuals, ranging in age from 16 to 55 years, were submitted to a clinical history questionnaire, meatoscopy, and pure tone and speech audiometry, using both TDH-39 supra-aural earphones and ER-3A insert earphones. Results: in both pure tone and speech testing, thresholds were higher when obtained using insert earphones, with statistical significant differences for 250Hz and 1000Hz. Considering right and left ear testing with the different transducers, this difference was greater for the right ear, with statistical significant differences only for 250 Hz. Regarding gender, it was observed that the difference between the transducers was greater in males, with statistical significant differences for 250 Hz. However, in the SDT (Speech Detection Threshold), the greatest difference was found in females. Conclusion: people with bilateral sensorineural profound hearing loss presented higher (worse) thresholds with insert earphones (ER-3A) than with supra aural earphones (TDH-39) for low frequencies (250Hz and 1000Hz), confirming the existence of vibrotactile responses with supra aural earphones.

**Key Words:** Earphones; Vibrotactile; Pure Tone Audiometry; Speech Audiometry..

**Resumo**

Tema: indivíduos com deficiência auditiva de grau profundo podem apresentar respostas por vibração com os fones supra-aurais devido a grande área do crânio exposta à vibração nestes transdutores. Objetivo: verificar a influência do tipo de transdutor na obtenção dos limiares auditivos por via aérea em indivíduos com deficiência auditiva neurossensorial de grau profundo. Método: 50 indivíduos, com idades variando de 16 a 55 anos, foram submetidos a anamnese, meatoscopia, e posteriormente, a audiometria tonal liminar e limiar de detecção de voz (LDV). As audiometrias tonal e vocal foram realizadas tanto com fones supra-aurais TDH-39 quanto com os fones de inserção ER-3A. Resultados: nas audiometrias tonal e vocal, notamos que, com o fone de inserção, foram obtidos limiares auditivos mais elevados do que os obtidos com o fone supra-aural, com significância estatística nas freqüências de 250Hz e 1000Hz. Ao observarmos a diferença entre os resultados obtidos com o transdutor TDH-39 e o ER-3A em cada orelha separadamente, notamos que a diferença foi maior na orelha direita com significância estatística somente na freqüência de 250 Hz. Em relação ao sexo, notamos que as diferenças entre os transdutores foram maiores no sexo masculino com significância estatística na freqüência de 250 Hz. No entanto, no LDV, a diferença maior foi encontrada no sexo feminino. Conclusão: deficientes auditivos neurossensorias de grau profundo bilateral apresentam limiares de audibilidade mais elevados (piores) com os fones de inserção do que com os fones supra-aurais nas freqüências baixas, evidenciando a existência das respostas por vibração com os fones supra-aurais.

**Palavras-Chave:** Fones de Ouvido; Vibração; Audiometria de Tons Puros; Audiometria de Fala.

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## Introduction

There are three types of earphones in clinical audiology (supra-aural, circum-aural and insert), which are used to determine audibility threshold for pure tones as well as speech.(1)

With supra-aural earphones, which are the conventional tranducers used in clinical audiology, the pad of the earphone is pressed against the auricular pavilion. Due to the large area of the cranium exposed to the vibrations of these transducers, it is possible for individuals with severe neurosensory hearing impairment to have vibration responses, thereby rendering the exact measurement of hearing sensitivity in such patients impossible, especially at low frequencies.(2)

ER-3A insert earphones were designed to reproduce the electro-acoustic characteristics of TDH-39 earphones. However, the manufacturer recommends correction factors when these transducers are used with equipment calibrated for supra-aural earphones.(3) The area of contact between the insert earphones and skin is minimal. This reduces the area of the head exposed to the sound stimulus due to the adaptation of the earphones within the external auditory meatus by means of disposable foam rubber plugs, which leads to a reduction in vibration responses.

A number of studies have concluded that insert earphones allow for a more comfortable exam and enable greater reliability of the exam in comparison to supra-aural earphones. Inserts are also reported to offer greater attenuation of ambient noise, greater interaural attenuation, reducing or even eliminating the need for contralateral masking; a reduction in the occlusion effect in testing through the bone pathway; and a significant reduction in the risk of a narrowing of the external auditory meatus.(4, 5, 6, 7) However, a number of authors cite the disadvantages of insert earphones, such as the geometric variability of the external auditory meatus, insufficient dynamic range at high frequencies and problems related to hygiene with the use of sponge plugs.(1, 8, 9, 10)

The aim of the present study was to determine the influence of transducer type on the acquisition of hearing thresholds in individuals with severe neurosensory hearing impairment, comparing the responses between the use of TDH-39 supra-aural earphones and ER-3A insert earphones.

## Method

The present study received approval from the ethics committee of the Universidade Federal de São Paulo (process number 1044/07). All subjects received information on the procedures to be performed and signed terms of informed consent authorizing their participation in the study (in compliance with Resolution 196/96).

The sample was selected and evaluated at the Audiology Clinic of the Audiology/Phonology Department of the Universidade Federal de São Paulo. Individuals sent for a hearing exam in order to obtain the benefit of free public transportation were evaluated. The following were the eligibility criteria: severe, symmetric, bilateral, neurosensory hearing impairment, with a remaining hearing capacity of no more than 1000 Hz; Type A tympanometric curve; and absence of evident neurological and/or cognitive impairment.

All the individuals were submitted to anamnesis, followed by meatoscopy.

The subjects underwent a hearing evaluation composed of tonal threshold audiometry (air and bone pathways) and logoaudiometry (voice-detection threshold - VDT). The hearing evaluation was performed in a sound booth, with an MA-41 Interacoustics audiometer, calibrated based on the ANSI 1969 standard. Tonal threshold audiometry and speech audiometry were carried out with the use of TDH-39 supra-aural earphones, followed by the use of ER-3A insert earphones. For the use of the ER-3A insert earphone on the same equipment, the following correction factors were added to the threshold values obtained, as suggested by the manufacturer (Etymotic Research, 1985): 250Hz = 5dB; 500Hz = 0dB; 1000Hz = 5dB; 2000Hz = 5dB; 3000Hz = 5dB; 4000Hz = 0dB; 6000Hz = -10dB; 8000Hz = -10dB. According to the manufacturer's recommendations, the insertion of the plug should be placed deep (2 to 3 mm) in order for the insert to achieve the ideal performance, ensuring a total insertion depth of approximately 16 mm into the external auditory meatus, measured from the plane of the conch.(3, 11, 12).

During the study of the audibility thresholds (performed at frequencies of 250 to 8000 Hz), the participants were instructed to raise their hand for all stimuli heard, even at a weak intensity. The initial test was at 1000 Hz, followed by hearing thresholds at frequencies of 2000, 3000, 4000, 6000, 8000, 500 and 250 Hz, in that order.

A descending method used to determine the threshold with each transducer, involving the following steps: a) the sound stimulus was presented at an intensity level easily perceived by the participant; b) the intensity was diminished by intervals of 10 dB until the stimulus became inaudible; c) the intensity was increased by intervals of 5 dB until the participant could perceive the sound again. The hearing threshold was considered the lowest intensity level the participant perceived in two out of four presentations (50% of times).

In the speech audiometry (VDT), the participants were instructed to raise their hand for all speech stimuli heard. The VDT was performed using a speaker phone initially at 100 dB NA and the lowest intensity level at which sound was detected was then determined.

For the statistical analysis, the non-parametric Wilcoxon and Mann-Whitney tests were used. For statistical purposes, when an individual did not respond, a value of 10 decibels above the maximal output of the device was considered. Results with statistical significance are highlighted with an asterisk (*); those with a tendency toward significance are highlighted with the number sign (#). Confidence intervals were constructed with 95% statistical confidence. The level of significance was set at 5% (0.05).

## Results

One hundred fifty individuals were evaluated and 50 were selected for the study, as the remaining individuals did not fulfill the eligibility criteria. Among the 50 participants, 25 were female and 25 were male, with ages ranging from 17 to 55 years (mean = 35.52) and 16 to 55 years (mean = 33.56), respectively.

The anamnesis revealed that 82% of the participants had congenital hearing loss and 18% had acquired hearing loss. Twenty-four percent experienced dizziness and 6% had ringing in the ears.

Tables 1 to 3 display the results obtained from the TDH-39 supra-aural earphones and the ER-3A insert earphones as well as their comparisons according to gender and ear side (right or left).

TABLE 1. Descriptive values (mean, median and standard deviation) of the hearing thresholds obtained using the supra-aural TDH-39 earphones and ER-3A insert earphones on 50 male and female individuals.

| Transducers | | Mean | Median | Standard Deviation | p-value |
|---|---|---|---|---|---|
| 250 Hz | ER-3A | 88.8 | 90 | 12.85 | 0.025* |
| | TDH-39 | 85.0 | 85 | 11.07 | |
| 500 Hz | ER-3A | 96.7 | 95 | 11.50 | 0.483 |
| | TDH-39 | 95.3 | 95 | 9.89 | |
| 1 kHz | ER-3A | 109.1 | 110 | 8.12 | 0.014* |
| | TDH-39 | 106.1 | 105 | 8.66 | |
| 2 kHz | ER-3A | 114.9 | 115 | 9.10 | 0.751 |
| | TDH-39 | 115.4 | 115 | 9.99 | |
| 3 kHz | ER-3A | 121.7 | 120 | 10.52 | 0.124 |
| | TDH-39 | 119.5 | 120 | 11.58 | |
| 4 kHz | ER-3A | 122.4 | 130 | 12.86 | 0.562 |
| | TDH-39 | 123.4 | 130 | 11.48 | |
| 6 kHz | ER-3A | 117.5 | 120 | 8.72 | 0.690 |
| | TDH-39 | 117.5 | 120 | 8.45 | |
| 8 kHz | ER-3A | 108.9 | 110 | 5.84 | 0.235 |
| | TDH-39 | 107.8 | 110 | 8.02 | |
| VDT | ER-3A | 85.9 | 85 | 12.03 | 0.507 |
| | TDH-39 | 86.7 | 85 | 9.46 | |

Legend: kHz = kilo hertz; p<0.05 Wilcoxon; VDT = voice-detection threshold.

TABLE 2. Descriptive values (mean, median and standard deviation) of difference in hearing thresholds obtained using the supra-aural TDH-39 earphones and ER-3A insert earphones in the right and left ears of 50 male and female individuals.

| Difference | | Mean | Median | Standard Deviation | p-value |
|---|---|---|---|---|---|
| 250 Hz | RE | -5.60 | -5.0 | 8.37 | <0.001* |
| | LE | -2.10 | 0.0 | 8.58 | |
| 500 Hz | RE | -1.90 | 0.0 | 5.52 | 0.336 |
| | LE | -0.80 | 0.0 | 6.17 | |
| 1 kHz | RE | -2.90 | -5.0 | 4.53 | 0.672 |
| | LE | -3.00 | -5.0 | 4.74 | |
| 2 kHz | RE | 0.30 | 0.0 | 6.26 | 0.754 |
| | LE | 0.70 | 0.0 | 5.98 | |
| 3 kHz | RE | -2.10 | 0.0 | 6.32 | 0.665 |
| | LE | -2.20 | 0.0 | 6.16 | |
| 4 kHz | RE | 1.30 | 0.0 | 4.93 | 0.480 |
| | LE | 0.80 | 0.0 | 5.28 | |
| 6 kHz | RE | 0.50 | 0.0 | 2.72 | 0.047* |
| | LE | -0.50 | 0.0 | 3.54 | |
| 8 kHz | RE | -1.10 | 0.0 | 4.55 | 1.000 |
| | LE | -1.10 | 0.0 | 4.08 | |
| VDT | RE | 0.40 | 0.0 | 6.38 | 0.257 |
| | LE | 1.20 | 2.5 | 7.18 | |

Legend: kHz = kilo hertz; p<0.05 Wilcoxon; VDT = voice-detection threshold; RE = right ear; LE = left ear.

TABLE 3. Descriptive values (mean, median and standard deviation) of difference in hearing thresholds obtained using the supra-aural TDH-39 earphones and ER-3A insert earphones in individuals of each gender (female and male).

| Difference | | Mean | Median | Standard Deviation | p-value |
|---|---|---|---|---|---|
| 250 Hz | Female | -1.50 | 0.0 | 8.28 | 0.004* |
| | Male | -6.20 | -5.0 | 8.36 | |
| 500 Hz | Female | -0.40 | 0.0 | 5.52 | 0.150 |
| | Male | -2.30 | 0.0 | 6.08 | |
| 1 kHz | Female | -2.80 | 0.0 | 4.76 | 0.444 |
| | Male | -3.10 | -5.0 | 4.51 | |
| 2 kHz | Female | 1.00 | 0.0 | 5.71 | 0.428 |
| | Male | 0.00 | 0.0 | 6.47 | |
| 3 kHz | Female | -2.60 | 0.0 | 6.08 | 0.399 |
| | Male | -1.70 | 0.0 | 6.36 | |
| 4 kHz | Female | 1.10 | 0.0 | 5.47 | 0.810 |
| | Male | 1.00 | 0.0 | 4.74 | |
| 6 kHz | Female | 0.00 | 0.0 | 1.75 | 0.500 |
| | Male | 0.00 | 0.0 | 4.16 | |
| 8 kHz | Female | -0.90 | 0.0 | 4.00 | 0.477 |
| | Male | -1.30 | 0.0 | 4.61 | |
| VDT | Female | 3.00 | 5.0 | 6.47 | 0.001* |
| | Male | -1.40 | 0.0 | 6.39 | |

Legend: kHz = kilo hertz; p<0.05 Wilcoxon; VDT = voice-detection threshold.

## Discussion

Table 1 displays the descriptive values of the hearing thresholds with the TDH-39 supra-aural earphones and ER-3A insert earphones in 50 male and female individuals. The insert earphones obtained higher hearing thresholds at 250 Hz, 500 Hz, 1000 Hz, 3000 Hz and 8000 Hz than those obtained with the TDH-39 supra-aural earphones, with statistically significant differences at 250 Hz and 1000 Hz. These results may be explained by the fact that individuals with severe bilateral neurosensory hearing impairment can exhibit a vibration response with supra-aural earphones, especially at low frequencies (250 Hz, 500 Hz and 1000 Hz), due to the large area of the cranium exposed to vibration, which hinders the exact measurement of hearing sensitivity in these patients. The same does not occur with insert earphones.

Vibration responses can compromise the adequate referral of a case and, in some situations, may explain the differences in performance with the use of amplification in individuals with severe hearing impairment who have some remaining hearing capacity at low frequencies, as such individuals may exhibit a lesser benefit with the use of amplification. In the specialized literature, we found one study that cited a reduction in responses that are more vibratory than auditory as one of the advantages of insert earphones.(2) The present study confirms this finding.

Regarding the other frequencies (Table 1), the results were either the same or similar between the two types of transducers (maximal difference of 1.7 dB). However, caution should be used when considering these results, as few individuals in the sample had remaining hearing capacity above 1000 Hz. Thus, the similarity between the devices should not be generalized to populations with other hearing characteristics.

Table 2 displays the differences in the results between the TDH-39 and ER-3A transducers in each ear separately. This difference was obtained by subtracting the mean of the results with the supra-aural and insert earphones for each ear. The difference between transducers was greater in the right ear at 250 Hz, 500 Hz, 4000 Hz, with a statistically significant difference only at 250 Hz. At the other frequencies, with the exception of 6000 Hz and 8000 Hz, and for the VDT, the difference was greater in the left ear, but without achieving statistical significance. At 2000 Hz, 4000 Hz, 6000 Hz (only in the right ear) and for the VDT, the thresholds obtained with the TDH-39 earphones were higher than those obtained with the ER-3A earphones.

Table 3 displays the differences in results obtained with the TDH-39 and ER-3A earphones between genders. The difference between transducers was greater among males at 250 Hz, 500 Hz, 1000 Hz and 8000 Hz, with a statistically significant difference favoring the TDH-39 earphones only at 250 Hz, meaning that the hearing threshold obtained with the ER-3A earphones was higher than that obtained with the TDH-39 earphones. At the other frequencies and for the VDT, this difference was greater among females, with a statistically significant difference favoring the ER-3A earphones only for the VDT, meaning that the hearing threshold obtained with the TDH-39 earphones was higher than that obtained with the ER-3A earphones.

A large number of studies cite variables that interfere in the obtainment of hearing thresholds with insert earphones, including individual differences in the geometry of the external auditory meatus.(1,9,10) A number of researchers cite this geometric variability as one of the disadvantages of insert earphones.(1,8,9,10) Considering the differences in size and geometry of the auditory meatus between men and women, we may expect differences in hearing thresholds when using insert earphones. As the external auditory meatus is smaller and shorter in women than in men, it can be inferred that the residual space in the auditory meatus after the insertion of the sponge plug is also smaller in women, which would contribute toward a reduction in the amount of physiological noise in this space and would consequently enable obtaining lower thresholds.(9) This may explain the finding in the present study of significantly poorer thresholds with insert earphones among men when compared to the supra-aural earphones, whereas, for women, the results between transducers were similar or better with the insert earphones when compared to the supra-aural earphones.

The results of the present study demonstrated vibration responses with the use of supra-aural earphones. This demonstrates the usefulness of insertion earphones on individuals with severe hearing impairment in order to delineate a more effective rehabilitation strategy for such individuals.

## Conclusion

From the analysis of the results, we may conclude that individuals with severe bilateral neurosensory hearing impairment require higher hearing thresholds with the use of insert earphones (ER-3A) than the use of supra-aural earphones (TDH-39) at low frequencies (250 Hz and 1000 Hz). This difference between transducers was found to be greater in the right ear and among males at 250 Hz.

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