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Study the Relationship between Roughness and Stimulus Levels and Their Impact on OAEs

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ABSTRACT

The term "roughness" describes the random heterogeneity in the mechanisms of splitting the cochlea along the basilar membrane (BM) and this characteristic (heterogeneity) may determine the emission status at different levels of stimulation. In the context of this research work, the relationship between levels of severity and roughness was studied, and this study was carried out using the nonlinear model by monitoring the transient-evoked otoacoustic emissions (TEOAEs) in each change. It was showed that otoacoustic emissions (OAEs) were affected by changes in roughness and classification of low, medium and high stimulation levels.

Keywords: Roughness; OAE; Stimulus levels; TEOAEs

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INTRODUCTION

Otoacoustic emissions (OAEs) are signals that are generated in the cochlea, in the absence of external stimulation, in which case they are known as spontaneous optoacoustic emissions. OAEs are cochlear responses that give important information about cochlear function. These emissions can be evoked by clicks, short stimulus, or by continuous tones, as well as a combination of tones[1]. There are two OAEs in the cochlea: nonlinear deformation and coherent linear processing[2]. In modern theory and through the studies that have been tried, it is suggested that the acoustic emissions of stimulus-frequency otoacoustic emissions (SFOAEs) and transient-evoked otoacoustic emissions (TEOAEs) are generated mostly by linear and reflection position[3]. The changeful wave may be mainly reflected by the irregularity of small distances, and other studies of reflectivity resulting from heterogeneity in the long and extensive pattern of activity have been reviewed[4]. In 1983, the experimental results of Shera and Cooper also indicate two non-independent phenomena, namely the relationship between ripples in the spectral response spectrum OAE and BM spectrum[5].

The growth rates and varying TEOAE response time have made such an interpretation of the uncertainty about the emission response time and the difference in the growth rates of different acoustic emission components that it may transform the main response universe by increasing the level of stimulation so that latency is intermittent[6]. Helmholtz Use the terms of sensory indigestion and roughness to describe the texture of the sound in terms of clean or unpleasant qualities. At present, it is appropriate to use the term roughness to be considered more general[7], while in the mechanism of the division of the cochlea and according to Zweig and Shera is through the introduction of roughness, which is a random heterogeneity in the cochlear model and the introduction of roughness on the map of the frequency to be extended along the BM and this leads to hearing threshold fine structures and the generation of various OAE[8].

To date, most attempts to model OAE fine structures in terms of linear cochlear reflection have completely ignored the influence of nonlinearity. However, both nonlinearity and distributed roughness are thought to be present and to play significant roles in the function of the cochlea. It is thus important to characterize more precisely their combined effects. Taking into account of the influence of nonlinearity on cochlear fine structure provides the basis for extending the range of levels over which the phenomena can be analytically described. Distributed roughness and nonlinearity are believed to play an important role in the work and employment of the cochlea, taking into account the fact that nonlinearity affects the structure of the cochlea in order to provide capacity for the range of levels and enable us to describe these phenomena in analysis[9], Yates and Withnell discussed the effect of distributed and linear roughness on TEOAEs by external clicks[10], the roughness of the cochlea breaks the progressive identification so integration is not empty in the real cochlea[11].

METHOD

The calculations were carried out using the non-linear model, one of the models that simulated emission in the ear. Different values of roughness were used, as well as the use of different levels of stimulation starting from 30 dB to 90 dB. This work was done in three stages according to the change in the roughness values in the BM.

RESULTS AND DISCUSSION

The purpose of this work is to study the relationship between BM roughness and stimulus levels and their effect on otoacoustic emissions (OAEs). The BM, which extends along the cochlea, is characterized by its ability to distinguish frequencies where this membrane is filled with sensory cells that form the cochlear nerve. The relationship between roughness and stimulus levels was studied by studying the behavior of TEOAEs using the nonlinear. Different levels of stimulation were used, and different values of roughness were used. The idea was to see the behavior of TEOAEs according to the roughness values and their effect on different levels Low, medium and high stimulation. The results were obtained using a nonlinear model by observing the transient evoked otoacoustic emission by studying the latency-frequency relationship.

Case I: Low levels of stimulation

In this case, the 30 dB stimulation level was taken as a low level to study the effect of varying BM roughness on the otoacoustic emission status.

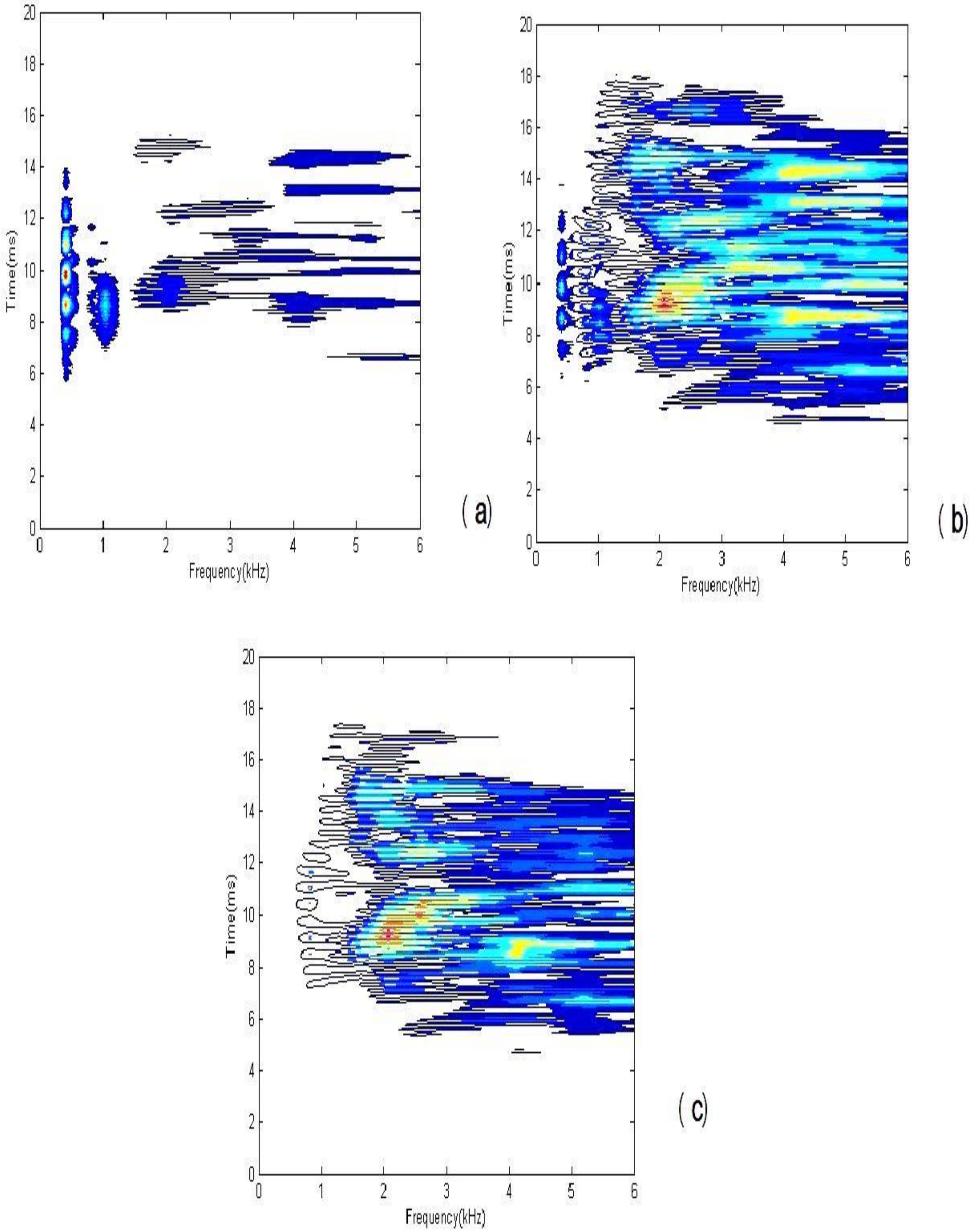

Figure 1. Shows the energy distribution of TEOAEs to 30 dB level for three different values of roughness

Figure 1 shows the energy distribution of TEOAEs obtained from the nonlinear model of three values of roughness for the same stimulus level. (Fig. 1, left) shows that TEOAEs were not present or absent in the frequency range of up to 6 kHz, where the roughness in this case less than the other two cases taken. However, when the roughness values were changed at this level, clear emissions were observed where (Fig.1,right) shows the energy distribution in most of the frequency band and also the presence of TEOAEs in the hearing sensitive frequencies at (c). These results indicate that not all roughness values may affect OAEs at low levels, which means that the impact of roughness at these levels is partial and that the level and echo TEOAEs and their growth rates reckon on the pattern and the amount of roughness in the cochlea.

Case II: Medium levels of stimulation

The level of stimulation here is 50 dB as the medium level and in this case the emission behavior is studied when there is a roughness with different values.

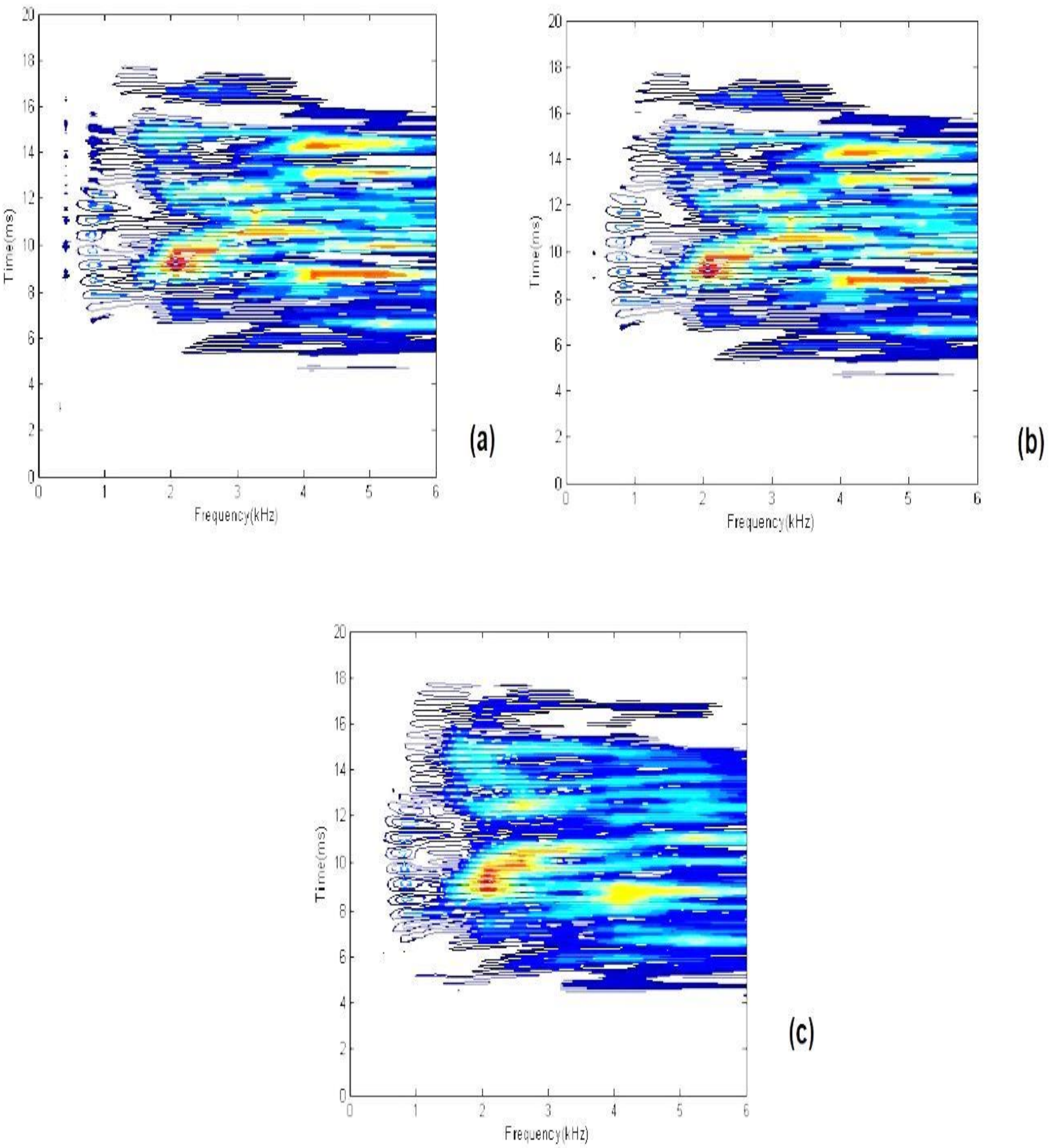

Figure 2: Shows the energy distribution of TEOAEs to 50 dB level for three different values of roughness

At different levels of roughness in the basilar membrane at this level, the process of emission from the ear can be seen, and the energy distribution within the range of natural frequencies of hearing as well as the growth of OAEs in the rightmost as in Figure 2 (left and right), and this gives an indication of the impact of roughness at these levels of stimulation as described above for the studied cases. The intermediate levels, which are within the good sound range and sensitive to hearing, showed TEOAEs responses to the various roughness patterns, as well as the continuous distribution of energy and this indicates the importance of roughness and its impact.

Case III: High levels of stimulation

90 dB was taken to a highest level of stimulation to study its relationship with changes in roughness levels and the status of its TEOAEs.

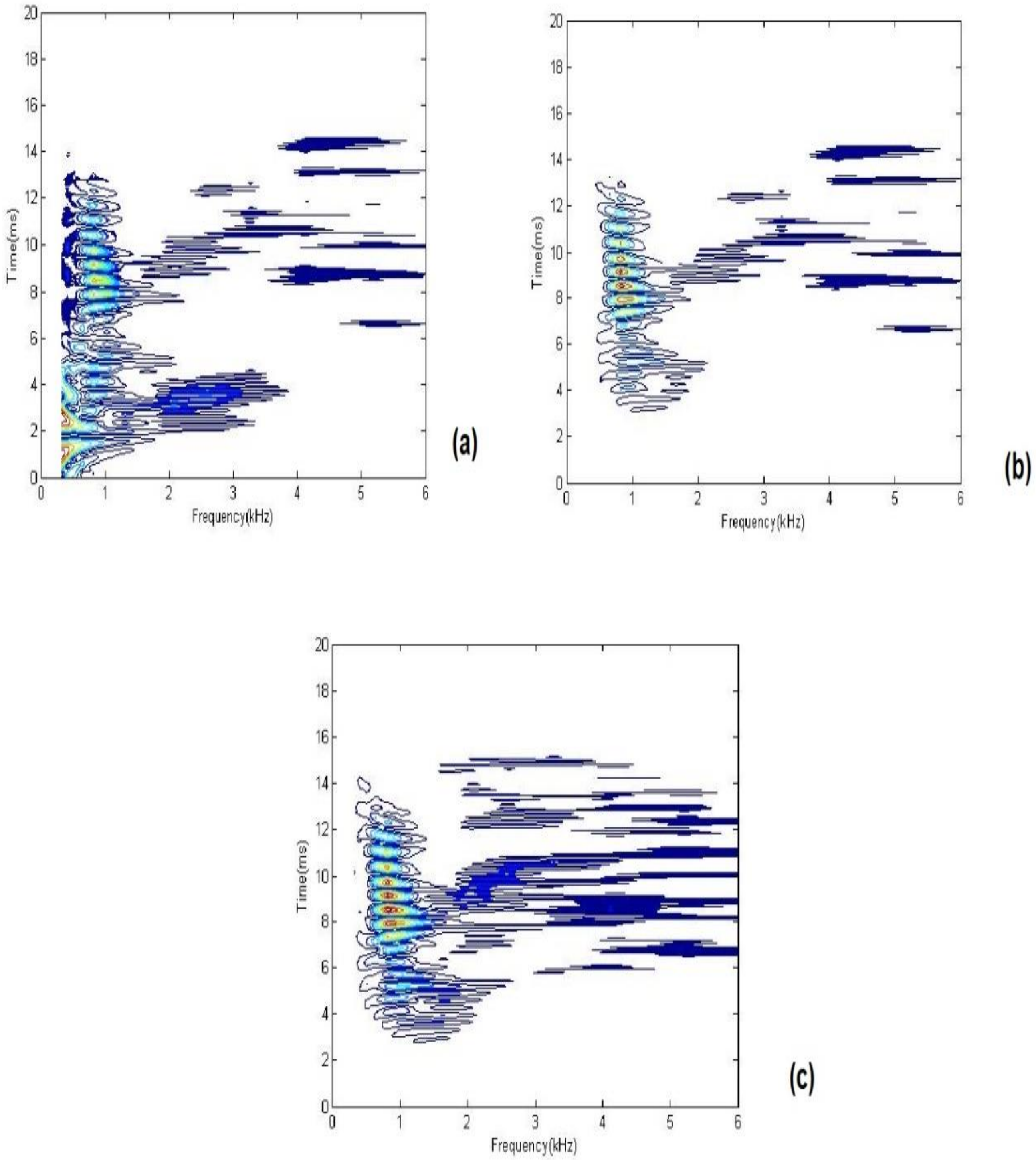

Figure 3: Shows the energy distribution of TEOAEs to 90 dB level for three different values of roughness

At this level, it was observed that the response to the roughness was not clear and the differences between the responses were low and that the OAEs were in the low frequency band where the TEOAEs were limited to a frequency of less than 1 kHz. As noted in Figure 3, the right side is free of OAE, which meant that the high stimulation level caused the emission reduction in the ear and that the change in roughness had a lower effect at these levels. Despite the different roughness patterns at this level, the emission is shown to be restricted at these levels. The results showed that high levels were the least affected by the change in roughness and there was a variation in the effect at low levels. Some values showed an effect and other values of roughness did not show any effect, whereas the results showed a relationship between the levels of stimulation and the feature of roughness and their impact on OAEs clearly showed the levels of medium stimulation, which are within the range of sensitive hearing, which means that the relationship between them affected OAEs and this is an indication that roughness has an impact on the auditory process and this result is consistent with the previous study[12]. The results also showed that the growth and response of OAEs are dissimilar in different patterns of roughness of the same level, where there is a difference for each pattern of different random roughness.

CONCLUSION

Compared to previous studies and in agreement with previous investigations (Zweig and Shera, 1995; Talmadge *et al.*, 1998; Talmadge *et al.*, 2000; Shera and Guinan, 1999) [2, 4, 9, 13], it was found that the results obtained showed that OAEs were affected by cochlear roughness, which means that they affect hearing efficiency. The most prominent points derived from the results of this work can be explained as follows:

1. OAEs were affected by the relationship between the levels of stimulation and the roughness feature. The results showed that not all levels of stimulation had the same efficiency and response to roughness, and that their effect was entirely at some levels and at other levels was a molecule.
2. The studied middle levels (50, 60 and 70), which are sensitive levels of hearing, have been shown to be strongly affected by roughness, which means that one of the most important signs of the efficiency of the hearing process is the presence of cochlear roughness.
3. 50 dB, it was observed that the presence of different amounts of roughness in the basal membrane gave emissions within the sensitive ranges and this result indicated that the presence of roughness at intermediate levels has a clear effect on acoustic emissions, and this suggests that the presence of roughness at these levels has an effect on the auditory process. Thus, the roughness in general has an effect on the state of emission and thus on the auditory process and this is consistent with studies[3,12].
4. Not only the roughness in the cochlea has an effect on the auditory process, but the case of roughness also affects it, as shown in Figs. 1, 2 and 3 of cases a, b, c.

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Conflict of Interest: None to declare.

Ethical Clearance: All experimental protocols were approved under the Department of Medical Physics, College of Science, Al-Karkh University of Science, Baghdad, Iraq and all experiments were carried out in accordance with approved guidelines.

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