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Research Article

AUDITORY ACUITY IN DIABETES MELLITUS TYPE II: A CASE−CONTROL STUDY

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ABSTRACT

Objectives: The objective of the study was to analyze the status of auditory acuity in patients with Type II diabetes mellitus (DM) as compared to healthy individuals of comparable age groups using pure tone audiometry.

Methods: This was a case–control study in which 80 known cases of DM were enrolled as cases (Group D) and a similar number of age-matched healthy individuals were included as the control group (Group N). Demographic details such as age and gender were compared. A detailed history was taken and a general and systemic examination was done. Pure tone audiometry (250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz, 6000Hz, and 8000 Hertz frequencies) was done in all the patients, and air conduction and bone conduction of both the ears were determined. SSPE 21 software was used for statistical analysis. $p<0.05$ was considered to be statistically significant.

Results: Both groups were found to be comparable in terms of gender and age distribution with no statistically significant difference ($p<0.05$). Mean fasting and postprandial blood sugar levels as well as HbA1c were found to be higher in Group D as compared to Group N and the difference was highly significant ($p<0.0001$). In Group D (Diabetic patients), mild, moderate, and severe sensorineural hearing loss (SNHL) at speech frequency was seen in 31 (38.75%) whereas moderate and severe SNHL was seen in 22 (27.50%) and 18 (22.50%) patients. In Group N (Non-diabetic), 5 (6.25%) patients had mild SNHL and moderate and severe hearing loss was not seen in any of the patients. The mean hearing threshold (Both Ears) for bone as well as air conduction was found to be more in Group D as compared to Group N at all frequencies and the difference was statistically significant ($p<0.05$).

Conclusion: Individuals with Type II DM are found to have an increased incidence of subclinical hearing loss. This subtle hearing loss may go undetected for a considerable period of time and hence regular audiometric evaluation is required for early diagnosis of subclinical hearing loss in patients of DM.

Keywords: Diabetes mellitus, Auditory acuity, Audiometry, Sensorineural hearing loss.

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INTRODUCTION

The global pandemic of diabetes mellitus (DM) has emerged as an important health-care problem that is affecting millions of individuals worldwide. With deteriorating food habits and sedentary lifestyle, there is exponential increase in cases with metabolic syndrome and its consequences such as DM, hypertension as well as dyslipidemia [1]. DM Type II is characterized by raised blood glucose secondary to end-organ resistance to action of insulin (Type II DM). The pandemic of diabetes has reached alarming proportions and according to various reports approximately 537 million people were living with diabetes in 2021, and this number is expected to rise dramatically in the coming years. The primary causes of diabetes include genetic factors, sedentary lifestyle, and dietary factors that collectively contribute to the development of insulin resistance and consequently DM [2].

With strict control of blood glucose levels, the complications of DM can be attenuated; however, they cannot be wholly prevented. The complications in cases of DM are well documented and include nephropathy, retinopathy, and neuropathy among many other consequences [3]. While the complications of diabetes are well-documented and extend beyond glycemic control, there is growing evidence that suggests that there is a potential link between diabetes and auditory acuity [4]. The auditory system, comprising the delicate structures of the ear and the intricate neural pathways involved in hearing, may be adversely affected by the metabolic imbalances associated with diabetes [5]. Therefore it is important to analyze the impact of diabetes on the auditory acuity of individuals having DM [6].

Although the complications of uncontrolled diabetes such as diabetic nephropathy, retinopathy, and neuropathy have been extensively researched the relationship between DM and hearing loss has not been researched comprehensively [7]. The exploration of the correlation between sensorineural hearing loss (SNHL) and Type 2 DM dates back to 1857 when Jordao's documented a single case demonstrating hearing loss linked to an early stage of diabetic coma [8]. Since then, research is being done, although less frequently, on the impact of the prolonged metabolic disturbances inherent in DM and its impact on auditory acuity [9]. Individuals having Type 2 diabetes are at increased risk of auditory complications, including sensory neuropathy, cellular damage, accelerated atherosclerosis, and vasculitis [10]. DM is known to affect cochlear cells, spiral ganglion neurons, the organ of Corti, and the stria vascularis thereby affecting auditory acuity in individuals with DM [11]. In addition to hearing loss, these changes also have repercussions that could account for symptoms such as dizziness and tinnitus [12].Despite knowing that DM affects hearing this aspect of management largely remains neglected and all the efforts are directed toward managing diabetes and its other complications [13]. Very few studies have been undertaken on the topic of auditory acuity in diabetes patients and a notable knowledge gap exists in our understanding of the specific mechanisms and the degree of impact on auditory acuity in individuals with Type II DM [14].

We undertook this case–control study to analyze the status of auditory acuity in patients with Type II DM in comparison with healthy individuals of a comparable age group using pure tone audiometry.

METHODS

This was a case–control study conducted by a department of ENT of a tertiary care hospital. 80 patients having DM Type II (cases group) and 80 age-matched healthy individuals (control group) were included on the basis of a predefined inclusion and exclusion criteria. The sample size was calculated by using formula N = (Z α2) X SD2/d2 using OPENEPI software version 3 on the basis of pilot studies done on the topic auditory acuity in DM Type II assuming 90% power and 95% confidence interval, the sample size required was 80 patients so we included 80 patients with DM Type II and the same number of healthy individuals as the control group.

- Group D: 80 adult patients with DM as cases.
- Group N: 80 healthy adult individuals enrolled as control group.

Demographic details such as age and gender were noted. In the case group, the duration of diabetes and the treatment (type of oral hypoglycaemic drugs) that was being taken was noted. The presence of comorbidities such as hypertension or any other systemic illness was also noted. General and systemic examinations were conducted for all cases, with a specific focus on a thorough examination of the ears, nose, and throat. Standard investigations, including assessments of blood sugar levels, complete blood count, and glycosylated hemoglobin, were performed for all individuals. Audiometry evaluations were conducted on all patients, encompassing assessments of cochlear response, air conduction, and bone conduction for both ears.

Audiometry procedure

1. Using a pure tone audiometer in a sound proof room air and bone conduction thresholds were measured for tones of 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz, 6000Hz, and 8000 Hertz frequencies In Group D (patients with DM) and Group N (healthy controls) individuals mean air conduction as well as bone conduction threshold for various frequencies were assessed.
2. The mean hearing threshold for speech frequency for both ears was calculated.
3. The mean air conduction, mean bone conduction, mean air conduction threshold, and mean hearing threshold for speech frequency were compared in both groups.

Statistical analysis was done using SPSS 21.0 software. Quantitative data were depicted as mean and standard deviation. Qualitative data were presented as incidence and percentage tables. For quantitative data, an unpaired t-test was applied and for qualitative data, a Chi-square test was used. $p<0.05$ was taken as statistically significant.

Inclusion criteria

The following criteria were included in the study:

1. Known cases of DM (diagnosed on the basis of fasting blood sugar level more than 140 mg/dL and postprandial blood sugar level of 200 mg/dL on at least two separate occasions) were included as cases.
2. Age-matched healthy individuals enrolled in the control group.
3. Those who gave informed and written consent to be part of the study.
4. Patients more than 18 years of age.

Exclusion criteria

The following criteria were excluded from the study:

1. Those who refused consent to be part of study.
2. Family history of hearing loss.
3. Cases having middle ear pathologies such as chronic suppurative otitis media and history of prior ear or mastoid surgery.
4. Patients having psychiatric illnesses, uncontrolled systemic illnesses such as uncontrolled hypertension or bronchial asthma.
5. Patients on antipsychotics, ototoxic, and antineoplastic drugs.

RESULTS

Out of 80 patients in Group D, there were 52 (65%) males and 28 (35%) females with a M: F ratio of 1:0.53 whereas in Group N, there were 49 (61.25%) males and 31 (38.75%) females with a M: F ratio of 1:0.63. Both groups were comparable in terms of gender distribution with no statistically significant difference (Table 1).

Age distribution of the studied cases showed that the most common age group in Group D (DM Type II) was above 50 years (32.50%), followed by 46–50 years (28.75%) and 41–45 years (27.50%). In Group N (Normal Individuals), the most common age group was found to be above 50 years (33.75%), followed by 46–50 years (31.25%) and 41–45 years (21.25%). The mean age of Group A and Group B was found to be 49.64±11.24 and 52.52±14.32, respectively. The age groups were comparable and with no statistically significant difference in the mean age of both groups (p=0.1322) (Table 2).

In Group D, the mean fasting and postprandial blood sugar values were found to be 182.78±38.44 and 268.52±52.64 mg/dL and in Group N, the mean fasting as well as postprandial blood sugar levels were found to be 88.44±16.64 and 102.34±22.12 mg/dL, respectively. The mean HbA1c in Group D and Group N was found to be 7.4±2.3% and 4.9±1.4%, respectively. Fasting blood sugar, postprandial sugar levels, and HbA1c levels were found to be higher in Group D as compared to Group N, and the difference was found to be highly significant (p<0.0001) (Table 3).

The analysis of cochlear response to audiometry showed that in Group D (Diabetic patients), mild, moderate, and severe SNHL at speech frequency was seen in 31 (38.75%) whereas moderate and severe SNHL was seen in 22 (27.50%) and 18 (22.50%) patients. In Group N (Non-diabetic), 5 (6.25%) patients had mild SNHL and moderate and severe hearing loss was not seen in any of the patients (Table 4).

The hearing threshold for bone conduction in both groups was examined by pure tone audiometry at 250, 500, 1000, 2000, 4000, 6000, and 8000 Hz frequencies. The mean hearing threshold (Both Ears) was found to be more in Group D as compared to Group N at all frequencies and the difference was found to be significant (p<0.05) (Figs. 1 and 2).

The hearing threshold for air conduction in both groups was also examined by pure tone audiometry at 250, 500, 1000, 2000, 4000,

Table 1: Gender distribution among the studied cases

Gender distribution	Group D		Group N		p-value
	No of cases	Percentage	No of cases	Percentage	
Male	52	65.00%	49	61.25%	p=0.7433
Females	28	35.00%	31	38.75%	Not
Total	80	100.00%	80	100.00%	significant

Table 2: Age group of the studied cases

Age Group	Group A		Group N	
	No of patients	Percentage	No of patients	Percentage
<30 years	3	3.75	2	2.50
35–40 years	8	10.00	9	11.25
41–45 years	20	27.50	17	21.25
46–50 years	23	28.75	25	31.25
>50 years	26	32.50	27	33.75
Total	80	100.0	80	100.0
	Mean Age: 49.64±11.24		Mean Age: 52.72±14.32	

p=0.1322 (Not Significant)

Table 3: Mean fasting and postprandial blood sugar levels in both groups

BSL	Group D	Group N	Significance
Fasting (mg/dl)	182.78±38.44	88.44±16.64	p≤0.0001 Highly Significant
Postprandial (mg/dl)	268.52±52.64	102.34±22.12	p≤0.0001 Highly Significant
HbA1c	7.4±2.3%	4.9±1.4%	p≤0.0001 Highly Significant

Table 4: Comparison of sensorineural hearing loss in both the groups

Sensorineural Hearing loss	Group D		Group N	
	No of cases	Percentage	No of cases	Percentage
No Hearing loss	09	11.25	75	93.75
Mild	31	38.75	5	6.25
Moderate	22	27.50	0	0.00
Severe	18	22.50	0	0.00
Total	80	100	80	100

p<0.0001 Highly significant

6000, and 8000 Hz frequencies. The mean hearing threshold (for both ears) was found to be more in Group D as compared to Group N at all frequencies and the difference was found to be statistically significant ($p<0.05$) (Figs. 3 and 4)

DISCUSSION

In our study, 80 individuals diagnosed with Type II DM were included as cases and a similar number of healthy individuals were enrolled as the control group. The analyses of gender distribution in the studied groups showed that though in both groups, the gender distribution was comparable. The mean age of patients in both groups was also found to be comparable with no statistically significant difference. The mean fasting as well as postprandial blood sugar levels as well as mean HbA1c levels was found to be high in Group D as compared to Group N and the difference was found to be statistically highly significant.

In Group D (Diabetic patients), mild, moderate, and severe SNHL at speech frequency was seen in 31 (38.75%) whereas moderate and severe SNHL was seen in 22 (27.50%) and 18 (22.50%) patients. In Group N (Non-diabetic), 5 (6.25%) patients had mild SNHL and moderate and severe hearing loss was not seen in any of the patients. Kakarlapudi *et al.* conducted a study to investigate the prevalence of SNHL among individuals with diabetes compared to the general population and explore the potential connection between diabetes control and the severity of hearing impairment [15]. In this study, the authors analyzed electronic medical records of 53,461 non-diabetic age-matched subjects and 12,575 diabetic patients. The analysis revealed a higher occurrence of SNHL in diabetic patients as compared to age-matched non-diabetic counterparts within the same healthcare institutions. In addition, the study observed that inadequate diabetes control was associated with more severe hearing loss in diabetic individuals with SNHL. On the basis of these findings, the authors concluded that patients with diabetes exhibit a heightened susceptibility to SNHL compared to non-diabetic controls. Furthermore, the severity of hearing loss appeared to be linked to the progression of diabetes, as evidenced by elevated serum creatinine levels, potentially indicating microangiopathic involvement in the inner ear. A similar incidence of SNHL in diabetics was also reported by the authors such as Harkare *et al.* [16] and Lerman-Garber *et al.* [17].

In our study, hearing threshold for bone conduction as well as air conduction in both the groups was examined by pure tone audiometry at 250, 500, 1000, 2000, 4000, 6000, and 8000 Hz frequencies. The mean hearing threshold (Both Ears) for bone as well as air conduction was found to be more in Group D as compared to Group N at all frequencies and the difference was found to be statistically significant ($p<0.05$). Meena *et al.* conducted a study to examine the relationship between DM and hearing loss [18]. In this investigation, the hearing status of 50 individuals diagnosed with Type 2 DM and having a diabetes duration of <120 months, was compared with that of 50 age-matched healthy volunteers. The assessment utilized pure-tone audiometry, transient evoked otoacoustic emissions (TEOAE), and auditory brainstem responses (ABR). The study showed that diabetic patients, as compared to their healthy counterparts, exhibited significantly higher mean hearing thresholds across all frequencies in pure-tone audiometry. In addition,

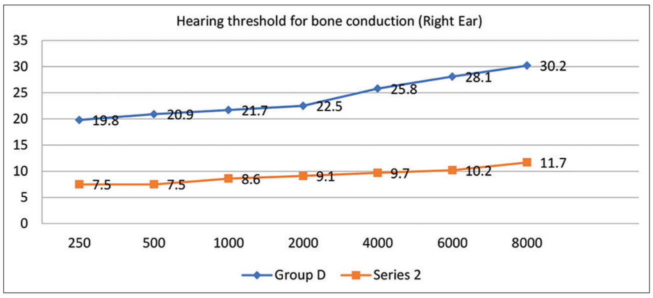

Fig. 1: Hearing threshold of the right ear for bone conduction in both groups

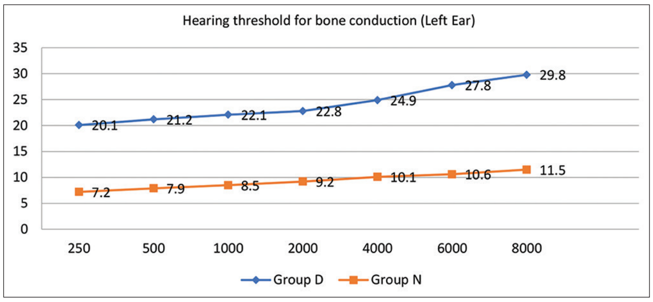

Fig. 2: Hearing threshold of the left ear for bone conduction in both groups

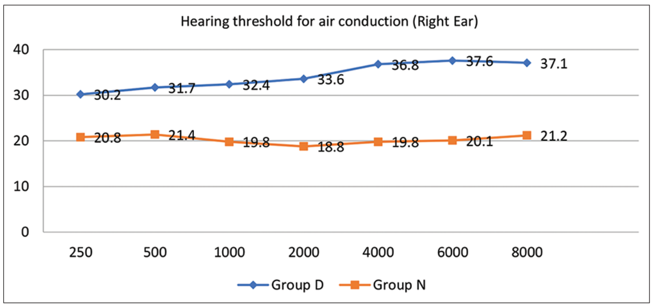

Fig. 3: Hearing threshold of the right ear for bone conduction in both groups

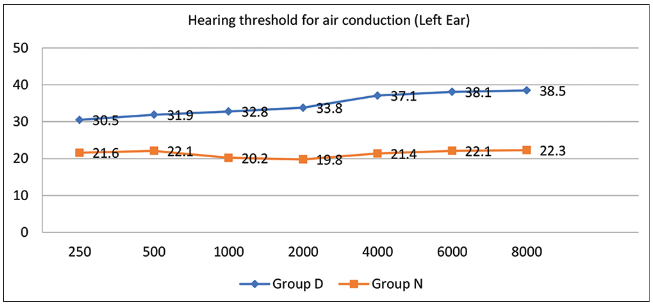

Fig. 4: Hearing threshold of the left ear for air conduction in both groups

the mean amplitude of TEOAE was lower, and there were prolonged latency times for waves III and V, as well as intervals I-III, III-V, and I-V in ABR. Based on these observations, the author concluded that there is an elevated occurrence of hearing loss in individuals with diabetes compared to those without diabetes. Consequently, the authors recommended regular audiological monitoring for individuals with diabetes to assess the potential development of hearing loss. Similar findings were also reported by authors such Diaz de Leon-Morales *et al.* [19] and Taylor and Irwin [20].

CONCLUSION

Patients with DM are more likely to have subtly progressing hearing loss which may go undetected for a considerable period of time before significant hearing loss occurs. It is therefore imperative that these patients are routinely screened for hearing loss by audiometry.

CONFLICTS OF INTEREST

None.

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