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Evaluation of Hearing Status in Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Observational Study

ABSTRACT

Objective: Hearing loss as a complication of diabetes is a debatable issue with a handful of contradictory studies. The objective of the present study was to evaluate the status of hearing in patients with type 2 diabetes mellitus and to correlate the severity of hearing loss with the duration of diabetes mellitus.

Methods: This is an observational cross-sectional study which was done at a tertiary care teaching hospital over a period of 12 months. Two hundred consecutive type 2 diabetic patients in the age group between 18 and 60 years were enrolled. Patients were subjected to blood sugar levels, glycosylated hemoglobin, and pure tone audiometry. Possible confounders for hearing loss were excluded. The chi-square test was applied and $P < .05$ was considered significant.

Results: The average age of the patients was 47.18±8.65 years with a male to female ratio of 1.19 : 1. The mean duration of diabetes was 5.60±4.15 years. Out of 200 patients, hearing loss was observed in 55%. The prevalence of sensorineural hearing loss was 50%. Higher frequencies (4 kHz-8 kHz) were most affected. The association of fasting blood sugar and HbA1c levels with hearing loss was significant while no association was observed between the duration of diabetes and hearing loss.

Conclusion: The study confirmed hearing loss in almost half of the diabetic patients while no association was observed between the duration of diabetes and hearing loss. It is recommended that the audiological screening must be included in the initial evaluation of the diabetic patient to detect and prevent further hearing loss.

Keywords: Audiogram, fasting blood sugar, glycosylated hemoglobin, hearing, sensorineural hearing loss

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INTRODUCTION

Diabetes mellitus (DM) is a chronic multifunctional endocrine disorder that affects almost all parts of the body. In diabetes, type 2 is the most predominant one, making it one of the major non-infectious global health issues.[1] Complications of diabetes are quite frequent and are responsible for high morbidity and mortality. Complications of diabetes affect almost all organs depending on the duration and its poor metabolic control over time.[2] This study was done to assess the hearing status in patients having type 2 diabetes and find out its association with the duration of diabetes.

Diabetes mellitus may cause hearing loss as one of its complications as it may impair auditory functions.[3] Therefore, for the care of diabetics, it may be necessary to monitor auditory function and moreover, it may be preventable, if hearing loss relies on the severity or metabolic control of diabetes.[4] This study was done to evaluate the hearing status in patients with type 2 diabetes and to find the association of hearing loss with the duration of the disease.

Hearing loss may be one such complication associated with diabetics that often confounds with age-related presbycusis in advanced age.[5] Per se, hearing loss is one of the commonest sensory disabilities in the middle aged and elderly, which can be of conductive, sensorineural, mixed, and central type caused by genetic factors and/or the environmental factors including both organic and non-organic causes.[6] The connection of hearing loss

with diabetes has been a subject of debate for a long time. The association appears quite controversial as different studies have produced conflicting results.

Long-standing diabetes can be a major etiological factor for deterioration of hearing in the aged population. The mechanistic hypothesis of microangiopathy- and macroangiopathy-induced cellular and molecular pathways in chronic diabetes could well be the theoretical explanation for hearing loss, as applicable for other well-known complications of type 2 diabetes like cardiovascular, ophthalmic, vascular, and renal ones.[7] Though it is still unknown how diabetes leads to hearing loss, the probable contenders are inner ear microangiopathy, cochlear nerve neuropathy, either alone or in combination, outer hair cell dysfunction of outer hair cells, or a disruption in the potential of endolymph. Further, the effects of duration of diabetes, blood sugar control, and the presence of end organ damage on hearing loss have not yet been clarified, despite several studies addressing the topic. Studies done by Kim et al[3] and Dadhich et al[8] showed DM was associated with the development of bilateral sensorineural hearing loss.

Thus, the present study was aimed to assess the hearing status in patients with type 2 diabetes in the state of Uttarakhand and to find the association of hearing loss with the duration of diabetes, glycemic control, and other complications of diabetes.

METHODS

This observational cross-sectional study was conducted in the Department of Otorhinolaryngology in Himalayan Hospital. A total of 200 consecutive diabetic patients were selected from the routine outdoor and indoor patients after explaining the purpose of the study and obtaining their written informed consent. The study was approved by the Institutional Ethics Committee (ISRHU/HIMS/ETHICS/2018/91).

All diabetic patients with type 2 DM as per American diabetes association diagnostic criteria (patients with fasting glucose $\geq$ 126 mg/dL and HbA1C $\geq$ 6.5%) were included in the study.[9] Patients having age more than 18 years and less than 60 years were taken. Cases beyond the age limits as well as all cases having a history suggestive of noise trauma, ototoxicity, ear surgery, head trauma, any middle ear disease or any family history of deafness, hypothyroidism, or any other known cause of hearing loss were excluded from the study.

In all subjects, detailed relevant history along with the history of duration of diabetes and its associated complications like neuropathy, retinopathy, and nephropathy was taken. They were subjected to relevant routine investigations pertaining to diabetes like fasting glucose and glycosylated hemoglobin. All subjects were assessed for hearing impairment through otorhinolaryngological examination, tuning fork tests, and pure tone audiometry (250-8000 Hz). The degree of hearing loss was calculated by taking the mean of the degree of hearing loss found at 0.5 kHz, 1 kHz, 2 kHZ, and 4 kHz. WHO (2008) classification[10] was used for its assessment. Type of hearing loss was also noted, that is conductive, sensorineural, and mixed. In suitable cases, special tests like tone decay test and short increment sensitivity index tests were done to compare between cochlear and retro-cochlear pathology. Tone decay test and short increment sensitivity index tests were done at 0.5 KHz, 1 kHz, 2 kHz, and 4 kHz at supra-threshold level.

Statistical Analysis

The data were accumulated and entered in MS excel 2010. Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM SPSS Corp.; Armonk, NY, USA), different statistical analysis was performed. Considering quantitative variables, statistics which were descriptive were calculated. Categorical variables which were qualitative, frequency as well as percentages were calculated. Graphical representation of the variable was shown to understand the results clearly and the categorical data were analyzed using the chi-square test. The chi-square test was used for statistical analysis and a P value of $< .05$ was considered significant.

RESULTS

The age of the patients ranged from 18 to 59 years with the mean age of 47 years with a standard deviation of 8.651. The maximum number of patients (82 cases; 41%) belonged to the age group of 51-59 years. There were 109 (46%) males and 91 (54%) females enrolled in the study with a male to female ratio of 1.19 : 1 (Table 1).

Out of 200 patients, 79 patients had complaint of hearing impairment, out of which 60 (75.9%) patients had a hearing loss on audiological investigation and 121 patients did not have any complaint of hearing impairment, out of which 50 (41.3%) patients had a hearing loss on audiological investigation.

Hearing loss was detected by pure tone audiometry in 110 (55%) patients that were bilaterally symmetrical. Mean hearing loss was 34.10 dB in both the ears of the affected patients. Out of 110 patients with hearing loss, 87 (79%) had sensorineural hearing loss, 13 (12%) had mixed hearing loss, and 10 (9%) had conductive hearing loss. The commonest presentation of hearing loss was a bilateral, symmetrical mild sensorineural loss. The prevalence of sensorineural hearing loss was 50%. Seventy-three (66.3%) patients had mild hearing loss, 34 (30.9%) patients had moderate, and only 3 (2.7%) patients had severe hearing loss.

Among the sound frequencies detected by pure tone audiometry in affected patients, there was an increase in the mean value of the hearing threshold from 1 kHz. The most affected frequencies were between 4 kHz and 8 kHz, the mean hearing threshold being 55.91 dB, 50.82 dB, and 48.09 dB at 4 kHz, 6 kHz, and 8 kHz,

Table 1. Gender- and Age-Wise Distribution of Diabetics (n = 200)

	No. of Patients	Percentage
Gender		
Males	109	54.5
Females	91	45.5
Total	200	100
Age (years)		
18-30	6	0.03
31-40	46	0.23
41-50	66	0.33
51-59	82	0.41
Total	200	100

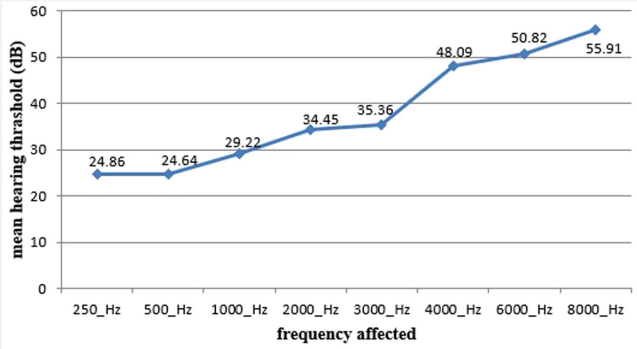

Figure 1. Mean hearing threshold at various frequencies among affected patients (n = 110).

respectively. This showed that higher frequencies were the most affected frequencies (Figure 1).

Ninety-seven (48.5%) patients having sensorineural hearing loss were subjected to short increment sensitivity index and tone decay tests to rule out cochlear or retrocochlear pathology. Patients with sensorineural hearing loss had a short increment sensitivity index score between 70 and 100% while the tone decay test was negative. Patients with mixed hearing loss had a short increment sensitivity index score between 30 and 70%. This could be due to conductive impairment and the tone decay test was negative. In all 97 (100%) patients, tone decay test result was negative that was not suggestive of retrocochlear pathology whereas the short increment sensitivity index test was positive that was suggestive of cochlear pathology.

From the total of 200 patients enrolled in our study, 60 (77.9%) out of 77 patients who had fasting blood sugar more than 170 mg/dL had hearing loss, 47 patients had fasting blood sugar between 141 and 170 mg/dL, out of which 23 (48.9%) patients had hearing loss and 27 (35.5%) out of 76 patients having fasting blood sugar less than 140 mg/dL had hearing loss. Mean fasting sugar was 176.13±80.21 mg/dL. A significant association was seen between fasting blood sugar and hearing loss (*P* value < .05) (Table 2).

Out of 60 patients with HbA_{1c} levels between 5.97 and 6.80% (good control), 18 (30%) patients had hearing loss. Twenty (55.5%) of total 36 patients with HbA_{1c} levels between 6.81 and 7.63% (fair control) had hearing loss. Seventy-two (69.2%) out of 104 patients having HbA_{1c} levels more the 7.64 (poor control) had hearing loss. A statistically significant association (*P* value < .05) was seen between HbA_{1c} levels and hearing loss (Table 3).

Table 2. Relation of Fasting Blood Sugar with Hearing Loss (n = 200)

Fasting Blood Sugar (mg/dL)	Total No. of Patients	Patients with Hearing Loss	Percentage	*P*
<140	76	27	35.5	.000*
141-170	47	23	48.9	
>170	77	60	77.9	
Total	200	110	55	

*$P < .05$ was significant, chi-square test.

Table 3. Relation of HbA_{1c} Levels with Hearing Loss (n = 200)

HbA1c Levels	No. of Patients (n)	Patients with Hearing Loss	Percentage	*P*
5.97-6.80	60	18	30.0	.000*
6.81-7.63	36	20	55.5	
>7.64	104	72	69.2	
Total	200	110	55	

*$P < .05$ was significant, chi-square test.

The mean duration of diabetes among the patients was 5.60 years. Newly diagnosed diabetics were 12 (6%), out of which 6 (50%) patients had hearing loss. Seventy-five out of 200 cases had a duration of less than 5 years (75/200 = 37.5%), and out of 75 patients, 35 (46.6%) had hearing loss. The majority of patients (90 cases; 45%) had a duration of the disease between 5 and 10 years, out of which 52 (57.7%) had hearing loss. Twenty-one (10.5%) patients had a duration of the disease between 11 and 15 years, out of which 15 (71.4%) had hearing loss and 2 had a duration between 16 and 20 years and both had hearing loss (100%). Statistically no significant (*P* value > .05) association was observed between the duration of diabetes and hearing loss (Figure 2).

Out of 200 patients, 23 (11.5%) diabetic patients had complications out of which 17 (73.9%) had hearing loss while 177 (88.5%) diabetics did not have complications, and out of which 93 (52.5%) had hearing loss. The findings implied that hearing loss was not associated with other diabetic complications. Out of 17 patients with complications, 5 (29.4%) had retinopathy, 11 (64.7%) had neuropathy, and 4 (23.5%) had nephropathy.

DISCUSSION

In the present study, findings support that hearing impairment can be one of the consequences of diabetes. Kashyap et al[11] and Renj et al[12] also showed similar observations thus pointing toward the fact that hearing loss can be considered as a complication of DM. Kashyap et al[11] took 120 diabetic patients in their study and found that the prevalence was increased in diabetic compared with non-diabetic patients (*P* < .001). In a study by Renj et al.[12] higher thresholds were seen at 4000 Hz and 8000 Hz in diabetic

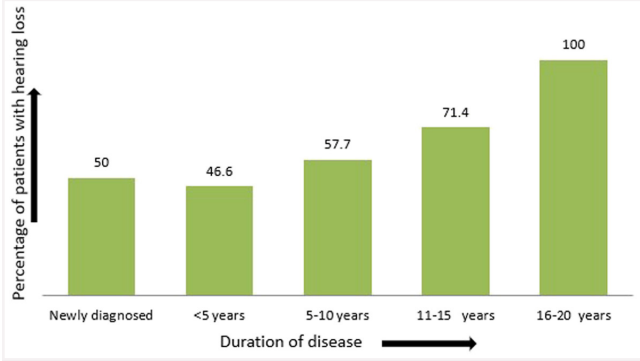

Figure 2. Relation of the duration of diabetes with hearing loss (n = 200).

cases ($P < .01$) along with escalated wave V and interwave I-V latencies ($P < .01$) as opposed to non-diabetic cases which indicated that cases with type 2 diabetes can have a sensorineural hearing impairment.

In the present study, 55% of patients had some degree of hearing loss on pure tone audiometry. Hearing loss in the study was mostly bilateral, symmetrical, high frequency, and of sensorineural type. The prevalence of sensorineural hearing loss was 50% which may be due to diabetic microangiopathy and neuropathy. A similar observation was seen in studies done by Jankar et al[13] and Qaiyum et al.[14] In a study by Jankar et al.[13] statistically highly significant progressive sensorineural hearing loss was observed in the diabetic group than in the non-diabetic control group ($P = .0001$). This shows that diabetes affects the inner ear and thus sensorineural hearing loss is seen. Nine percent had conductive hearing loss. Diabetes does not cause conductive hearing loss. Conductive hearing loss as seen in few patients could be due to abnormal otoscopic findings like dimeric membrane or retracted tympanic membrane or there may be otosclerosis behind the intact tympanic membrane.[15]

In most of the patients, high frequencies were most affected (4-8 kHz). The mean hearing threshold was 55.91 dB, 50.82 dB, and 48.09 dB at 4 kHz, 6 kHz, and 8 kHz, respectively. Therefore, based on this result, we can say diabetic patients are very prone to high-frequency hearing loss. Patients with a history of noise-induced hearing loss and barotrauma were excluded as these patients usually have a dip at 4 kHz on pure tone audiometry.[16] Patients having a family history of hearing loss were also excluded in view of ruling out otosclerosis which showed a dip at 2 kHz on pure tone audiometry.[17]

The results were similar to Pani et al.[18] who also viewed impairment of hearing in the middle and higher frequencies. Sheetal Krishanppa et al[19] found hearing loss in higher frequencies only. In contrast, Salvinelli et al[20] did not observe hearing impairment in diabetic patients. Inner ear microangiopathy, cochlear nerve neuropathy, either alone or in union, is possible causes for reduced auditory acuity.

Special hearing tests were evaluated to detect the type of sensorineural hearing loss. Patients having sensorineural and mixed hearing loss were subjected to these tests. The tests revealed a cochlear type of sensorineural hearing loss in all patients. Thus, in the present study, cochlear hearing loss was evident presumably due to diabetes-induced microangiopathy in the cochlea. In support of our study, similar findings were reported in a 5-year prospective study on diabetics.[21] Three patients had severe sensorineural hearing loss (>70 dB), and they were not subjected to these special tests because of audiometric limitation.

In the present study, a significant association was found between fasting blood sugar and hearing loss. This association was also documented by Thimmasettaiah et al.[22] whose views of the level of blood glucose and impaired hearing showed a highest incidence of sensorineural hearing loss of moderate degree in the elevated level of blood glucose than in the normal range level of blood glucose ($P = .005$).[22]

In our study, no association was found between the duration of diabetes and hearing loss. Patients with longer duration having well controlled sugar levels may not have hearing loss as the optimum sugar levels may not have affected the inner ear.[23] Thus, this study supports the hypothesis that the time duration of diabetes does not alter the hearing threshold if there is optimum control of blood sugar levels. Other studies also showed a similar result concluding that duration of diabetes is not associated with the hearing loss.[9,23] While other studies contradict this showing a significant association between the duration of diabetes and hearing loss.[6,24]

Our study also dealt with glycosylated hemoglobin (HbA_{1c} levels) that depicts the control of diabetes over the past 3 months. An association was found between HbA_{1c} levels and hearing loss. This shows that poorly controlled diabetics have elevated hearing threshold as opposed to well-regulated diabetics. Therefore, diabetic control is important to prevent hearing loss. A study from Bengaluru also showed that hearing threshold increases with levels of HbA_{1c} greater than 8%.[25]

No association was seen between diabetic patients with complications (neuropathy, nephropathy, or retinopathy) and hearing loss (P value > .05). In this study, 73.9% patients out of 23 patients who had complications had hearing loss while 52.5% out of 177 patients who were without complications had hearing loss. Had we had taken a greater number of diabetic patients having complications, we might have been able to find its association with hearing loss.

In contrast to our study, Renj et al[12] in 2009 showed that diabetic patients with complications had an increased risk of hearing deterioriation than those who had better control of hyperglycemia. Nonetheless, the controlled hyperglycemics were also at risk for hearing loss.[12] Similarly, Taylor and Irwin also discovered a relation between diabetic complications and hearing loss.

Therefore, the diabetic patients, at least, need to be recommended to maintain their glycemic levels under fine control to avoid any hearing loss.

The main limitation of this study was no controls were taken. Therefore, no comparison could be done which would have made the results of this study stronger. In addition to this, the number of patients taken was less as diabetes is a common condition. Also, there was no extended high-frequency audiometer available for assessing the hearing loss in frequencies beyond 8 kHz and as diabetes more commonly affects higher frequencies. Thus, hearing status in these frequencies could not be attained.

The present study showed that long-standing diabetes can cause sensorineural hearing loss specially affecting higher frequencies. Hearing loss was associated with fasting blood sugar and glycosylated hemoglobin (HbA_{1c}) levels but not with the duration of diabetes. This showed that no matter how long the duration of the diabetes is patient's sugar levels should be under strict control to prevent hearing loss. The present study stressed the necessity of auditory screening along with the screening for retinopathy, neuropathy, and nephropathy in type 2 diabetics. Ascertainment of hearing loss timely may put a halt to it further by strictly managing the level of glucose in the diabetics.

Consequently, an early diagnosis of hearing loss and its appropriate management along with diabetes may prevent further harm and complications.

Ethics Committee Approval: Ethics committee approval was received from the Ethics Committee of Swami Rama Himalayan University (letter no. SRHU/HIMS/ETHICS/2018/91).

Informed Consent: Informed consent was obtained from all individual participants included in the study.

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