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FINE STRUCTURE DISTORTION PRODUCT OTOACOUSTIC EMISSION DURING PREGNANCY

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ABSTRACT

Level of both ovarian hormones increases from the normal levels during process of pregnancy, which alter functioning of cochlea affecting hearing sensitivity. Then in order to quantitatively monitor minute changes within the cochlea OAE's are used. Therefore present study was undertaken with aim to understand the variations in fine structure DPOAE between the three trimesters of pregnancy. Participants included were healthy pregnant women within the age group of 19 – 40 years. Three groups of 30 women each (n=90), grouped on the basis of their trimester of pregnancy (1st, 2nd, or 3rd) participate in this study. Significant effect were observed on fine structure DPOAE (ripple prevalence, ripple density and ripple spacing) when compared across trimesters of pregnant women. Overall fine structure DPOAE across the three trimesters of pregnancy had effect and these effects were more pronounced in the low frequencies hearing.

KEY WORDS: **Fine structure DPOAE, Ripple prevalence, Ripple density and Ripple spacing, Pregnancy.**

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INTRODUCTION

Oto-acoustic emissions (OAEs) are low-level sounds that are produced in the cochlea and which are transmitted back via the middle ear into the external ear canal, where these emissions can be recorded using sensitive miniature microphone systems.These OAE's are used in order to quantitatively monitor minute changes within the cochlea and for early identification of the cochlear component of a hearing disorder, which is otherwise undetectable by other audiological methods.[1] Distortion-product otoacoustic emissions (DPOAEs) are those distortions which are produced in the cochlea in response to two concurrent pure tones (f1 and f2, f1<f2), and can be recorded from those frequencies that are related to the stimulus frequencies mathematically.[2] The experimental data on DPOAE suggest that large amplitude response is obtained at frequency 2f1-f2.[3] Clinically, DPOAEs are commonly measured at few stimulus frequency pairs per octave and provide a snapshot of overall outer hair cell function. However, when recorded using more closely spaced stimulus frequencies, a pattern of alternating maxima and minima in both DPOAE level and phase is obtained, known as fine structure.[4, 5] This fine structure is understood to essentially be an interference pattern between multiple integrals of the DPOAE at 2f1-f2.[4] Pregnancy is a process of fertilization and development of one or more offspring in humans. Pregnancy approximates nine months and its course is often described as lasting three trimesters, each trimester being approximately three months.[6] The first trimester consists of the first 12 weeks of pregnancy and during this stage there will be a sudden drop of estrogen level in mother's body, which will affect her hearing sensitivity.[7] Second trimester consists of 13 to 28 weeks of the pregnancy and most of the hormonal variation will stabilize at this stage. During the third trimester, that is, 29 to 40 weeks of the pregnancy, the hormonal variation will reach its peak level.[6] During the period of pregnancy, auditory symptoms such as variations in auditory sensitivity, aural fullness or tinnitus have been reported.[8, 9] These symptoms are found to be associated with auditory neuropathy, Meniere's disease, otosclerosis, and preeclampsia.[10] OAE's are used to quantitatively monitor minute changes within the cochlea, thus enabling early identification of the cochlear component of a hearing disorder, which is otherwise undetectable by other audiological methods.[1] During the process of fertilization and development of offsprings in humans, the level of both ovarian hormones increases from the normal levels, which alter functioning of cochlea affecting hearing sensitivity. Thus understanding the changes in cochlear hair cell functioning across trimesters in pregnancy due to variation in hormones level becomes essential. Thus the present study was undertaken with an aim to understand the variations in fine structure DPOAE between the three trimesters of pregnancy.

METHODS

This is cross sectional normative design study, which followed nonrandom convenient sampling.

Participants

Three groups of 30 women each (n=90), grouped on the basis of their trimester of pregnancy (1st, 2nd, or 3rd) conceded to participate in the study. Participants included healthy pregnant women within the age group of 19 – 40 years. The following exclusionary criteria were employed: history or presence of any otological diseases (like ear discharge, malformation, etc.), history or presence of any degree of hearing loss before pregnancy, history of any disease condition (HELLP Syndrome, jaundice, measles, etc.) before or during pregnancy.

Instrumentation

Fine structure DPOAE data from the three different groups (1st, 2nd and 3rd trimester) were recorded in a sound treated room using the computer-based DPOAE analyzer GSI Audera. DPOAEs were documented for a total of 47 pairs of frequencies between 500Hz to 8000Hz with a resolution of 12 points per octave. A constant f2:f1 ratio of 1.2 was maintained across all conditions.[11, 12] In this study, DPOAE data was denoted with reference to the f2. Intensities of f1 and f2 were maintained constant at 65/55 dB SPL. Data acquisition for each frequency took approximately 30 seconds, regardless of the signal to noise ratio. The frame was not accepted if it exceeded the 30dB SPL rejection criterion or if the intensity level f1 and f2 of pure tone fluctuated by more than 2 dB from the target criterions. These test rejection/acceptance criteria were adopted to maintain reliability and uniformity in instrumentation generally incorporated across clinical settings.[13]

Procedure

Pure tone audiometry was initially done to evaluate the hearing sensitivity of the participants at octave frequency bands between (250 Hz - 8 KHz). A pure tone average of up to 25dB hearing level was considered for recruiting participants in concurrence with Kemp (1978); as OAEs are present only when subjective threshold levels are better than 30dB hearing level. Immitance audiometry (GSI Tympstar) was done to rule out any middle ear pathology since OAEs are transferred via middle ear to the ear canal from the cochlea and OAE characteristics are directly influenced bythe conduction properties of the middle ear. Only the 'A' type of tympanograms were considered as indication for normal middle ear functioning. In a sound treated room, each participant was asked to sit on a comfortable recliner and remain as quiet as possible throughout the session. Disposable ear tips were used to cover the probe and seal them snugly in the ear canal during testing while emissions were recorded. All fine structure DPOAE measurements were completed in a single session. The recorded data of fine structure DPOAE comprised of peaks and valleys in the Dp-gram. Ripples were examined on the basis of three parameters in line with earlier recommendation[14]: ripple spacing, which is the frequency difference between two minima; ripple density or the level difference between a maxima and the mean of the minima, and ripple prevalence, which is the number of ripples >3 dB in height per 1 octave. Only maxima which were 6 dB beyond the noise floor estimate were considered for data analysis.[15]

Analysis
The recorded Dp-grams were analyzed by two audiologists for the identification of ripple prevalence, ripple spacing, and ripple density of the fine structure DPOAE. Only data exhibiting an agreement between the audiologists in the three above mentioned parameters was employed for analysis. This obtained data was then tabulated and statistically analyzed using the statistical software SPSS version 16.0. Two-way repeated measures ANOVA and the adjusted Bonferonni t-test were adopted to investigate the significant effects of fine structure DPOAE across the three trimesters of pregnancy. Only p values < 0.05 were deemed statistically significant.

RESULTS

Effect of pregnancy on ripple prevalence
Two-way repeated measures of ANOVA were employed to investigate the difference in ripple prevalence across different trimester and octave band of fine structure DPOAE. Results revealed a significant main effect of trimesters on ripple prevalence [F (2,58) = 5.837, p=0.005]. Result also revealed significant effect of ripple prevalence on octave bands [F (3, 87) = 37.245, p=0.000]. Analysis of the data also indicate a significant interaction effect of trimesters on octave bands [F (6, 174) = 6.555, p = 0.000]. Since an interaction effect did exist, the Bonferroni pair wise comparison was adopted to scrutinize this difference between trimesters. Result of the same revealed a significant difference only between 1st and 2nd trimesters (p= 0.015) with no significant difference between 1st and 3rd trimesters (p> 0.005), and 2nd and 3rd trimesters (p>0.005). Two-way ANOVA with repeated measures was further carried out to evaluate the difference across the frequency band width 500-1KHz in each of the 3 trimesters. Analysis revealed a significant difference between 1st and 2nd (p=0.020), and 2nd and 3rd (p=0.015) trimesters' for frequency band width of 500-1KHz, but no statistically significant difference between the 1st and 3rd trimesters' was seen for the frequency band width of 500-1KHz (p> 0.05). On adopting the same statistical procedure across the 4-8 KHz frequency bandwidth, results obtained revealed a significant difference between the 1st and 2nd (p=0.000), and the 1st and 3rd (p=0.001) trimesters. In figure 1 prevalence of number of ripple as a function of octave bands across trimesters are shown.

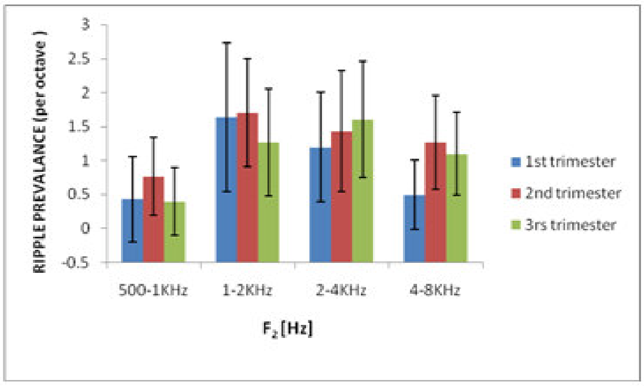

Figure 1
Comparison of ripple prevalence (Mean ± 1 SD) as a function of four octave bands across different trimesters.

Effect of pregnancy on ripple density
To assess the main effect on Ripple density across different trimester and octave band of fine structure DPOAE, a two-way repeated measures ANOVA was performed. Results revealed a statistically significant main effect of trimesters on ripple density [F (2, 58) = 31.96, p=0.000]. Results also revealed that ripple density had a significant effect on octave bands [F (3, 87) = 64.75, p=0.000]. Further analysis indicated a significant interaction of trimesters on octave bands [F (6, 174) = 41.95, p = 0.000]. Since an interaction between octave bands across trimesters was obtained, pairwise comparison with Bonferroni correction was carried out to evaluate the difference between trimesters. Results revealed a significant difference between the 1st and 2nd trimesters (p=0.001), and the 1st and 3rd trimesters (p= 0.007) with no significant difference between trimesters 2nd and 3rd (p>0.05). Two-way ANOVA with repeated measures was again employed to assess differences across the frequency band width of 500-1KHz in each trimester. Analysis revealed a significant difference between the 1st and 2nd (p=0.000), and the 2nd and 3rd (p=0.000) or frequency band width of 500-1kHz, but no statistical significance was observed between trimesters 1st and 3rd (p>0.05). In figure 2 shows ripple density as a function of octave bands across trimesters.

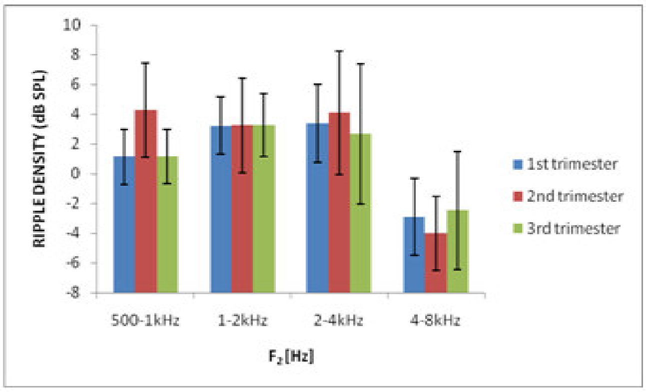

Figure 2
Comparison of ripple density (Mean ± 1 SD) as a function of four octave bands of different trimesters.

Effect of pregnancy on ripple spacing

Two-way repeated measures of ANOVA were employed to investigate the difference in ripple spacing across different trimester and octave band of fine structure DPOAE. Results revealed a significant main effect of trimesters on ripple spacing [F (2,58) = 10.24, p=0.000]. Results also revealed that ripple spacing had an effect on octave bands [F (3, 87) = 82.640, p=0.000]. Further analysis of the data also indicated a significant interaction effect of trimesters on octave bands [F (6, 174) =6.5, p = 0.000]. Since a statistically significant effect existed for octave bands across trimesters, the adjusted Bonferroni pairwise comparison was adopted to scrutinize the difference between trimesters. Results revealed a significant difference between 1st and 2nd trimesters (p=0.001), and 1st and 3rd trimesters (p=0.007) but no significant difference between trimesters 2nd and 3rd (p >0.05). Two-way ANOVA with repeated measures was again employed to evaluate the disparity for the frequency band width of 500-1KHz in each of the 3 trimesters. Analysis revealed, there was a significant difference between 1st and 2nd (p=0.011) trimesters for the frequency band width of 500-1kHz. Frequency band width of 4-8 KHz also revealed that there is significant difference between 1st and 2nd (p=0.001), 1st and 3rd (p=0.020) trimesters frequency band width. In figure 3 shows ripple spacing as a function of octave bands across trimesters.

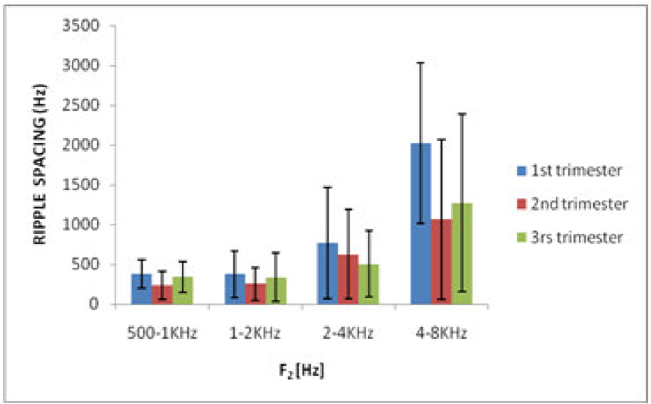

Figure 3
Comparison of ripple spacing (Hz) (Mean ± 1 SD) as a function of four octave bands of different trimesters.

DISCUSSION

The state of pregnancy is a period associated with compromised auditory function such as a low frequency sensorineural hearing loss and a reduced loudness tolerance mimicking a cochlear pathology. During pregnancy, not only do the levels of ovarian hormones steeply increase, other physiological changes taking place as well.[16] These changes result in the retention of fluids and subsequently hyper dynamic circulation, which may influence the circulation in the cochlea and consequently the cochlear fluid homeostasis. Empirical research has suggested that outer hair cell functioning can be compromised due to a variety of factors, ranging from hypertension to vascular hemorrhages in inner ear or even excessive variations in ovarian hormones. These can result in compromised auditory function during pregnancy.[17] Statistical analysis showed a significant effect of pregnancy on fine structure DPOAE (ripple prevalence, ripple density and ripple spacing) when compared across trimesters of pregnant women. There was statistical significance difference between 1st and 2nd trimesters; however there was no significant difference between 1st and 3rd trimesters, and 2nd and 3rd trimesters. Overall 1st and 3rd trimester groups had lower ripple prevalence, higher ripple spacing and lower ripple density compared to the 2nd trimester group. The present finding is in accordance earlier observation, who reported disappearance of peaks and dips in fine structure DPAOE at early stages of outer hair cell dysfunction.[18] This difference across the trimesters may be due to the changes in body systems, such as cardiovascular system, hematological system and endocrine system. These changes begin from the 5th week of pregnancy continuing into the 8th week, and may entail a detrimental effect on auditory system at the level of cochlea.[17] Another possibility may be the variation in hormones leading to a sudden drop of the estrogen level in an expectant mother during the 1st and 3rd trimester of pregnancy which in turn affects the auditory function.[7] In 2nd trimester of pregnancy hormonal variations are stabilized.[6] Probably because of this, the fine structure DPOAE variations seen are comparatively stable. Therefore, it can be inferred that, during the 1st and 3rd trimesters of pregnancy, auditory functioning gets compromised to a higher extent than it in the 2nd trimester. Statistical significance was obtained between the 1st and 2nd, and 2nd and 3rd trimesters for ripple prevalence and ripple density while the same held true for ripple spacing only between the 1st and 2nd trimesters for the frequency band width of 500-1KHz. This difference obtained can be attributed to alterations in auditory function at low frequencies (125 Hz to 1000 Hz). A possible cause may be rapid metabolic and hormonal changes that lead to extreme salt and water retention, resulting in altered electrolyte balance within the cochlea during trimester 1 and 3, which increases as pregnancy advances.[7] Interestingly there was no statistical significance obtained between 1st and 3rd trimesters. This can be credited to rapid hormonal variation during these trimesters, resulting in similar fine structure DPOAE across both trimesters. Statistical significance was also obtained for the frequency band width of 4-8 KHz for ripple prevalence and ripple spacing between 1st and 2nd, 1st and 3rd trimesters. More specifically, the reduced number of ripple prevalence and wider ripple spacing may be implicitly linked to alterations in auditory function at higher frequencies. Alterations in auditory function at higher frequencies during normal pregnancy as a function of changes in blood coagulation and fibrinolysis ('hyper coagulable state') and vascular occlusion of microcirculation inside the cochlea also is recognized.[19] Auditory function alteration at higher frequencies (4-10 KHz) during pregnancy is also reported to be due to increased levels of systolic blood pressure.[20] This can be ascribed to the fact that the basal end of the cochlea is supplied by an extremely rich capillary network of stria vascularis which ensures the proper functioning of outer hair cells. Any pathological or physiological irregularities in this supply can cause more impact on high frequency sounds compared to low frequency sounds.[21] Statistical significance was not observed at 4-8 kHz frequency band width for ripple density. This could be because of the limited frequency resolution of fine structure DPOAE, i.e. 12 point per octave. With higher frequency resolution however, it may be possible to obtain more reliable outcomes. There was no statistical significance observed between frequency band widths of 1-2 KHz and 2-4 KHz for ripple prevalence, ripple spacing and ripple density, probably due to normal functioning of the cochlea at mid frequencies. These results seem to suggest that the hormonal, vascular and metabolic variations that occur during normal pregnancy may be inconsequential across the mid frequency region.The available literature advocates no change in auditory function at these frequencies. Similar findings were have been reported earlier.[22] They concluded of negligible changes in auditory functioning at the mid frequency for pure tone thresholds, which may explain unchanged fine structure DPOAE at the mid frequency. However, shifts in auditory function for the low frequencies were evident.

CONCLUSION

It can be concluded that pregnancy has an overall effect on fine structure DPOAE across the three trimesters and these effects are more pronounced in the low frequencies as compared to higher frequencies across the trimester.

CONFLICT OF INTEREST

We declare that the Authors of paper submitted "Fine structure distortion product otoacoustic emission during pregnancy" for publication in International Journal of Pharma and Bio-Sciences has no conflicts of interest.

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