Original Article

Diabetic Otopathy : Have We Heard Enough? — A Regression Analysis to Identify High Risk Factors

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Abstract

Background : Diabetic Otopathy (DO), is one of the less studied complications of Type II Diabetes Mellitus (T2DM) with lack of detailed assessment of various parameters like Age, Gender, Body Mass Index (BMI), Addiction, Family History and Duration of T2DM etc. and their association with Sensorineural Hearing Loss (SNHL). It is important to identify the high-risk factors associated with SNHL in T2DM to propose the potential screening strategy.

Aims and Objectives : To identify and evaluate the predictive value of the most common parameters leading to SNHL in T2DM.

Materials and Methods : A prospective, cross-sectional study was conducted on patients with T2DM (25- 85 years). A spectrum of parameters including Age, Gender, BMI, Addiction, Duration and Family history of T2DM, Glycemic control, PPI use, Presence/ absence of other Microvascular complications were analyzed to establish an association using Chi Square and regression analysis.

Results : A high prevalence of SNHL (73.30 %) was noticed among diabetics. After detailed statistical analysis of multiple parameters, on multivariate logistic regression, BMI (Adjusted Odds Ratio or AOR = 26.217, p = 0.001), Family history (AOR = 24.865, p = 0.006), Duration of T2DM (AOR =15.530, p = 0.037) and Glycemic control (AOR = 12.583, p = 0.018) were found to be significant predictors of SNHL.

Conclusion : In the present study, multiple parameters analyzed among adults with T2DM, positive Family history, Duration more than 10 years, BMI in overweight/obesity range, and poor Glycemic control were found to be significant and independent predictor factors for SNHL.

Key words : Diabetic Otopathy, Sensorineural Hearing Loss, Type II Diabetes Mellitus, Diabetes Mellitus.

It would not be an exaggeration to say that Diabetes Mellitus (T2DM) has reached a state of an epidemic Worldwide. According to the International Diabetes Federation (IDF), approximately 537 million people in the World and 90 million people in the South East Asia region have T2DM, whereas its prevalence in India is estimated to be more than 8.3% of the adult population[1].

It affects almost all organ systems of the body and as a consequence has many complications including Retinopathy, Nephropathy, Peripheral Neuropathy and atherosclerosis. Diabetic Otopathy (DO), ie, involvement of audio-vestibular system, is one of the less studied complications of T2DM, leading to significant deterioration of Quality of Life of those affected[2].

According to World Health Organization (WHO), SNHL, which is one of the significant non-vascular complications of T2DM, has been reported in approximately 466 million people (6.1% of the Global population)[3].

Editor's Comment :

- A diabetic patient with a positive family history, having a prolonged duration of T2DM more than 10 years with above normal BMI and poor glycemic control is at higher risk of developing SNHL.
- It is imperative to identify and screen such individuals for early detection of diabetic otopathy and prompt intervention.

Although the prevalence of measured hearing impairment in T2DM is approximately twice when compared to general population, it's magnitude and pathophysiology are not yet clearly defined and often underestimated[4].

The well-established complications like retinopathy, peripheral neuropathy and nephropathy, have prompted the American Diabetes Association to produce clear clinical recommendations suggesting a screening protocol. However, the epidemiological relationship between T2DM and Hearing Loss (HL) remained ambiguous[5].

There are many studies demonstrating an association between T2DM and SNHL but there is a lack of detailed assessment of various parameters like Age, Gender, BMI, Addiction, Family history and Duration of T2DM, Glycemic control, Microvascular complications, PPI use and their association with SNHL. Establishment of predictor variables for SNHL in T2DM might lead to identification

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Received on : 27/05/2025
Accepted on : 30/06/2025

How to cite this article : Diabetic Otopathy : Have We Heard Enough ? — A Regression Analysis to Identify High Risk Factors. Mukherjee D, Gon S, Thakur P, Dasgupta P, Acharia K, Dandapath A, Dey A, Patra A. *J Indian Med Assoc* 2026; **124(3):** 25-9.

of at-risk/high risk patients and effective screening protocols.

Hence, this study was conducted to identify and evaluate the predictive value of the most common parameters leading to SNHL in T2DM.

Materials and Methods

A single centered, hospital based, prospective, observational, cross-sectional study was conducted in a Tertiary Care Medical College & Hospital for fifteen months starting from December, 2023 to March, 2024 (after obtaining Institutional Ethics Committee approval). Consecutive patients with T2DM between 25 to 85 years of age were included, while, patient unwilling to be included in the study, suffering from congenital hearing loss, noise induced hearing loss, Meniere's disease, history of exposure to ototoxic drugs, middle ear surgeries or diseases and conductive hearing loss, history of systemic illness like Meningitis, Renal failure and others like Autoimmune disease, Hypertension and Thyroid dysfunction and history of Head or Ear trauma were excluded.

The informed consent and the demographic profile of the patients were recorded which included Age, Gender, BMI, Addiction, Duration and Family history of T2DM, Glycemic control, PPI use, Presence / absence of other Microvascular complications (Retinopathy, Nephropathy and Neuropathy). BMI was calculated and classified[6]. These parameters were finalized and selected from recent literature including a systematic review[7,8].

Otoscopic examination was done in all patients. Results of Fasting Blood Sugar (FBS), Postprandial Blood Sugar (PPBS) and glycosylated Hemoglobin (HbA1c) were noted. Assessment of HL was then done using Pure Tone and Speech Audiometry. The testing was performed using Auditivo Audiometer and TECMO MT- 30 Headphones. Pure Tone Audiometry was performed on both ears, one at a time, at frequencies of 0.125, 0.250, 0.5, 0.750, 1, 1.5, 2, 3, 4, 6, and 8 kHz. Before the test, the patient was asked to identify his or her better ear. From the Audiogram, hearing impairment for conversational speech was calculated as the Pure Tone Average (PTA) for the better ear as an average of four frequencies (0.5, 1 & 2 KHz) and was classified as per American Speech Language and Hearing Association[9,10]. All the included patients were also assessed using Speech Audiometry. The patients' Speech Discrimination Score (SDS) was measured with the help of listed monosyllable words (intensity $\geq$ 40 dB). Speech Reception Threshold (SRT) analysis was done using listed bisyllable words[11].

The relevant operational definitions are presented in Table 1.

Table 1 — *Operational Definitions*[12]

Test	Pre-diabetes	Diabetes	Comments
Fasting Plasma Glucose	Impaired Glucose Tolerance $\geq$100 <126 mg/dl	>126mg/dl	No caloric intake for at least 8 hours
2-hour Plasma Glucose (during an oral glucose tolerance test)	Impaired Glucose Tolerance $\geq$140 <200mg/dl	$\geq$200 mg/dl	Using glucose load of 75g anhydrous glucose dissolved in water
HbA1c	Increased diabetes risk HbA1c 5.7-6.4%	$\geq$6.5 %	

Sensorineural Hearing Loss (SNHL) - The most commonly used definition of SNHL, as endorsed by the American Academy of Otolaryngology-Head and Neck Surgery (AAOHNS) and the National Institute of Deafness and Other Communication Disorders (NIDCD), is hearing loss of at least 30 dB (dB) in three sequential frequencies in the standard pure tone audiogram[13,14].

Study parameters were entered in Microsoft Excel Worksheet and data was analyzed using Statistical Package of Social Sciences (SPSS) version 20.0. Significant threshold established prior to beginning the study considering p as 0.05. Association of study parameters with presence or absence of SNHL was tested with Chi square test. Variables (parameters) which were found to have significant association with SNHL were subjected to uni-variate and multivariate logistic regression model to assess independent predictive value of each variable (while adjusting for the covariates).

Sample size of 86 was calculated using Cochrane's formula where expected population proportion (expected prevalence in population under study obtained from comparable studies) as 66%[15].

Results

In this study, most participants were in the age group of 46-55 years (33.7%). Male to Female ratio was 1.5:1 and males were found to be more afflicted by SNHL. Prevalence of SNHL among 86 diabetics was found to be 73.30%. Among the study subjects 32.6% were Overweight and 40.7% were Obese. All Obese and 75% of Overweight diabetics had SNHL. A positive family history of T2DM was seen in 41.9% of the participants out of which 88 % had SNHL. History of long duration of T2DM (>10 years) was seen in 51.2% patients. SNHL was found in 38.3%, 66.7%, 90.9% patients suffering with T2DM for less than 5 years, 5-10 years, more than 10 years respectively. In the present study 65.1% of the patients had poor glycemic control status. Among the patients with poor glycemic control, 83.9% were found to be suffering from SNHL. HL was noted in 14% of the Smokers and 15.1% of those addicted to Alcohol. It was found that 90% of the diabetics with microvascular complications had SNHL. Amongst PPI users 77.2% had SNHL.

PTA test revealed SNHL to be almost bilaterally symmetrical, more so in the higher frequencies, ranging from 4-8 kHz (Table 2). Similarly, most of the patients had hearing loss in both Right and Left ears as per the results of SRT. However, SDS did not show significant hearing loss in the patients (Table 2).

Analysis of individual parameters using chi square test was done. BMI, Duration of disease, Family history, Glycemic control were significantly associated with SNHL, while no significant association was seen with Age & Gender, Addiction, PPI and Presence/absence of other Microvascular complications. A summary of the results obtained in this study are shown in Table 3.

On univariate logistic regression, Body mass index (OR = 18.296, p <0.001), Family history (OR = 24.865, p = 0.006), Duration of T2DM >10 years (OR=15.714, p = 0.000) and Poor Glycemic control (OR = 4.569, p = 0.003) were found to be risk factors for developing SNHL.

On multivariate logistic regression, Body Mass Index (AOR = 26.217, p = 0.001), family history (AOR = 24.865, p = 0.006), Duration of T2DM (AOR = 15.530, p = 0.037) and Glycemic control (AOR = 12.583, p = 0.018) were found to be significant predictors of SNHL (Table 4). The model fitting statistics was good. It had significant Omnibus test value (p <0.001) and insignificant Hosmer Lemeshow (p = 0.747).

Discussion

The most important finding of the current study is that out of the multiple parameters analyzed, positive family history of T2DM, duration more than 10 years, BMI in overweight / obesity range and poor glycemic control were found to be significant and independent predictor factors for SNHL in T2DM.

Family history of T2DM was found to be significantly associated with SNHL similar to results of Bhavita, *et al* and Gadag RP, *et al*[16,17]. The reason could be attributed to maternally inherited Diabetes linked to mitochondrial DNA mutations, a known cause of hearing loss. Moteki, *et al* also mentioned 3243 A>G (mitochondrial) and P2X2 gene mutations to be associated with T2DM and SNHL, respectively[18].

A strong correlation between the duration of Diabetes and SNHL is noted in our study similar to the findings of studies by Srinivas C V, *et al* and Gadag RP, *et al* but contradictory to the findings of a study by Axelsson A, *et al*. The increase in hearing threshold may be attributed to the microvascular angiopathy in the capillaries of stria vascularis[15,17,19]. An association between duration of Diabetes Mellitus and SNHL was made in a study by Jyothi, *et al* showing that patients with more than 10 years of T2DM had a maximum prevalence of hearing loss when compared to fewer years of duration[20]. Thimmasettaiah, *et al* in their study done in Bengaluru, stated that Diabetes of more than 5 years duration was found to have more hearing impairment (79%) as compared to freshly detected diabetics (42%)[21]. The proposed mechanism may be due either microangiopathy or neuropathy. These changes may be

Table 2 — *Prevalence of Hearing Loss in T2DM Patients based on PTA, SDS* and SRT tests

PTA (dBHL)	Right Ear	Left Ear
<25	44(51.2%)	44(51.2%)
25-40	24 (28%)	25(29.1%)
41-55	11(13%)	10(12%)
56-70	6(7%)	5(6%)
71-90	1(1.2%)	2(2.3%)
>90	0	0
Hearing loss level	SDS, SRT (PERCENTAGE (%)	
	Right Ear	Left Ear
Hearing Loss +	3.2%, 69%	7.6%, 80%
Hearing Loss -	97.8%, 30%	94.2%, 27%

PTA - Pure Tone Audiometry, SDS - Speech Discrimination Score, SRT - Speech Reception Threshold, dBHL - Decibel Hearing Loss

Table 3 — *Frequency of Sensorineural Hearing Loss in various parameters and Chi Square test*

Variables	Hearing loss		Chi-square value	p value
	Absent [n (%)]	Present [n (%)]		
Age :				
25-35	0 (0.00)	1(1.1)	3.506	0.061
36-45	5 (5.8)	7 (8.3)		
46-55	9 (10.4)	20 (23.3)		
56-65	5 (5.8)	21 (24.4)		
66-75	4 (4.7)	12 (13.9)		
76-85	0 (0.00)	2 (2.3)		
Gender :				
Male	14 (16.28)	38 (44.19)	0.002	0.963
Female	9 (10.46)	25 (29.07)		
BMI :				
Underweight	0 (0.0)	0 (0.0)	34.347	0.000
Normal	16 (18.7)	7 (8.1)		
Overweight	7 (8.1)	21 (24.4)		
Obese	0 (0.0)	35 (40.7)		
Smoking :				
Absent	14 (16.3)	41(47.7)	2.181	0.1397
Present	9 (10.5)	12 (14)		
Addiction to Alcohol :				
Absent	16 (18.6)	50(58.1)	0.906	0.3412
Present	7 (8.1)	13 (15.1)		
Family h/o of T2DM :				
Absent	19 (22.1)	31 (36.0)	7.724	0.005
Present	4 (4.6)	32 (37.3)		
Duration of T2DM :				
< 5 years	11 (12.8)	7 (8.1)	18.382	0.000
5-10 years	8 (9.3)	16 (18.6)		
>10 years	4 (4.7)	40 (46.5)		
Glycaemic control :				
Good (<6.5)	14 (89.1)	16 (10.9)	9.333	0.002
Poor (>6.5)	9 (16)	47 (84)		
Microvascular complications :				
Absent	22(26)	54 (63)	1.619	0.2032
Present	1 (1.2)	9(10.4)		
PPI use				
Absent	10(11.6)	19 (22.1)	1.337	0.2476
Present	13 (15.1)	44 (51.1)		

Table 4 — *Univariate and Multivariate Regression Analysis*

Variables	Odds Ratio/OR	p value	Adjusted Odds Ratio (AOR)	95% Confidence Interval (CI)		p value
				Lower	Higher	
BMI :						
Normal (n = 23)	ref	-	-			-
Overweight and Obese (n = 63)	18.286	<0.001	26.217	3.737	183.909	0.001
Family history of T2DM :						
Absent (n = 50)	ref	-	-			-
Present (n = 36)	24.865	0.006	24.865	2.552	242.229	0.006
Duration of T2DM :						
< 5 years (n = 18)	ref	-	-			-
5- 10 years (n = 24)	3.143	0.078	4.433	0.517	37.971	0.174
> 10 years (n = 44)	15.714	0.000	15.530	1.180	204.301	0.037
Glycaemic control :						
Good (< 6.5) (n = 30)	ref	-	-			-
Poor (> 6.5) (n = 56)	4.569	0.003	12.583	1.540	102.785	0.018

evident from the autopsy of T2DM patients which showed internal auditory artery thickening, spiral ganglion atrophy or cranial nerve degeneration, especially VIII cranial nerve[17].

Majority of the Overweight and all Obese diabetics had SNHL and a significant association between BMI and SNHL was noted. The reason for significant association could be attributed to the excess body fat. Moreover, diabetic patients have lipid metabolism dysfunction which may be a cause for inner ear malfunction on a biochemical basis. There is very limited literature exploring this association. However, study findings by Huang, *et al* showed an inconclusive association[22].

We found significant association between Glycemic control and SNHL where Diabetics with HbA1c more than 6.5% were found to be more affected (55%). The relation between the Random Blood Sugar levels and Hearing Threshold in a study by Srinivas C V, *et al* was inconclusive, as Random Blood Sugar gives an idea of Present Blood Sugar level, but it does not signify about long-term sugar control. In our study, HbA1c was taken into consideration as it directly gives an idea about the Blood Sugar control of the patient in the recent past 3 months. Srinivas, *et al* found that patients with poor control (HbA1c>8 %) of their Glycemic status had raised Auditory Thresholds[15]. In a study by Jyothi, *et al* diabetic patients with poor control of disease had increased prevalence of SNHL[20]. Huang, *et al* didn't find any association between hearing impairment and HbA1c in diabetic patients[22]. Poor Glycemic control can lead to SNHL because it damages the tiny blood vessels in the inner ear, which are crucial for supplying Oxygen and nutrients to the delicate hair cells responsible for hearing, ultimately leading to their dysfunction and hearing loss. It reflects that poor glycemic control contributes to more pronounced Cochlear hair cell damage, primarily attributed to increased oxidative stress and inflammation.

This study shows Hearing Thresholds are affected more in higher frequencies similar to the study by Rajendran, *et al*[23]. Tay, *et al* stated that the HL was seen in mid and low frequencies and same was the finding of Taylor and Irwin, *et al*[24,25]. Fangchao et al. found HL in diabetics only in 500Hz frequency[26]. Axelsson, *et al* has showed no significant relation between the two[19]. It is hypothesized that high frequency sounds are affected more due to accelerated atherosclerosis, thickening of basement membrane, which decreases blood flow to cochlea, mainly to the basal and middle turn leading to cell degeneration and loss of high frequency hearing sounds[27] .

In the opinion of the authors, the most important clinical utility of the current study is in identification of high-risk individuals. Diabetics with high BMI, duration of T2DM>10 years, with Family History and poor Glycemic control may be at the highest risk for developing SNHL. Efforts must be directed towards developing a targeted screening methodology in such high-risk individuals so as to allow for timely intervention and development of management strategies to minimize further HL.

Limitations :

There are some limitations of the present study. Patients are between 25-85 years of age and thus presbycusis comes into the picture. T2DM is known to cause bilateral progressive SNHL. With aging, both HL as well as risk of Diabetes increases. So, the HL seen in patients with T2DM would be similar to that of presbycusis but with more severe losses and early onset than expected by aging alone. As a result, it is difficult to distinguish whether HL in T2DM is due to aging or due to biochemical and vascular abnormalities associated with T2DM. Presbycusis, by definition, is a diagnosis of exclusion and hence, in this study, SNHL can be attributed to T2DM[28].

This study may be subjected to referral bias. Being a Tertiary Care Referral Center, it is possible that the prevalence of Otopathy may be higher in our included sample than in the community.

Failure to use objective HL assessment methods may be considered as another limitation of the study. However,

pure tone Audiometry is the most commonly employed screening tool (owing to its availability and cost effectiveness) at all level of Health Care Centers. In the authors' opinion, the targeted screening of high-risk individuals should also include PTA before going for higher objective assessment methods.

Conclusion

Among the various parameters analyzed in adults with T2DM, a positive family history, disease duration exceeding 10 years, Overweight / Obese BMI, and poor Glycemic control emerged as significant and independent predictive factors for SNHL.

Funding : None.

Conflict of Interest : None.

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