Main Article

Clinical Assessment of Sensorineural Hearing Loss among Diabetes Mellitus Patients

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Raveendra P Gadag,[1] Puneeth S Nayak,[2] Tejaswini J S[2]

ABSTRACT

Introduction

Hearing impairment is known to hamper the quality of life among patients, especially among diabetics due to the association of neuropathy with diabetes mellitus (DM). However, the prevalence and degree of the sensorineural hearing loss (SNHL) depends upon different factors, such as age, gender, disease duration of DM, family history and glycaemic status of the patients. Therefore, this study aimed to assess the association of SNHL with DM duration and familial DM and gender preponderance among SNHL–DM patients.

Materials and Methods

140 patients with DM were assessed for hearing impairment using Rinne, Weber and Absolute Bone Conduction Tests along with pure tone audiometry. Patients' glycaemic status was determined by estimating fasting blood glucose (FBG) and post prandial blood glucose (PPBG) levels. Independent t-test, chi-square, ANOVA and Pearson's correlation tests along with linear regression model were used to find association and correlation using R software.

Results

Out of 140 patients, 60 were suffering from SNHL and majority was suffering from bilateral minimal hearing loss. SNHL was significantly associated with family history, age, duration of DM. FBG and PPBG levels were (p values:1.79E08, 4.41E-06 and 0.02), however, significantly correlated with duration of DM, FBS and PPBG level (r value:0.14–0.41). Furthermore, significant SNHL at 500 and 8000Hz was observed in the present study (p value:0.002).

Conclusion

A conclusive proof was drawn that family history of DM serves as a valuable variable in assessing the SNHL among DM patients.

Keywords

Hearing; Hearing Loss, Sensorineural; Diabetes Mellitus, Type 2; Audiometry, Pure-Tone

Diabetes mellitus (DM) is a non-communicable, metabolic and chronic disease, marked by the high blood glucose level due to either absolute or relative insulin hormone deficiency. According to the International Diabetes Federation report, 7.5 billion people were recorded to have DM worldwide in 2017 with 8.8% prevalence among adult population. In the Indian population, approximately 72.9 million individuals have been diagnosed with DM.[1] Frequently encountered complications of DM include hearing loss, tinnitus, cardiovascular disease, neuropathy and retinopathy.[2,3] Among these, hearing impairment affects mostly the quality of life of affected individuals by impacting their personal and social lives. However, hearing impairment is also frequently associated with age-related degenerative changes of auditory organs in

1 - Department of Othorthinolaryngology& Head and Neck Surgery, Karnataka Institute of Medical Science, Hubli Karnataka
2 - Department of Othorthinolaryngology& Head and Neck Surgery, Jawaharlal Nehru Medical College, Belgavi, Karnataka

Corresponding author:
Dr Tejaswini J S
email: tejurohu@gmail.com

elderly persons.[4]

Researchers have reported hearing loss of low, mid and high frequencies[5,6] which can be due to either neuropathy[7] or micro vascular complications.[8] Hearing loss complications in DM can be bilateral (B/L) and sensorineural (SN)and may be gradually progressive. Sensorineural hearing loss (SNHL) is a disorder of the inner ear, vestibulocochlear nerve or central brain processor unit impairment that can be congenital or acquired. Cochlear changes, such as increased thickness of basal membrane and stria vascularis vessel walls, internal auditory artery sclerosis[9] and inner ear neural system degeneration[10] are responsible for hearing impairment among DM patients. Hearing impairment can be due to either combined effect of neural and vasculature system impairment or they can independently cause auditory loss among DM patients. However, there is a persistent disagreement among researchers on DM being a possible cause for SNHL.[5, 10]

Researchers studied the association of SNHL with age,[11] duration of DM,[11] HbA1c,12 gender,13 hypertension,[13] hyperlipidemia,[14] obesity[13] and socioeconomic status,[13] along with drinking and smoking habits. Hawang et al.[13] reported that central obesity, hypertension alcohol intake and male gender are positively associated with high frequency SNHL. However, Parmar et al.[14] pointed out that patients with DM and hyperlipidemia have significantly higher hearing threshold at mid- and high frequencies as compared to normal subjects (control). However, few studies explored the association of family history of DM with SNHL.[15,16] Therefore, the present study is projected to assess SNHL and its pattern in DM patients with family history of DM.

Materials and Methods

The present study was conducted from January 2012 to December 2012 in the Department of Otorhinolaryngology after taking prior approval from Institutional Ethics Committee. A total of 140 patients with DM were enrolled and informed consents were obtained from them. Patients of both genders with symptoms of DM were included in the study. However, patients with history of noise exposure and ototoxic drug intake, hearing difficulty caused by other diseases and debilitated patients were excluded. The diabetic status of the patients was confirmed by analysing their blood sugar levels. Patients with Fasting Blood Glucose (FBG) level >100 mg/dL, first hour Post Prandial Blood glucose(PPBG) level > 200 mg/dL and random blood glucose (RBG) level >200 mg/dL were included in the present study. A detailed history was collected pertaining to DM, such as its duration, type and family history, history of other comorbid conditions along with demographics (age and gender) through an interview. Laboratory estimation of FBS and PPBS were carried out followed by ear; nose and throat (ENT) examination and findings were recorded on a predesigned and pretested Performa. Blood glucose assay was done using routine biochemical method.

Assessment of Hearing Impairment:

The patients were subjected to different tests, such as tuning fork and audiometric test to analyse their hearing status. The tuning fork test comprised of three tests, namely Rinne (to compare bone and air conduction)[17] Weber[17] and Absolute Bone Conduction (ABC; to identify SNHL)[18] tests for initial screening, followed by audiometric testing.[19] Rinne and Weber test are usually combined to identify the type of hearing loss. However, pure tone Audiometry was used to measure the hearing threshold at different frequencies, and to confirm the type of hearing loss.[21] Tests were done using 256 Hz, 512 Hz and 1024 Hz tuning forks. The audiometric tests consisted of Pure tone audiometry, Pure tone Air Conduction (AC) Threshold Audiometry, Pure Tone Bone Conduction (BC), speech reception and test for recruitment in order to measure ABC, speech reception threshold values and Short Increment Sensitivity Index (SISI).[19,22]

The pure-tone audiometry was conducted with ALPS Pure Tone Audiometer(Model AD 2000) at frequencies of 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz for each ear, which were categorized as low (125 and 250 Hz), mid (500-2000 Hz) and high-frequencies (4000 and 8000 Hz).6 Hearing loss scale defined by the American Speech-Language

Table 1: Prevalence and association of SNHL among patients of DM as per demographics of the patients

PARAMETERS		FREQUENCY	STATUS OF SNHL		P VALUE
			PRESENT	ABSENT	
Gender	Male	88 (62.86%)	35(58.33%)	53(66.25%)	0.34
	Female	52(37.14%)	25(41.67%)	27(33.75%)	
Family history of DM	Positive	47 (33.57%)	28(46.67%)	19(23.75%)	0.004**
	Negative	93 (66.43%)	32(53.33%)	61(76.25%)	

Note: SHNL: sensorineural hearing loss and DM: diabetes mellitus

*** signifies p values<0.01*

Hearing Association (ASHA), was used to categorize DM patients as normal (-10 to 15 dB) and SNHL with varying degree of hearing loss (16 to 91+).[23]

Statistical Analysis:

Statistical analysis was performed using R software v 3.6.0 for evaluating frequency distribution, percentage, independent t-test, chi-square, ANOVA and Pearson's correlation tests and p values of <0.05, considered as statistically significant. The results of continuous data were presented as mean ± standard deviation while mean difference between different groups were compared using independent t-test. The correlation of various factors with SNHL was assessed using Pearson's correlation test.

Results

140 DM patients enrolled for the study aged between 20 to 50 years with the mean age being 40±9.2 years and duration of the DM being 4.87±3.64 years. The mean FBS and PPBS levels were 124.71±37.79 mg/dL and

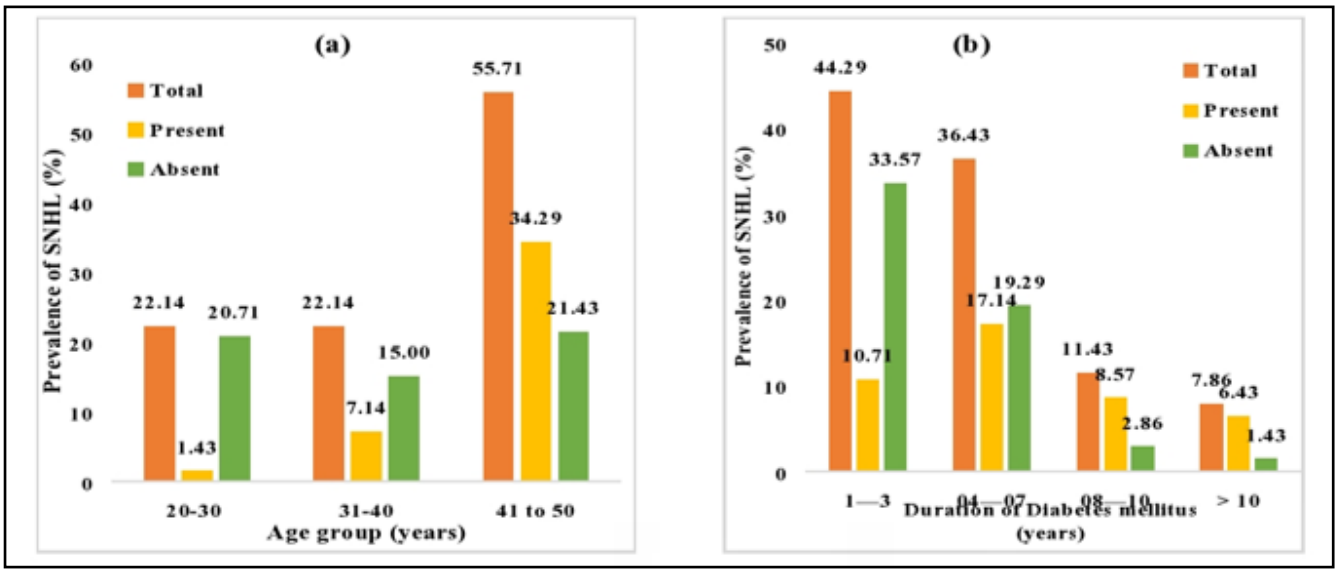

Fig. 1. Sensorineural hearing loss patients distribution based on (a) age and (b) duration of diabetics

Table II: Prevalence of SNHL different categories among different groups

SNHL DIFFERENT CATEGORIES		B/L MIN	B/L MILD	B/L MODERATE	B/L MODERATELY SEVERE	L MIN	R MILD & L MIN	R MIN	R MIN & L MILD	TOTAL
Total		**26**	**19**	**5**	**4**	**2**	**1**	**1**	**2**	**60**
Age Group (Years)	**20-30**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2**
	31-40	**5**	**1**	**3**	**0**	**0**	**0**	**0**	**1**	**10**
	41-50	**20**	**18**	**2**	**4**	**1**	**1**	**1**	**1**	**48**
Duration of diabetes (Years)	**1–3**	**9**	**1**	**1**	**0**	**1**	**1**	**1**	**1**	**15**
	4–7	**12**	**10**	**2**	**0**	**0**	**0**	**0**	**0**	**24**
	8–10	**2**	**7**	**1**	**0**	**1**	**0**	**0**	**1**	**12**
	Above 10	**3**	**1**	**1**	**4**	**0**	**0**	**0**	**0**	**9**
Positive family history cases		**14**	**9**	**2**	**1**	**1**	**0**	**0**	**1**	**28**

Note: SNHL: sensorineural hearing loss, B/L: bilateral, Min: minimum, L:left and R: right

188.98±53.47 mg/dL, respectively. (Table 1 and Fig. 1) The patients' distribution based on the tuning fork test and pure tone Audiometry revealed that 12 patients with reduced ABC (3 patients had reduced ABC and normal SISI) and 12 patients with reduced SISI (3 patients had reduced SISI and normal ABC level).

Out of 140, sixty patients were diagnosed with SNHL; rest eighty had normal hearing levels. Male dominance of 62.86% (88) among the subject population was observed, out of which 35 were suffering from SNHL. Among female patients, 25 were suffering from SNHL (Table I). Age-wise distribution of patients revealed majority of patients (78) belonged to age group of 41-50 years, out of which 48 were suffering from SNHL (Fig. 1-a). Highest numbers of SNHL cases (24) were observed in the group having diabetic history of 4-7 years; however, majority of SNHL cases (32) were observed in the group which did not have any family history of DM (Fig. 1-b).

Out of 60 cases of SNHL, there were 26 cases of B/L minimum(16–25 dB),19 cases of B/L mild (26–40 dB), 5 cases of B/L moderate (41–55 dB) and 4 cases of B/L severely moderate (56–70 dB). 2 cases had left min. (Table II) Right mild with left min, right min and right min with left mild, respectively had 1 case each. However, none of the patients suffered from severe hearing loss (71–90 dB) or profound hearing loss (91+). The prevalence of B/L min cases were found to be higher among all other categories. The age group of 41–50 years had highest number of B/L minimum hearing loss cases (20). Similarly, patients having 4–7 years of DM disease duration (12) or patients with positive family history of DM (14) were also most frequently suffering from B/L minimum hearing loss (Table II).

The association of SNHL with various variables, such as age, disease duration, gender, family history, FBG and PPBG is presented in Table I and III. Age, disease duration, PPBG and family history were found to be significantly associated with SNHL (P value of1.79E-08, 4.41E-06, 0.02 and 0.004, respectively) using independent t-test and chi square tests for continuous and non-continuous variables. In case of patients with positive history of DM, 28 patients had SNHL while 19 patients hadn't. Patients having SNHL belonged to higher age group (44.57±6.05 years) compared to patients without SNHL (36.56±9.69). Similar scenarios

Table III: Association of SNHL with various parameters among DM patients

VARIABLES		SNHL		P VALUE
		ABSENT	PRESENT	
		MEAN±SD	MEAN±SD	
Age (Years)		36.56±9.69	44.57±6.05	1.79E-08**
Duration of DM (Years)		3.6±2.56	6.57±4.15	4.41E-06**
GlycemicStatus	FBS (mg/dL)	120.04±37.48	130.93±37.61	0.09
	PPBS (mg/dL)	179.9±54.02	201.08±50.68	0.02*

Note: SNHL: sensorineural hearing loss, SD: Standard deviation, DM: Diabetes mellitus, FBS: Fasting blood sugar and PPBS: Post prandial blood sugar
** and ** indicates statistically significant, P values of <0.05 and <0.01*

were observed in case of disease duration and PPBG.

The mean values of disease duration and PPBG among SNHL patients were found to be 6.57±4.15 and 201.08±50.68 respectively. Furthermore, the SNHL was also correlated with duration of diabetics, FBG and PPBG (Pearson's correlation). Slight positive correlation was found between SNHL and FBG (r value=0.14). Similar results were observed while correlating PPBG with SNHL (r value=0.2). However, moderate positive correlation was found between duration of diabetes and SNHL (r value=0.41). Furthermore, the results of frequency-wise assessment of SNHL with fasting glucose level are tabulated in Table IV. Significant increase in hearing threshold was observed among the patients with varying FBS concentration in either left or right across low, medium and high frequencies (P value: 0.02–0.002), except 1000–8000Hz for left ear and 125 Hz for right ear, based on ANOVA analysis. However, SNHL for both ears were observed with low (250 Hz) and mid-frequency (500 Hz) with P values of 0.02–0.002. (Table IV)

Discussion

DM is frequently associated with hearing damage as it affects both microscopic and large sized blood vessels. The underlying cause of nerve damage can be micro vessel diseases, neural tissue hypoxia, changes due to atherosclerotic and metabolic disorders, especially in DM. Among DM patients, majority of hearing loss cases belong to high frequency SNHL, therefore, either they go unreported or overlooked. Hence, the present research is focused on clinically assessing the SNHL among DM patients, with respect to family history along with other variables, namely demographics and glycaemic status.

This study demonstrated the prevalence of 42.85% SNHL cases among 140 DM patients that was not in accordance with other studies, which showed varying degree of SNHL.[24,25] Rajamani et al. reported the SNHL prevalence of 51.3%.[24] Conversely, a prospective study done by Harkare et al. reported higher incidences (74.07%) of SNHL among DM patients.[25] Majority of SNHL patients were suffering from bilateral minimum SNHL (26/60) similar to results reported by Dadhich et al. (48/73).[11] Although gender did not significantly affect SNHL, male diabetics (58.33%) had slightly higher incidence of SNHL as compared to females (41.67%) that accorded with results of Harkare et al.[25]

We observed that age, disease duration, PPBG and family history was significantly associated with occurrence of SNHL on evaluating the status of SNHL among DM patients. Among these variables, age is usually associated with hearing loss in elderly person. Age-linked hearing loss is classified as hearing loss that starts at mid to late adulthood, which can be bilateral and progressive SNHL devoid of any underlying causes, such as loud noise exposure, otological diseases and toxic drugs and other medical conditions

Table IV: Comparative account of SNHL with blood glucose levels

FREQUENCY (HZ)	EAR	"FASTING BLOOD GLUCOSE LEVELS (MG/DL) MEAN ± SD				P VALUE
		<100	100-150	151-200	>200	
125	Left	14.71±12.85	14.80±12.82	23.75±16.96	23.33±8.76	0.019*
	Right	14.71±12.91	14.67±14.20	23.96±21.31	20.83±9.70	0.054
250	Left	14.12±12.46	15.33±12.26	23.75±17.71	23.33±13.29	0.02*
	Right	14.26±12.98	14.87±13.78	25.21±20.88	29.17±12.42	0.004**
500	Left	12.65±10.89	14.87±13.24	25.21±17.35	22.50±10.84	0.002**
	Right	11.76±10.79	14.93±12.66	23.96±16.94	25.00±13.04	0.002**
1000	Left	12.35±11.89	14.08±14.46	20.63±15.83	19.17±13.93	0.124
	Right	12.94±11.62	13.64±13.55	22.50±19.89	22.50±14.05	0.028*
2000	Left	14.56±14.05	16.78±17.08	23.54±17.72	20.00±12.65	0.204
	Right	13.68±12.02	15.39±15.44	26.25±19.80	20.00±14.14	0.013*
4000	Left	16.03±15.70	17.11±19.92	22.71±19.17	29.17±16.56	0.25
	Right	14.56±14.69	16.18±19.63	29.58±27.18	30.83±19.85	0.0097**
8000	Left	18.82±18.30	17.96±21.36	26.25±25.16	39.17±21.78	0.06
	Right	21.76±17.96	17.76±20.93	31.04±28.28	41.67±28.40	0.012*

*Note: SNHL: Sensorineural hearing loss, SD: Standard deviation and Hz: Hertz * and ** indicates statistically significant, P values of <0.05 and <0.01*

(hypertension and atherosclerosis). According to the Dadhich et al., SNHL prevalence increases with age among DM patients that accorded with our results, which showed that elderly adult patients (41-50 years) had significantly increased incidences of SNHL with p value of 1.79E-08.[11] Furthermore, such hearing loss still persists after senile deafness correction.[26] We used linear model to check the confounding effect of age on the relationship of FBS and hearing loss, which showed a strong association between age and FBS (p value = 0.00934), indicating that age has a strong relation with FBS. However, no such relation was observed between FBS, age and SNHL patients with DM due to unequal distribution of samples along the age groups. Therefore, conclusion could not be drawn that SNHL was due to either age or DM.

Another association probed was between SNHL and disease duration, i.e. duration of DM. We found that significant association existed between the duration of DM and SNHL (p value: 4.41E-06) and our results were in accordance with findings of Srinivas et al[12] and Bhasker et al.[27] In contrast, Harekare et al reported existence of insignificant association between duration of DM and SNHL (P value: 0.29).[25] The increased hearing threshold may be owing to the neurological and microvascular complications associated with DM that results in either microangiopathy or neuropathy.[28] These changes can be evident from the autopsy of DM patients which showed internal auditory artery thickening, spiral ganglion atrophy or cranial nerve degeneration, especially 8th cranial nerve.[29] We also found that there was moderate correlation between duration of diabetes and SNHL (r value=0.41), similar to the Pemmaiah & Srinivas;[30]

however, they reported significant correlation between SNHL and disease duration at two different frequencies, namely 2000Hz and 4000Hz with r values of 0.561 and 0.727, respectively.

In the present study, the glycaemic status of the patients, i.e. only PPBG levels were significantly associated with the SNHL (Pvalue:0.02) and accorded with the findings of Harkare et al.[25] They reported 100% incidence of SNHL among patients having blood glucose level 301 mg/dL. We found a slight positive correlation between SNHL and blood glucose levels (FBG with r value=0.14 and PPBG with r value=0.2), however, insignificant association were noted with FBG levels.

We also studied the comparative account between SNHL and FBG with respect to low-, mid- and high-frequencies that demonstrated the significant SNHL among all the frequencies and in accordance with findings of Ren et al.[5] and Weng et al.[6] However, Ren et al.[5] reported only low and high-frequency SNHL whereas Weng et al.[6] noticed low- and mid-frequency loss in DM patients with sudden SNHL. Another variable which was tested for association was family history of DM that was found to be significantly associated with SNHL (P value: 0.004) which is in accordance with the results of Bhavitha and Simha.16 We observed 46.67% SNHL prevalence among DM patients with positive family history, however, they reported a significant higher prevalence (58.70%) of SNHL with DM family history with p value of 0.002. A genetic study was done by Moteki et al., where they pointed out that there is coexistence of mutations, i.e., 3243 A>G (mitochondrial) and P2X2 gene mutations, which associated with DM and SNHL, respectively.[15]

Many researchers highlighted the association of different variables with SNHL,[11-14,32] however, few studies assessed the family history of the patients.[15,16] Therefore, the present study has focused on the association of SHNL with family history of DM among adult population along with age, duration of DM and glycaemic status. The present study concluded that all these parameters were significantly associated with SNHL among DM patients and majority of the patients suffered from B/L minimal SNHL only. However, the limitation of the present study is the non-age-matched sample. Hence, the future studies are recommended using equal sample distribution with age matched DM and normal control samples to assess the SNHL.

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