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Audiological Assessment in Type 2 Diabetes Mellitus Patients with Otoacoustic Emissions (OAE)

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Abstract **Original Research Article**

Hearing loss is an increasing problem globally. It may be worsened by some medical conditions like hypothyroidism, diabetes, hyperlipidemia etc. the present study is to evaluate the hearing loss in 50 patients of type 2 diabetes mellitus in comparison with 50 nondiabetic subjects by audiological assessment using otoacoustic emissions (OAE). All the subjects belong to either gender and are within the age group of 30-50 years. All the subjects are tested for two types of evoked OAE [Transient Evoked otoacoustic emissions (TEOAE) and Distortional Product otoacoustic emissions (DPOAE)]. Random blood sugar analysis and HbA1c tests were done to assess the glycemic status and control.Overall the study sample is male predominant. In diabetics, the mean RBS level was 193.85 ± 50.83 mg/dl, the glycemic control status, i.e., HbA1c level was 7.39 ± 0.86. In the diabetic patients around 30(60%) patients had audiological complaints, of these decreased hearing is in 15 (30%), tinnitus in 10(20%) and both in another 5 (10%) members and the remaining 20(40%) members did not have audiological problems. In diabetics the results showed alterations in the TEOAE in 36(72%) members and DPOAE in 39 (78%) members. Both the DPOAE and TEOAE showed that the mean SNR (signal noise ratio) values were lower in all frequencies in diabetics when compared to nondiabetics; however the values were significantly reduced in higher frequencies. Hearing loss is mostly effected by diabetes among the people belonging to age group of 46 to 50 years. This study concludes that the diabetics are at a greater risk of developing auditory dysfunction. It is recommended that all newly diagnosed diabetic cases should undergo a complete audiological evaluation and regular follow up is warranted for early detection of damage to auditory functions.

Keywords: Type 2 diabetes mellitus, Hearing loss, Otoacoustic emissions, Transient Evoked otoacoustic emissions, Distortional Product otoacoustic emissions, signal noise ratio, auditory assessment.

INTRODUCTION

Diabetes mellitus is a common medical problem due to insulin resistance. Its prevalence has been estimated to be 425 million people worldwide and around 72.9 million people in India [1] [2]. People with diabetes mellitus are at increased risk of developing chronic health complications. Hyperglycemia can affect the heart and blood vessels, eyes, kidneys and nerves [3]. Changes in the inner ear are also identified. It is believed that one of the causes of hearing loss in individuals with DM is microangiopathy, that can interfere with the supply of nutrients and oxygen from the cochlea. This can affect either directly by reduction of oxygen and nutrient transport caused by the thickening of the walls of the capillaries or indirectly, by reducing the blood flow due to vascular narrowing, leading to the death of cells and biological tissues. In addition to the cochlear changes, the DM can also cause secondary degeneration of the eighth cranial nerve, provoking neural hearing loss [4, 5].

Hearing loss is the fourth highest cause of disability worldwide, with an estimated annual cost of over 750 billion dollars. The WHO has estimated that there are approximately 466 million people with disabling hearing loss globally [6]. Hearing loss is the 15th greatest cause of the burden of disease as disability-adjusted life years (DALYs)in both sexes and all ages [7].

Hearing loss is defined as an unaided, measured, bilateral pure-tone hearing loss at frequencies of 500, 1000, and 2000 Hz averaging 40 dB or more in the better ear on the most recent audiological evaluation conducted by a qualified professional [8]. It may be worsened by some medical conditions like hypothyroidism, diabetes, hyperlipidemia, among others.

Since many studies have reported contradicting results regarding hearing impairment in diabetic patients, this present study is undertaken in the Department of ENT, Government ENT Hospital, Visakhapatnam to evaluate the hearing loss in type 2 diabetes mellitus with Transient Evoked otoacoustic emissions (TEOAE) and Distortional Product otoacoustic emissions (DPOAE).

MATERIALS AND METHODS

The present study was a hospital based cross-sectional study, between September 2018 to August 2019,which includes 50 cases of known diagnosed patients of type 2 diabetes mellitus who attended the out-patient department of ENT, Government ENT hospital / King George Hospital, Visakhapatnam, which is a tertiary care referral hospital, and the control group includes 50 nondiabetics who were the attendants of the inpatients and volunteers from staff of Government ENT Hospital, Visakhapatnam. The study population includes the people between 30 to 50 years of age and of both genders.

The exclusion criteria were the people out of the age group of 30 to 50 years, having a history of middle ear disease, head injury, ear surgery and cigarette smoking, exposed to noise trauma and intake of ototoxic drugs, systemic diseases like hypertension, and family history of hearing loss.

Prior permission from the institutional ethics committee was taken. For all the patients, informed consent was taken, detailed history and duration of diabetes was noted, routine ENT examination was done, an otoscopic examination was done to rule out any middle ear pathology. Audiological evaluation with TEOAE and DPOAE was done. Maico Ero-Scan OAE screener (Figure-1) was used. Random blood sugar analysis and HbA1c tests were done to assess the glycemic status and control.

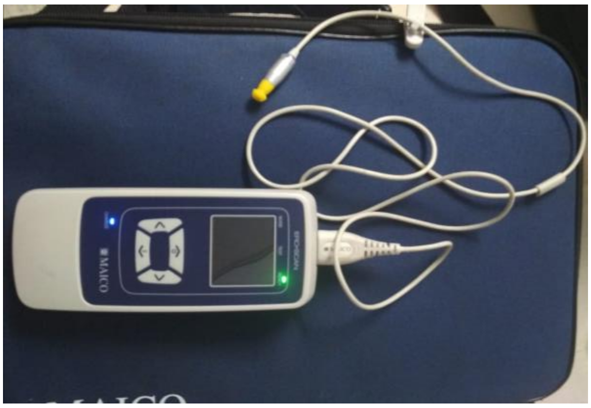

Fig-1: Maico Ero-Scan OAE Screener

The OAE are measurable sounds produced due to cochlear functions and are by-products of this cochlear amplifier mechanism. In 1948 Thomas Gold and RJ Pumphrey proposed that the motility of Organ of Corti in living cochlea was the probable biomechanism for the sensitivity and precision of the human cochlea. David Kemp recorded the sound generated by the biological activity of normal human cochlea, which were called as Otoacoustic emissions (OAE). They are of two types: spontaneous and evoked .

Spontaneous OAE (SOAE) generated automatically found in 50% of normal humans, and they are of low intensity, continuous, very narrow band or pure tone sounds, average intensity -3 dB to 2.6dB. Detection of SOAE in an ear indicates that the hearing threshold is within normal limits in and around the frequency at which SOAE is generated.

Evoked OAE is of two types a) Transient Evoked (TEOAEs) b) Distortional Product (DPOAEs).

TEOAE uses a click stimulus that will elicit a response from a large part of the basilar membrane with a latency span of several milliseconds. Clicks or tone bursts mainly generate a response from 1000 to 4000 Hz. This response can be separated into frequency bands for further analysis of cochlear function. When hearing thresholds are >20dB, then TEOEAs are expected to be present in 99%. An absent response indicates a hearing loss of >30dB.

For the DPOAE testing, two pure tones of different frequencies are presented simultaneously (F1 and F2, F2/F1 = 1.22), with intensities of F1 and F2 as 65dB NPS (L1) and 55dB NPS (L2) respectively. These responses are called distortion products, and the most prominent is the cubic difference distortion product 2f1-f2. Frequencies 1.5; 2; 2.5; 3; 3.5; 4; 4.5; 5; 5.5; 6; 7 and 8 kHz were analyzed, this being considered present emissions when the signal/noise was greater than or equal to 6dB. DPOAE SNR (signal to noise ratio- SNR) has been considered to be better in detecting hearing loss than DPOAE amplitude. DPOAE is more frequency specific than TEOAE and is most reliable for testing high frequencies up to 8000Hz [9, 10].

STATISTICAL ANALYSIS

Data were analyzed according to averages and standard deviation. Chi-square test was used to verify the association between the variables. The data were tabulated and analyzed in the program IBM SPSS (*Statistical Package for the Social Sciences* -SPSS version 20.0).

RESULTS

The study results include 50 subjects of diabetics between the age group of 30 to 50 years, whose mean age was 44.41 years and in the control group of 50 people who were non diabetics, the mean age was 43.95yeras. Most of the patients belongs to the age group of 40 to 50 years.

In the study population of diabetics, 36(72%) were males, and 14(28%) were females, in the control group 35(70%) were males, and 15(30%) were females. Overall the study sample is male predominant. In diabetics, the mean RBS level was 193.85 ± 50.83 mg/dl, the glycemic control status, i.e. HbA1c level was 7.39 ± 0.86 and all are having less than 5 years duration of history of diabetes. In the diabetic patients around 30(60%) patients had audiological complaints, of these decreased hearing is in 15 (30%), tinnitus in 10(20%) and both in another 5 (10%) members and the remaining 20(40%) members did not have audiological problems. All the demographic details are mentioned in Table-1.

Table-1: Demographic details

	Diabetics	Non diabetics
Number Males Females	50 36(72%) 14(28%)	50 35(70%) 15(30%)
Mean Age (years)	44.41	43.95
Glycemic status RBS (mg/dl) (Mean ± SD)	193.85 ± 50.83	102.38 ±19.84
Glycemic control HbA1c (Mean ± SD)	7.39 ± 0.86	5.72 ± 4.1

On audiometric analysis with evoked OAE done in all the 100 members of the study sample, the recording of TEOAE and DPOAE were done and analyzed. In diabetics, the results showed alterations in the TEOAE in 36(72%) members, and DPOAE in 39 (78%) members, whereas in the control group showed alterations in TEOAE in 3 (6%) members and DPOAE in 4(8%).

Table-2: Distribution of signal, noise ratio (SNR) of TEOAE among the study groups

Frequency (Hz)	Diabetics		Non diabetics		
	Mean SNR	SD	Mean SNR	SD	p value
1000	11.7	7.8	12.56	7.9	0.198
2000	11.4	7.5	13.25	7.45	0.115
3000	10.98	7.0	12.31	6.89	0.096
4000	7.8	7.4	11.56	6.54	<0.001

Significant p value <0.05 : Chi-Square test

The results of TEOAE showed the mean signal noise ratio (SNR) decreased in all frequencies (Hz) at 1k,2k 3k and 4k in diabetics compared to nondiabetics and values are statistically significant at higher frequency 4000Hz (Table-2).

Table-3: Distribution of signal, noise ratio (SNR) of DPOAE among the study groups

Frequency (Hz)	Diabetics		Non diabetics		
	Mean SNR	SD	Mean SNR	SD	p value
2000	10.8	6.6	12.1	5.9	0.001
3000	9.8	6.1	13.28	6.84	0.001
4000	8.42	8.09	11.15	10.25	0.001
5000	11.75	9.26	14.78	10.42	<0.001
6000	8.85	10.79	12.14	11.48	0.001
7000	6.78	8.38	10.55	10.02	<0.001
8000	5.56	7.50	9.75	8.79	<0.001

Significant p value <0.05 : Chi-Square test

The DPOAE showed that the mean SNR values were lower in all frequencies in diabetics when compared to nondiabetics; however, the values were significantly reduced in higher frequencies (Table-3).

Table-4: Age distribution of absence of TEOAE and DPOAE among diabetics

Age group	Total Number	Absent TEOAE	Absent DPOAE
30 to 35	1	0 (0%)	0 (0%)
36 to 40	3	1(2%)	1(2%)
41 to 45	22	15(30%)	16(32%)
46 to 50	24	20(40%)	22(44%)
Total	50	36(72%)	39(78%)

Distribution of the absence of evoked otoacoustic emissions in the different age groups in the study population is mentioned in Table-4. Hearing loss is mostly affected by diabetes among the people belonging to the age group of 46 to 50 years.

DISCUSSION

This study has evaluated the hearing loss in patients with diabetes and the influence of hyperglycemia on hearing. In diabetics, the results showed alterations in the TEOAE in 36(72%) members when compared to the nondiabetics of the same age group whose results showed alterations in 3 (6%) members. DPOAE, which is more specific than TEOAE, showed absent of emissions in 39 (78%) members of the diabetic group, whereas in the control group showed alterations in 4(8%) members. Previous studies show the incidence of audiological problems ranging from 30% to 95%. Friedman *et al*., [11] showed a 55% incidence of hearing loss in diabetic patients. Kakarlapudi *et al*., [12] found that hearing loss was more common in diabetic patients (13.1% prevalence) than the control nondiabetic healthy subjects. Weng *et al.*, [13] noted that among the 67 diabetic subjects examined, 44.8% of them had hearing loss.

OAEs are recordable, and the absence of these can provide indication of cochlear pathology, even earlier to the other clinical tests. TEOAE evaluate cochlea as a whole and is restricted to 1 kHz to 5 kHz. The DPOAE evaluates a specific part of the cochlea and varies from 0.5 to 8 kHz. It is observed that the TEOAE recordings are not very frequency selective as compared to DPOAE [14].

In the present study, results of TEOAE showed the mean signal noise ratio (SNR) decreased in all frequencies (Hz) at 1k,2k 3k and 4k in diabetics compared to nondiabetics and values are statistically significant at higher frequency 4000Hz (Table-2).

In the present study, mean DPOAE SNR values for diabetics were lower in all frequencies (1000, 2000, 3000, 4000, 5000, 6000, 7000 and 8000 Hz) for diabetics. An early onset high frequency cochlear dysfunction in diabetics was indicated by lower SNR values with significant decrease for 4, 5 and 6 kHz. In the age group 41- 50 years, all frequencies showed a significant decrease in SNR in diabetic patients (Table-3). However, the present study failed to detect change in DPOAE SNR value, when compared on basis of duration of diabetes.

Similar results were reported by Lisowska et al. in their study, where DPOAE SNR value were significantly reduced in the diabetic group, but no correlation was ascertained between DPOAE SNR value and duration of diabetes [15].

Abo-Elfetoh *et al.*, also reported a decrease in DPOAE SNR value in diabetes especially at higher frequencies suggesting peripheral auditory system dysfunction [16].

Walter di Nardo studied, 47 diabetic patients and compared with controls. A significant difference in mean amplitude between patients and controls was found. DPOAE was reduced below 2SD of control mean in 32% of diabetic patients; however, no significant association between EOAEs and duration and control of diabetes was found [17].

The results of study conducted by Eren *et al.*, were contradictory to present study, in which no statistically significant difference is there between DPOAE amplitude (Ldp) between 40 diabetics and 24 control group in frequencies 1, 2, 2.5, 3,4, 5, 6, 7, and 8 kHz, however small study group can be a limitation of their study [18].

Bayindir *et al.*, investigated the role of glycaemic control on outer hair cell functions.They found that there is no statistical difference in DPOAE function in controlled and non-controlled diabetics [19].

The present study showing that DPOAE was valuable in assessing subclinical auditory dysfunction as a consequence of diabetes and can be utilised in early screening of central as well as outer hair cells damage, before conventional methods of audiological assessment. It is believed that one of the causes of hearing loss in individuals with DM is probably due to microangiopathy, that can interfere with the supply of nutrients and oxygen from the cochlea. This can affect either directly by reduction of oxygen and nutrient transport caused by the thickening of the walls of the capillaries or indirectly, by reducing the blood flow due to vascular narrowing, leading to the death of cells and biological tissues. This decreased blood flow may cause secondary degeneration in eighth cranial nerve leading to hearing defect. Also hyperglycemia may lead to changes in the glucose concentration of the inner ear which affects the hearing.

Diabetes mellitus can not only affect the peripheral and autonomic nervous system but can also equally involve the central nervous system. The auditory functions are also affected by diabetes, and various variables like age, sex, age of onset, duration, severity and control of diabetes are subject of research.

The results of the study suggest that diabetes have a definite and adverse effect on all constituents of the auditory system, which usually go unnoticed. The cochlear and retrocochlear auditory system needs regular evaluation in patients of diabetes. Diabetic patients should be instructed about this damage and how to prevent it, aiming to improve glycemic control [20], avoid exposure to loud noises, ear infections and tympanic membrane perforations, which can jeopardize healthy hearing of these patients [21].

BERA (Brainstem Evoked Response Audiometry) can prove to be an advantageous method to detect both eighth nerve and CNS impairment at the earliest. Apart from BERA, DPOAE is a reliable, non-invasive test for early identification of damage to cochlear functions. In view of a diverse results from the studies on the subject, standardisation of results might be required before implementation into routine clinical practice, which will require studies with large sample size and probably multicentric studies.

CONCLUSION

This study concludes that the diabetics are at definite risk of developing auditory dysfunction. It is recommended that all newly diagnosed diabetic cases should undergo a complete audiological evaluation on diagnosis and a regular half-yearly or yearly follow up is warranted for early detection of damage to auditory functions.

REFERENCES

1. Kumar V, Fausto N, Abbas AK, Cotran RS, Robbins SL. Robbins and Cotran: Pathologic Basis of Disease (7th Ed). Philadelphia, Pa.: Saunders;2005:1194-5.
2. World Health Organization. Definition and diagnosis of diabetes mellitus and intermediate hyperglycemia : report of a WHO/IDF consultation. World Health Organization, 2006.
3. International Diabetes Federation. IDF Diabetes Atlas. 7ed. Brussels, Belgium: International Diabetes Federation; 2015.
4. Akinpelu OV, Ibrahim F, Waissbluth S, Daniel SJ. Histopathologic changes in the cochlea associated with diabetes mellitus-a review. Otol Neurotol. 2014; 35(5): 764-74.
5. Rolim LP, Rabelo CM, Lobo IFN, Moreira RR, Samelli AG. Interação entre diabetes mellitus e hipertensão arterial sobre a audição de idosos. CoDAS. 2015; 27(5): 428-32.
6. Action On Hearing Loss. Hearing Matters Report. 2015. Available at:https://www.actiononhearingloss.org.uk/-/media/ahl/documents/research-and-policy/reports/hearing-matters-report.pdf.
7. WHO. The World Health Report 2001. Leading causes of disability adjusted life years (DALYs), in all ages and in 15– 44 year-olds, by Sex, estimates for 2000.
8. Case Definitions - Centers for Disease Control and Prevention. https://www.cdc.gov/ncbddd/developmentaldisabilities/casedefinitions.html
9. Shera CA, Abdala C. Section I: Otoacoustic emissions—mechanisms and applications .In: Kelly L. Tremblay, editor. Translational perspectives in auditory neuroscience hearing across the life span assessment and disorders. Plural publishing; 2012.
10. Gorga MP, Neely ST, Bergman B, Beauchaine KL, Kaminski JR, Peters J, et al. Otoacoustic emissions from normal-hearing and hearing-impaired subjects: distortion product responses. J Acoust Soc Am. 1993;93:2050-60
11. Friedman SA, Schulman RH, Weiss S. Hearing and diabetic neuropathy. Arch Intern Med. 1975 ;135(4):573-6.
12. Kakarlapudi V, Sawyer R, Staecker H. The effect of diabetes on sensorineural hearing loss. Otol Neurotol. 2003 ;24(3):382-6.
13. Weng SF, Chen YS, Hsu CJ, Tseng FY. Clinical features of sudden sensorineural hearing loss in diabetic patients. Laryngoscope.2005 ;115(9):1676-80.
14. Fernandes LC, Casais-Silva L, Ladeia AM. Dysfunction of the peripheral and central auditory pathway in patients with type 1 diabetes mellitus. J Diabetes Mellitus. 2012;2(1):76-81.
15. Lisowska G, Namyslowski G, Morawski K, Strojek K. Early identification of hearing impairment in patients with type 1 diabetes mellitus. Otol & Neurotol. 2001;22(3):316-20.
16. Abo-Elfetoh NM, Mohamed ES, Tag LM, El-Baz MA, Ez Eldeen ME. Auditory dysfunction in patients with type 2 diabetes mellitus with poor versus good glycemic control. Egypt J Otolaryngol. 2015;31:162-9.
17. Di Nardo W, Ghirlanda G, Paludetti G, Cercone S, Saponara C, Del Ninno M, Di Girolamo S, Magnani P, Di Leo MA. Distortion-product otoacoustic emissions and selective sensorineural loss in IDDM. Diabetes care. 1998 Aug 1;21(8):1317-21.
18. Eren E, Harman E, Arslanoglu S, Onal K. Effects of type 2 diabetes on otoacoustic emissions and the medial olivocochlear reflex. Otolaryngol-Head and Neck Surg. 2014;150(6):1033-9.
19. Bayindir T, Erdem T, Uze E, Toplu Y, San R, Ozturan O. Evaluation of the auditory effects in controlled and uncontrolled type 2 diabetes mellitus using otoacoustic emissions. Journal of Turgut Ozal medical center. 2010;17(4):337-41.
20. Yang C-H, Schrepfer T, Schacht J. Age-related hearing impairment and the triad of acquired hearing loss. Front Cell Neurosci. 2015.
21. Hong O, Kerr MJ, Poling GL, Dhar S. Understanding and preventing noise-induced hearing loss. Dis Mon. 2013;59(4):110–8.