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# Cochlea Roughness and Its Effect on Teoae Behavior for the Same Stimulus Level

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**ABSTRACT**

Otoacoustic emissions (OAEs) are considered an indication of a response either to a stimulus or spontaneously in the absence of a stimulus, as OAEs display the frequency range and response time (latency) and show the effects of random roughness present along the basilar membrane in the cochlea. The primary goal is to determine whether roughness is responsible for the change in the behavior and activity of the OAE by observing the wave behavior and the propagation of transient otoacoustic emissions (TEOAEs), which gives an interpretation in the frequency domain of your acoustic behavior of the non-linear model and to help accurately determine hearing thresholds and determine the presence of impairment.



## Introduction

For inclusive assessment of auditory function, there are different techniques for auditory testing that provide a focused assessment of specific areas along the pathway from the cochlea territory to the brain territories[1]. Roughness, hoarseness, and breathiness. these are the dimensions that make up the acoustic sample and the auditory evaluation of the sound quality. The listener makes a judgment about this sample[2]. A well-damped oscillatory movement of the entire middle ear structure initiates the absorption of sound energy by the cochlea when a traveling disturbance is released along the basilar membrane inside the conventional cochlea. The source of excitation must be on the basilar membrane and extend over the region of the mechanical impedance gradient. It is here assumed that the impedance discontinuities originate in the cochlea, due to the mechanical response of the transmission mechanism to the stimulus which leads to reflection of the traveling wave[3]. Echoes or ringing (delayed secondary responses) of varying amplitude centered near the best frequency for the measurement site[4]. Evoked otoacoustic emissions, or EOAEs, are signals generated in the cochlea as a result of its response to an external stimulus. As for the structure of the cochlea, when EOAEs show a difference in amplitude and phase with frequency, these periodic differences with frequency are known as the fine structure of the cochlea[5]. Therefore, OAEs objective assessment of cochlear function in the inner ear is considered a clinical measurement tool[6]. TEOAEs and stimulus frequency otoacoustic emissions (SFOAEs) in humans, according to recent theoretical and experimental studies, are mostly generated by second linear reflection[7], while nonlinearity arises in the cochlea mechanism as a result to respond to acoustic stimulation is the result of the cochlear echo measured in the outer ear due to the biomechanical presence of the organ of Corti in the inner ear[8]. The ability to measure inside it revealed large and unexpected movements in the reticular lamina, as well as extending to enhanced and nonlinear responses in these areas to characteristic frequencies. Analyzing the vibrations within it to understand the mechanical processing that leads to adjusting the frequency/location of the cochlear amplification and measuring the movement of the traveling wave over tectorial membranes in vivo; Measuring vibration using a pure tone stimulator at several longitudinal locations, it was observed that the tectorial membranes had a larger and more pronounced peak that reached the maximum response[9]. TEOAEs appear in clinical performance as a transient echogenic response to stimuli, including clicks, tone bursts, or chirps[10].

OAEs testing is a non-invasive method through which we obtain information about disorders of an essential element in sound processing. OAEs also arise through the same physical mechanism, and these emissions provide the possibility of obtaining detailed, more powerful, and frequency-specific information about the functional state of the middle and inner ears and their specific feedback control mechanisms[11]. It is also an easy-to-use method for objective cochlear function, which is important for assessing hearing sensitivity and thus allows for the assessment of loss of sensitivity, pressure, and frequency selectivity[12]. It is also necessary to perform newborn screening because the integrity of the auditory system is important in verbal communication, individual communication, and social interaction[8]. Important information about the mechanisms of generating emission is available from a comparison between the physical retard of the wave packet and the phase gradient retard, measurable in the time domain using a transient stimulus[13].

**Method**

The effect of different amounts of roughness on the cochlear membrane for a stimulation level was tested several times when this was done at the hearing threshold of 2.5 kHz at click 0.2 ms, with different roughness levels 0.01, 0.003, 0.0003and the extent of its effect by studying the resulting audiograms that show the excited transient acoustic emissions, this was done using a non-linear model, which is one of the models that simulates the ear. Monitoring its behavior in the distribution of energy through the relationship between latency and frequencies.

**Results and Discussion**

The study was conducted in steps using a nonlinear model showing the simulated TEOAE response to a pSPL pulse. These resulting emissions allow us to represent the time frequency of the same signals, highlighting response peaks at different time intervals in each frequency band, perhaps related to different generation mechanisms. Behavioral observation of the time domain of nonlinear activity of TEOAE that shows energy distribution and waveform behavior response. The level dependence or growth of TEOAE is related to the form of compressive mechanical nonlinearity that appears in the cochlea, so studying the level dependence or growth of emission is a good way to find out whether the measured emission in the stimulation frequency ranges.

Firstly, the results of different values of roughness of the stimulation plane on the

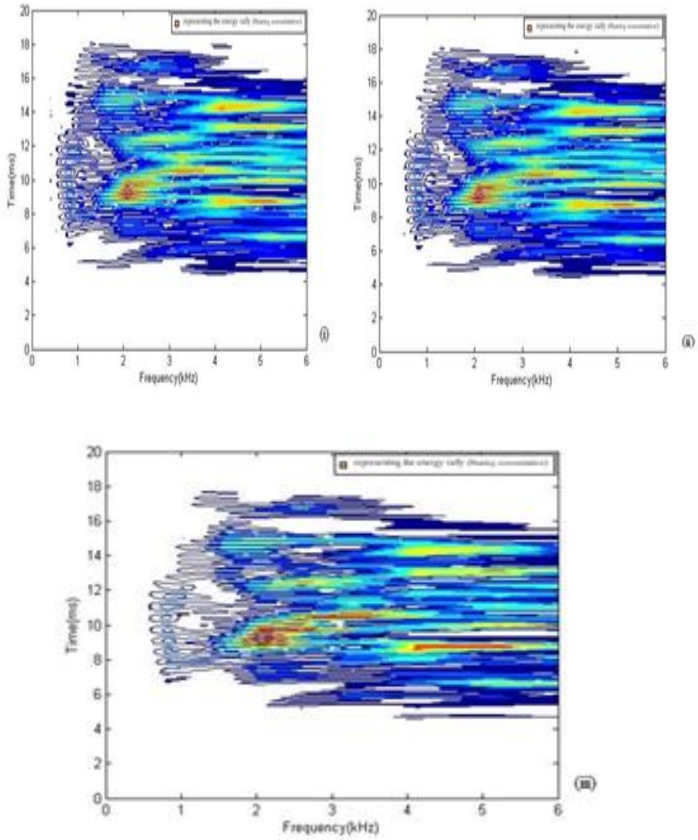



**Fig. 1 illustrates the energy distribution of TEOAEs at a stimulation level of 50 dB at roughness** value (i) the first value of roughness, (ii) the second the roughness value, (iii) the third state after changing the roughness

In comparison the three cases of cochlear interactions and their response to different roughness values on the BM in the cochlear parameters through OAE, which are shown in Figure 1, it is clearly shown by their concentration within the auditory frequency range in the three cases, where the energy distribution and concentration of TEOAEs reach a maximum frequency range of 6 kHz, where emissions are in good condition and not distorted or missing. Study these values of roughness by monitoring the state of excitation (TEOAEs) of the waveform behavior of the latency-frequency relationship, as shown in Fig. 2, time-frequency plot of the simulated OAE.

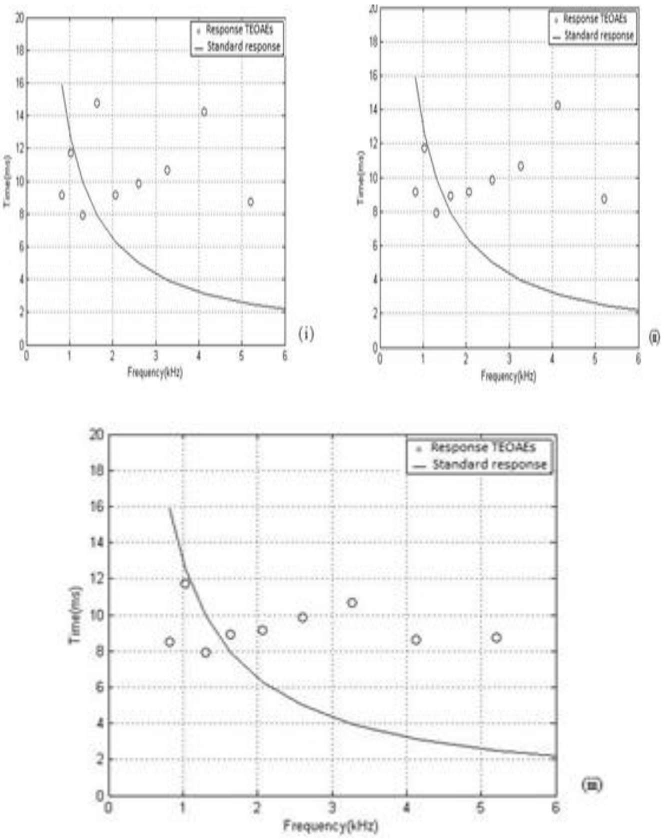
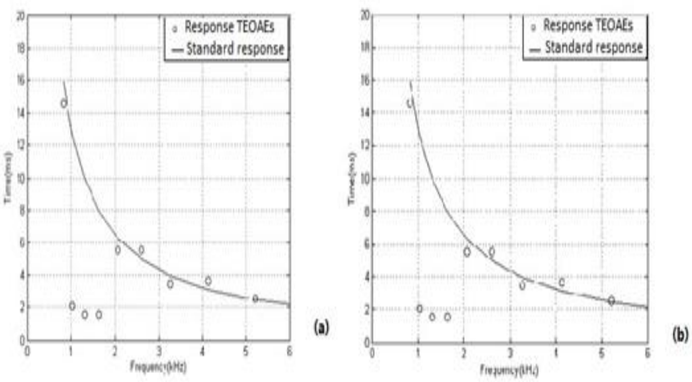



**Fig. 2 illustrates the waveform behavior TEOAEs at a 50 dB stimulation level at** (i) the first value of roughness (ii) the second the roughness value (iii) the third state after changing the roughness

The response to the roughness values is found from the wave behavior, as well as the excitation to attenuation, where the OAEs showed a non-linear response and within the natural frequency range, as the three cases above show the distribution of the TEOAEs signal that tends and spreads up the curve for three values of the roughness coefficients. Figures 1 and 2 give the emission spectra at frequencies for a stimulation level. The other part is to take the roughness factor and control its quantity on the basilar membrane in the cochlea and see the wave behavior and the extent of activity of the OAEs oscillators, as shown in the figure shown below.



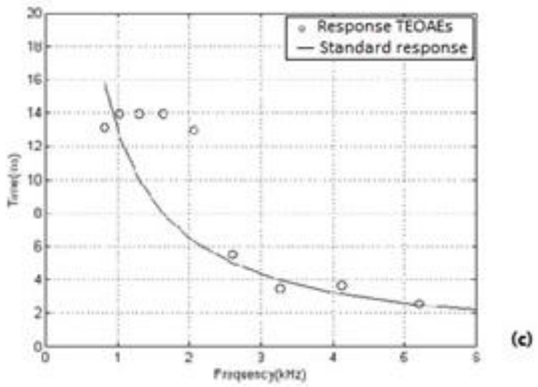



**Fig. 3 illustrates the waveform behavior TEOAEs at a 50 dB stimulation level and BM response to the initial roughness position (a), its increase to reach (b) (c). for the relationship latency-frequency**

The other side is when studying the wave behavior and the responses of the oscillators to OAEs, here we notice that when the roughness was removed, we noticed that the oscillators froze and no activity appeared for the TEOAEs, as in Fig. 3a. The inactivity of the emissions continued even when the basilar membrane of the cochlea was supplied with a very small percentage, and as the result showed in Fig. 3b, but this result did not persist. Providing the membrane with roughness only gave rise to the activity of oscillators and provoked OAEs at the top of the curve, as in Fig.3c, meaning that it generates synchronous mechanical forces that are then transferred to the BM to show TEOAEs.

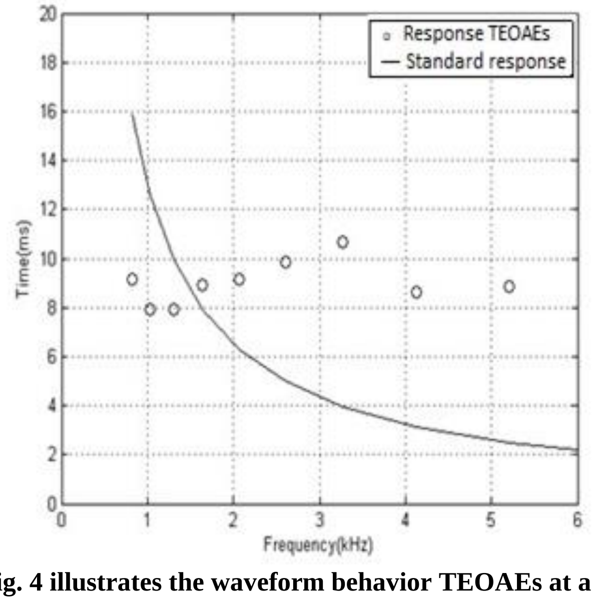



**Fig. 4 illustrates the waveform behavior TEOAEs at a 50 dB stimulation level and BM response to increased roughness to a greater level.**

As for Figure 4, when the roughness reached its highest levels on the basilar membrane of the cochlea, it showed activity of OAEs similar to the activity in the first case shown in Figure 2 when the cochlea was provided with different values of roughness.

Using frequency as an observational variable, we recorded data across different frequency bands for the three emission monitoring positions, and the magnitudes of the response components of click-evoked OAEs were studied. Initially, the energy distribution of TEOAEs was beyond 1 kHz, and in the case of higher waveform activity, TEOAEs also appeared with the same value, extending to 6 kHz. Moreover, the behavior of emissions is related to the parameters and may reveal the importance of all the main components that are necessary in detecting impairment or dysfunction of the auditory process.The results obtained from studying the behavior of the OAEs for the distribution of energies and wave behavior showed that the presence of roughness, despite its different values, showed emissions from the cochlea, but when we removed the amount of roughness, it affected the behavior of the emissions.

**Conclusion**

The non-linear behavior of the energy distribution and the wave behavior showed that the presence of roughness, despite its different values, gave TEOAEs in different cases and ranges, the OAEs, freezing them and not sparking them, which means that their presence is an important factor that affects the otoacoustic emissions. The absence of roughness led to the cessation of emissions, which gives an indication that the absence of this factor affected the cochlea, which means that damage to the acoustic process may occur, which may be the factor of roughness, enhancing the sensitivity to BM vibrations in the cochlea, including the dependence of the frequency adjustment on the intensity of the stimulus, this result is consistent with previous studies[14,15].

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