HEARING STATUS IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

OBJECTIVES

The aim of this study was to assess the audiological characteristics of type 2 diabetes mellitus patients and to find out the association of hearing loss, if any with age, duration and metabolic control of disease.

MATERIAL & METHODS

This study assessed the hearing thresholds of 50 diabetic subjects and 50 age and sex matched healthy controls on pure tone audiometry. All the participants were also subjected to assessment of fasting and postprandial glucose levels, glycosylated haemoglobin levels, serum creatinine and presence of microalbuminuria.

RESULTS

This study found statistically significant ($p<0.001$) increments in pure tone audiometric thresholds in diabetic patients in comparison to the control population along with hearing loss in 58% diabetics. The hearing loss was of sensorineural type varying from mild-to-moderate grades. Age correlated positively with pure tone audiometric thresholds in diabetic subjects. The duration of diabetes affected the presence of hearing loss in diabetics, but it did not affect the severity of hearing loss in the patients. Sex and metabolic control of the disease had no association with SNHL.

CONCLUSION

The use of audiological tests to monitor diabetic patients should be considered as a routine procedure in the same way as eye fundus examination and microalbuminuria assessment are.

KEYWORDS

Pure tone audiometry, Sensorineural hearing loss (SNHL), Type 2 Diabetes mellitus.

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INTRODUCTION: Type 2 diabetes mellitus consists of an array of dysfunctions characterised by hyperglycaemia resulting from the combination of resistance to insulin action, inadequate insulin secretion, and excessive or inappropriate glucagon secretion; associated with long term vascular and neurological complications.[1] Diabetic microangiopathy is characterised as a disorder of small vessels and is one of the major chronic diabetic complications involving diabetic neuropathy, retinopathy and nephropathy.[2] It has also been postulated that the microangiopathy[3] along with neuropathy[4] affect the hearing of individuals with diabetes. Histopathological studies have demonstrated that there is cochlear microangiopathy and degeneration of stria vascularis and cochlear outer hair cells in patients with type 2 diabetes mellitus.[5,6] Studies have also demonstrated that there is increased basal membrane thickening and strial atrophy in diabetics, which may be one factor in diabetic hearing loss.[7] The relationship between diabetes mellitus and hearing loss has been debated for many years.[8] Diabetes mellitus has been implicated as an independent causative factor of sensorineural hearing loss.[9] The relationship between adult onset diabetes mellitus has remained controversial in the literature since it was first reported by Edgar in 1857. Some authors conclude that there is no relationship between hyperglycaemia and hearing loss;[10,11] however, the bulk of the literature supports a poorly defined association. As to incidence of hearing loss in patients with diabetes mellitus, there is no consensus in the literature either ranging from zero to 93%.[12] Controversy in literature also exists as regards to the type of hearing loss; progressive, gradual bilateral sensorineural hearing loss, similar to presbycusis with more serious losses as expected by ageing;[12,13] early sensorineural loss;[14] at low or medium frequencies;[15] and, unilateral sudden loss.[4,15] This study was thus, undertaken to describe the pure tone audiological characteristics of type 2 diabetes mellitus (DM) patients and compare these findings against the test results of DM-free individuals of similar sex and age groups; and to study the association between degree of hearing loss, if any; with age, duration and metabolic control of the disease.

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MATERIALS & METHOD: Institutional Ethics Committee approval was taken prior to initiation of the study and informed consent was kept as one of the inclusion criteria. This cross sectional comparative observational study was carried out during March, 2013 and July, 2014. Other Inclusion Criteria were- Cases: Patients of Type 2 Diabetes Mellitus aged below 50 years (to avoid the impact of presbycusis) who had diabetes for less than 10 years (for the diabetic group) to exclude patients with advanced diabetic complications. Controls: Age and Sex matched non diabetic healthy individual volunteers preferably chosen from similar socio-economic status. Exclusion criteria (for both cases and controls): history of chronic suppurative otitis media and other infectious diseases; autoimmune diseases and other systemic diseases like hypertension; prolonged exposure to noise; history of ototoxic medications; and, family history of deafness. A total of 50 patients satisfying the inclusion and exclusion criteria were selected for the study from the patients visiting the Diabetes clinic of the institution. To keep the selection random, patients attending the clinic in 1st week of every month during the study period were selected for study. An equal number of non-diabetic healthy age and sex matched control population was picked up from the attending population of those days to match the socioeconomic status of both the groups, also satisfying the inclusion and exclusion criteria. Few controls were picked up from healthy volunteers from amongst the hospital staff. Detailed history with respect to age, sex, family history, duration of diabetes mellitus and, previous medical history were noted. Detailed systemic examination to rule out any diabetic complications was done and ENT examination was carried out by the specialist. Fasting and post-meal blood sugar levels were determined by Glucose oxidase method and HbA_{1c} levels were determined using spectrophotometric method with the help of Randox Imola machine. Blood biochemistry for serum creatinine levels and presence of microalbuminuria in urine were also done to assess the development of complications of Diabetes mellitus. Pure tone air and bone conduction thresholds were obtained by using Pure Tone Audiometer model AUL 12096 audiometer of Labat company in a sound proof room. Type and severity of hearing loss, if any was classified. The same procedure was carried for all participants of both the diabetic group and the control group. Same audiometer was used by the same examiner on all participants to reduce confounding factors. Pure tone air conduction thresholds were obtained for tones of 250, 500, 1000, 2000, 4000, 6000 and 8000 Hz and pure tone bone conduction thresholds were measured at 250, 500, 1000, 2000 and 4000 Hz. Hearing loss was defined as an unaided, measured mean pure-tone hearing loss at frequencies of 500, 1000, and 2000 hertz. Hearing impairment was graded as mild (26-40 dB); moderate (41-60 dB); severe (61-80 dB) and profound (>81 dB). A mean hearing threshold of both ears in pure tone audiogram was used for the purpose of comparison between the two groups in cases with normal hearing and bilateral losses, as intra aural variations were not significant. However, in cases with unilateral losses the hearing threshold of ear with hearing loss was used for comparison with control population. Data was tabulated using Microsoft Excel worksheet and was statistically analysed using SPSS version 16.0, through a statistician. The data from diabetic and control groups were compared using Z test and linear correlations were done in diabetic subjects between hearing function and age, duration of diabetes, and HbA_{1C} levels using the Karl Pearson's product moment correlation test. A p-value of <0.05 was considered to be statistically significant, and a p-value <0.001 was considered to be highly significant statistical parameter.

RESULTS: The mean age of our study population for the two groups was 43.2 years (standard deviation 7.2 years) and ranged from 25 to 50 years of age. In both the groups, 72% participants were males and rest 28% were females. According to the pure tone audiometric hearing thresholds, 29 diabetic patients (58%) and a single healthy control (2%) presented with hearing loss [Fig. 1]. Audiograms of the diabetic patients with hearing loss had no significant air bone gap, so the hearing loss was of the sensorineural type. It was observed that there was bilateral sensorineural hearing loss in more than three-quarters of the affected diabetics and four cases presented with unilateral hearing loss. 20% diabetic patients were found to have increased losses at higher frequencies, half of which revealed a normal hearing pure tone audiogram with dips at higher frequencies. The single case of hearing loss in the control group had mild grade of SNHL. Among the diabetic patients, 21(42%) patients had no hearing loss, 16(32%) had mild and 13 (26%) had moderate SNHL [Table 1]. None of the diabetics presented with severe or profound hearing losses. In the present study, SNHL was seen in 21(58.3%) out of 36 males and 8(57.15%) out of 14 females with diabetes mellitus. This study did not reveal significant differences between the two sexes as regards to the hearing loss and the audiological tests. The mean hearing thresholds of the diabetic group at all frequencies; i.e. 250–4,000 Hz for bone conduction and 250–8,000 Hz for air conduction were highly significantly ($p<0.001$) raised as compared to the control group with higher increments at high frequencies. [Table 2]. Pure tone audiometric hearing thresholds correlated positively with age. In the diabetic patients, the correlation of hearing thresholds with age was statistically significant for middle tone frequencies of 750 Hz and 1000 Hz (Correlation co-efficient; r=+0.227 for 750 Hz and +0.225 for 1000 Hz) [Table 3].

Age group	Mild SNHL	Moderate SNHL	No SNHL	Total (%)
21-30	01	00	03	04(08%)
31-40	00	05	08	13(26%)
41-50	15	08	10	33(66%)
Total (%)	**16(32%)**	**13(26%)**	**21(42%)**	**50(100%)**

Table 1: Distribution of Diabetics with and without SNHL & Its Grade

Frequency (Hz)	Bone conduction Hearing thresholds (dB)		Air conduction Hearing thresholds (dB)	
	Diabetics	Control	Diabetics	Control
250 Hz	20.60 ± 9.80*	7.20 ± 6.96*	29.75±8.81*	21.55±5.17*
500 Hz	21.75±9.65*	7.95±5.58*	28.95±8.37*	21.10±4.93*
750 Hz	21.70±8.81*	8.40±5.67*	29.05±8.32*	20.10±5.19*
1000 Hz	21.80±8.62*	8.10±5.97*	28.50±8.11*	19.10±5.28*
2000 Hz	22.60±9.55*	9.45±6.37*	28.50±10.04*	17.70±6.28*
3000 Hz	25.10±10.45*	10.25±6.77*	32.45±11.21*	18.25±7.75*
4000 Hz	27.85±12.59*	11.30±7.72*	37.10±13.45*	19.85±8.36*
6000 Hz	-	-	37.85±14.39*	19.95±11.06*
8000 Hz	-	-	36.25±15.00*	20.45±11.85*

Table 2: Hearing Thresholds for Bone and Air Conduction on Pure Tone Audiometry in Diabetics and controls

*- p<0.001 (Highly significant).

Frequency (HZ)	r-value	p-value	Significance
250	+ 0.103	> .05	NS
500	+ 0.158	> .05	NS
750	+ 0.227	< .05	Sig
1000	+ 0.225	< .05	Sig
2000	+ 0.179	> .05	NS
3000	+ 0.184	> .05	NS
4000	+ 0.120	> .05	NS
6000	+ 0.048	> .05	NS
8000	+ 0.169	> .05	NS

Table 3: Correlation between Age & Hearing Threshold at Particular Frequency in diabetic patients

Among the diabetic patients, 62% patients had less than five years duration of the illness and 38% patients were suffering from the disease for more than five years. On distributing the diabetic patients according to the duration of diabetes and hearing status, 71.4% of the diabetics with normal hearing and 76.9% of the diabetics suffering moderate grades of hearing losses fell in the group having less than 5 years duration of the disease. However, 62.5% patients amongst the 16 diabetics showing mild SNHL were suffering from diabetes mellitus for 5 to 10 years duration. The correlation of mild hearing loss and duration of diabetes was statistically significant in this study. Grouping the diabetics into controlled and uncontrolled group according to their HbA_{1C} levels with 7% levels acting as the reference point to judge the metabolic control of DM; our study population had 16 patients with < 7% and rest 34 patients having > 7% levels of HbA_{1C}. On comparing the metabolic control to the occurrence as well as severity of hearing loss, the test results of this study were not statistically significant. Both bone and air conduction thresholds showed negative correlation with the HbA_{1C} levels at lower frequencies and were found to be positively correlated at frequencies of 2000 Hz and more. Correlations between the metabolic control (guided by HbA_{1C} levels) with the hearing thresholds of air and bone conduction in pure tone audiogram at various frequencies were not statistically significant. There was no association between worsening metabolic control and severity of hearing loss. We also did not find any correlation of severity of hearing losses with fasting and post meal blood sugar levels. Development of complications as indicated by the deteriorating serum creatinine levels and presence of microalbuminuria also did not exhibit any association with the severity of hearing losses.

DISCUSSION: In the present study, diabetic subjects had a higher hearing threshold with bilateral, mild to moderate degree sensorineural hearing loss. The current study reported SNHL in 58% of the diabetics. The results of our study are in accordance with a number of previous studies, most of which report an increased incidence of hearing loss in diabetics as compared to healthy age and sex matched volunteers. Different studies conducted earlier have reported an incidence of hearing loss in patients with diabetes mellitus ranging from 13% to 95%. Our results are nearly similar to most studies;[14,16-19] but quite low as compared to few others.[9,20] However the present study reports a higher prevalence of SNHL in comparison to some studies.[8,21,22] The resulting variations can be attributed to the slight differences in the study populations, pertaining to the age groups of cases and controls, different methodologies, different inclusion and exclusion criteria and the heterogeneity of the study population. The pure tone audiograms of the diabetic patients had no significant air-bone gap and the hearing loss was mostly bilateral and sensorineural type with mild to moderate degree. We report a bilateral sensorineural hearing loss in majority of diabetics patients with hearing loss and unilateral losses in only four patients. Our observations were similar to majority of the earlier authors; however, few authors had denied a relationship between the two.[10,11]

Attributing hearing loss to diabetes alone is often difficult because of other vascular diseases in these patients and because of compounding variables such as presbycusis. The microvascular effects of hypertension are similar to those of diabetes, making these data plausible. This concept is important because the prevalence of hypertension in patients with diabetes varies between 10% and 80%, according to different reports. In the present study, we could exclusively correlate the relationship of Diabetes Mellitus and hearing loss, as the cases with co- existence of hypertension were excluded from the study. Also, diabetics of less than 50 years were included to avoid audiological derangements owing to presbycusis.

In the present study, the comparison of pure tone audiometric hearing thresholds of diabetics with control population was highly significant at all tested frequencies for both air and bone conductions. For all the diabetic subjects with hearing losses, the thresholds of hearing in both air and bone conductions showed greater increments at higher frequencies. Most other authors have reported similar findings;[8,9,19,20,22] but these authors have reported stronger association at higher frequencies; however, there are others who report the strongest association at low and middle tone frequencies.[14,15] The variations in sample size and selection criteria seem to be the probable causes of the variations observed.

In the present study, significant differences were not observed between the two sexes as regards to the hearing loss and the audiological tests; though, males with SNHL were slightly high in proportion to females with SNHL. Since most previous studies comparing males and females have found no sex differences in audiological tests;[8,9,22] a strict grouping of cases and controls between the two groups to assess gender differences were not tried in this study. One author has reported an equal incidence in both sexes.[20] There are two studies which concluded a greater hearing loss in one of the two sexes, i.e., a higher incidence in female diabetics [13] or male diabetic subjects.[23]

The present study found a positive correlation between age and pure tone audiometric thresholds which were statistically significant at middle tone frequencies. Thus, it can be concluded that there was increased existence of hearing loss with increasing age in the present study. Our findings are similar to most other studies,[8,19,20,22] but one, which reports no correlation with age.[9] Axelsson[24] showed that the incidence of pure tone hearing loss increases with age in patients with diabetes, even after correction for presbycusis.

The present study reports that the correlation between bone conduction thresholds and the duration of diabetes was negative for lower frequencies and positive for middle and higher frequencies. But, the air conduction thresholds on pure tone audiograms were positively correlated to the duration of diabetes; which was statistically significant for frequencies above 2000 Hz. Present study concludes that duration of diabetes affected the presence of hearing loss in diabetics, especially at higher frequencies but, it does not affect the severity of hearing loss in the patients. Our findings are similar to one study[19] but contradictory to others.[8,9,20] One study reports a significant association between duration of diabetes and severity of SNHL.[22] Variations in the study population and diagnostic tools are the possible reasons for the difference in the observations in the literature. Our findings are also in agreement to Celik[25] who observed that as the duration of diabetes increased to 15 years, the incidence of hearing loss also increased. After 15 years of diabetes, the influence on hearing loss was not significant. However, our study is silent on the second half of their statement due to the variation in inclusion criteria.

On comparing the metabolic control to the occurrence as well as severity of hearing loss, the test results of this study were not statistically significant. Both bone and air conduction thresholds showed negative correlation with the HbA_{1C} levels at lower frequencies and were found to be positively correlated at higher frequencies. But, none of these correlations between the metabolic control (guided by HbA_{1C} levels) with the hearing thresholds of air and bone conduction in pure tone audiogram at various frequencies were not statistically significant. Thus, the present study showed no association between the worsening metabolic control of diabetes mellitus and the existence or severity of SNHL. Our results are similar to few authors.[19,20] but contradictory to others.[8,9,22] who report that the worsening control of diabetes correlated with worsening of hearing loss. We also did not find any correlation of severity of hearing losses with fasting and postprandial blood sugar levels. Mozaffari[19] also reported similar results. In the present study, there was no association of serum creatinine levels with the occurrence of SNHL. Kakarlapudi[8] showed that in patients with diabetes and SNHL, worsening creatinine levels, and therefore worsening microvascular disease led to worse hearing. In the present study, there were six patients who presented with microalbuminuria but we do not report an association between the presence of microalbuminuria and the occurrence or severity of SNHL. Few studies have reported a strong correlation between hearing loss in diabetes mellitus and secondary complications.[8,9] As complications of diabetes were not effectively evaluated in the present study, it is unable to highlight the association between hearing loss and other complications of diabetic mellitus.

CONCLUSION: Our study confirmed the existence of auditory organ dysfunction in relatively young type 2 diabetic patients with a short duration of the disease and without clinically overt hearing impairment on audiology. Diabetic subjects had higher pure tone audiometric hearing thresholds in comparison to age and sex matched non-diabetic subjects. Majority of the diabetics presented with bilateral, mild-to-moderate degree sensorineural hearing losses. Sex and blood glucose level of diabetic patients had no association with hearing loss, while age and duration of diabetes correlated positively with the occurrence of sensorineural hearing loss.

As hearing loss can be considered to be a consequence of diabetes mellitus, a metabolic assessment may be useful for patients presenting with hearing loss so as to reduce the high rate of undiagnosed diabetes mellitus in the community. Although the study was performed on a small number of participants, our results demonstrated that a relationship between type 2 diabetes mellitus and auditory impairment exists. Thus, routine screening for hearing loss in diabetes patients as for other complications may also be helpful to diminish co morbidities among them and improve their quality of life.

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