

## Background

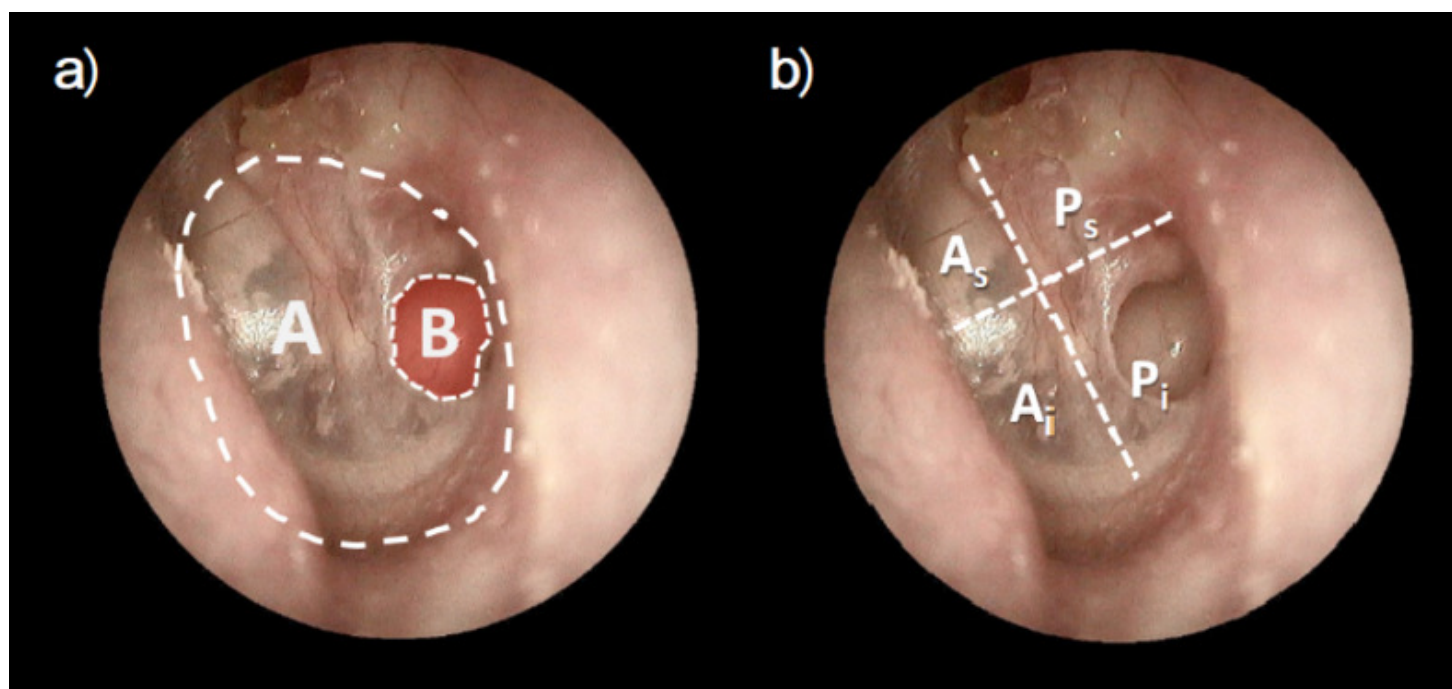
The two most commonly used Real-Ear Measurements (REM) are the Real-Ear Unaided Gain (REUG) and the Real-Ear-to-Coupler Difference (RECD). The REUG estimates the inherent resonance properties of the ear canal, while the RECD quantifies the difference in sound pressure levels between an individual's ear canal and a standardized 2cc coupler, enabling the conversion of measurement units between various transducers.

Tympanic membrane perforation, whether resulting from trauma, chronic otitis media, or iatrogenic factors, often alters the acoustic properties of the ear canal, affecting both REUG and RECD, with important implications for hearing aid fitting.

This study aims to investigate the impact of tympanic membrane perforations on real-ear measurements, focusing on differences in REUG and RECD between individuals with and without perforations

## Methods

The study included 28 participants with normal tympanic membranes, and 25 participants with tympanic membrane perforations, for a total of 51 and 31 ears evaluated, respectively.



**Figure 1:** a) The perforation size was determined by calculating the ratio between the perforation area (B) and the total tympanic membrane area (A). b) The perforation location was classified based on its position within the quadrants of the tympanic membrane.

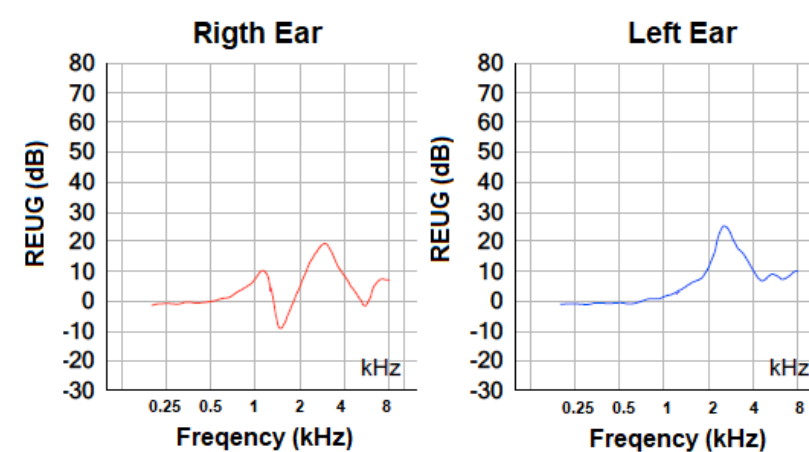
## Results

Size	No.	Percentage
Small	16	51,61 %
Medium	11	35,48 %
Large	3	9,68 %
Subtotal	1	3,23 %

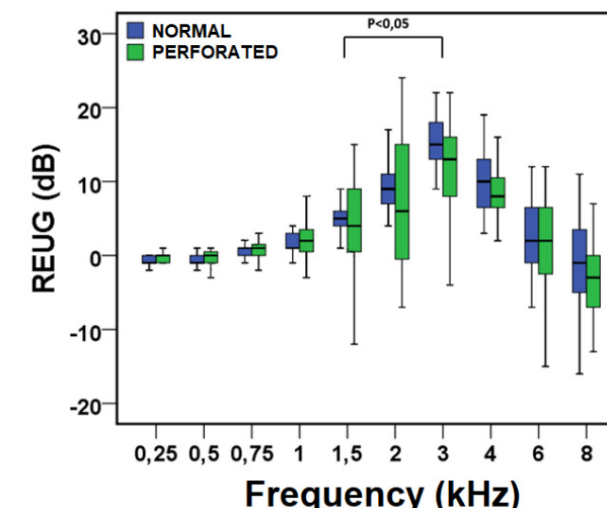
Table 1: Tympanic membrane perforation sizes

Site	No.	Percentage
Anterior Superior (A <sub>s</sub> )	16	23,19 %
Anterior Inferior (A <sub>i</sub> )	18	26,08 %
Posterior Superior (P <sub>s</sub> )	14	20,29 %
Posterior Inferior (P <sub>i</sub> )	21	30,43 %

Table 2: Tympanic membrane perforation sites



**Figure 2:** The REUG in the right ear of a patient with a tympanic membrane perforation shows the typical bimodal pattern, while the left ear, with an intact membrane, displays a normal REUG response.

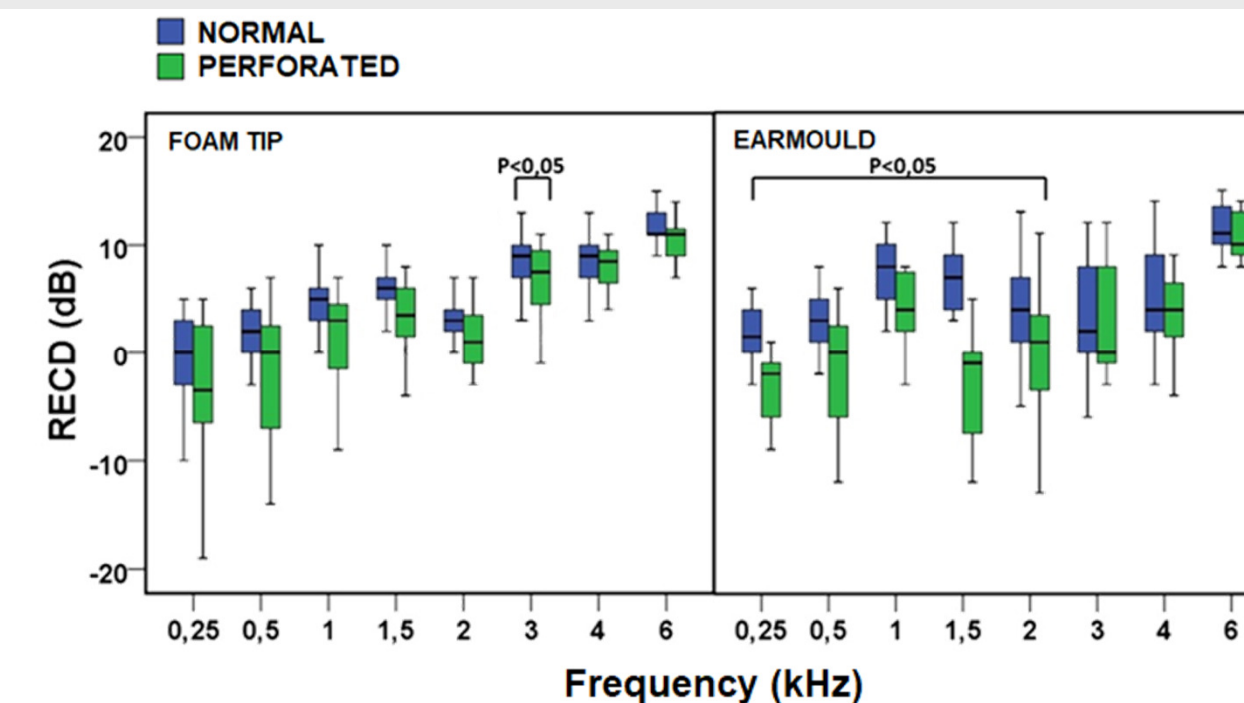


**Figure 3:** Box plot comparing the REUG measurements between participants with normal and perforated tympanic membranes.

The statistical analysis found no significant correlations between the size or location of the tympanic membrane perforations and the measurements of REUG or RECD in the participants with perforated tympanic membranes.

The independent-samples t-test conducted between the REUG obtained in the two groups (Figure 3) demonstrates statistically significant differences across the frequency range of 1.5 kHz to 3 kHz ( $p > 0.05$ ).

The analysis of the RECD between the two groups (Figure 4) revealed statistically significant differences. These differences were observed at the 3 kHz frequency for RECD measurements obtained using a foam tip ( $p > 0.05$ ), as well as across the frequency range of 0.25 to 2 kHz for RECD measurements obtained with earmoulds ( $p > 0.05$ ).



**Figure 3:** Box plot comparison of the RECD measurements between participants with normal and perforated tympanic membranes, obtained using foam tips or earmoulds.

## Conclusion

This study demonstrates that individuals with tympanic membrane perforations exhibit altered acoustic properties in their ear canals. These alterations are characterized by a bimodal REUG and reduced gain at resonant frequencies, as well as significant differences in RECD measurements compared to individuals with normal tympanic membranes. Such acoustical changes can lead to inaccuracies in hearing aid fittings. The findings underscore the importance of utilizing individualized REM assessments to prevent underestimation of gain and ensure effective hearing aid prescriptions for individuals with tympanic membrane perforations.

## References

Martin, H. C., Munro, K. J., & Lam, M. C. (2001). Perforation of the tympanic membrane and its effect on the real-ear-to-coupler difference acoustic transform function. *British Journal of Audiology*, 35(4), 259–264.

Moryl, C. L., Danhauer, J. L., & DiBartolomeo, J. R. (1992). Real ear unaided responses in ears with tympanic membrane perforations. *Journal of the American Academy of Audiology*, 3(1), 60–65.