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Research Article

PREVALENCE OF SENSORINEURAL HEARING LOSS IN TYPE 2 DIABETES MELLITUS PATIENTS AND ITS CORRELATION WITH MICROVASCULAR COMPLICATIONS

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ABSTRACT

Objectives: Studying the prevalence of sensorineural hearing loss in patients with diabetes mellitus (DM) and to find the relationship between the severity of Sensorineural hearing loss (SNHL) with microvascular complications according to age, sexual predominance, duration of disease, and glycemic control (HbA1C) in diabetic patients.

Methods: The study population comprised 101 type 2 DM (T2DM) patients as cases, and 101 non-diabetics as controls from the P.G. Department of Medicine, SCB Medical College, Cuttack, from July 2022 to January 2023, and were included in the study after considering the inclusion and exclusion criteria.

Results: Among 68 diabetic patients with SNHL, most had a mild degree of 30.7%, followed by a moderate degree of 27.7%, severe and profound being 6.9% and 2%, respectively. Overall, the prevalence of SNHL is 67.3% among cases compared to 21.8% among controls ($p<0.001$). The proportion of SNHL among diabetes patients with a duration of diabetes of more than 10 years is the highest. The table shows that the proportion of SNHL among diabetes patients with HbA1C between 9.1 and 11 is highest ($p=0.025$). In our study, as the age of the cases advances, the prevalence of SNHL increases ($p=0.013$).

Conclusion: SNHL is common in T2DM, with a high association with microvascular complications such as diabetic peripheral neuropathy, nephropathy, and retinopathy. As the duration of diabetes and the level of HbA1C progress, the prevalence of hearing loss is found to worsen. Routine audiological evaluation may be carried out to help in the early diagnosis of SNHL.

Keywords: Nephropathy, Retinopathy, Neuropathy, Diabetes, Sensorineural hearing loss.

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INTRODUCTION

Diabetes mellitus (DM) is a syndrome of several etiologies characterized by chronic hyperglycemia with the instability of carbohydrate, fat, and protein metabolism ensuing from defects in insulin secretion, insulin action, or both; often associated with long-term complications, involving organs such as eyes, kidneys, nerves, heart, and blood vessels [1]. As per data from the International Diabetes Federation in 2021, an estimated 10.5% of all adults in the age group of 20–79 years are living with diabetes, which is predicted to rise to 12.2% of all adults in the same age group by 2045. Thus, the number of people with diabetes is estimated to increase by 46% over this period [2,3]. Diabetes is one of the most frequent non-communicable diseases; it affects nearly all systems of the body.

Acute complications include hypo- and hyperglycemic emergencies, whereas chronic complications include microvascular disease (retinopathy, nephropathy, and neuropathy), macrovascular disease (coronary artery disease, cerebrovascular disease, and peripheral vascular disease), and diabetic foot. Nonvascular complications include infections, skin changes, hearing loss, an increased risk of dementia, and impaired cognitive function [4].

A frequent complication in T2DM is deafness. Hearing loss in diabetes is bilateral, gradually progressive, and sensorineural; it mostly affects the higher frequency and elderly patients. SNHL in diabetes is attributable to the thickening of the basal membrane of the stria vascularis capillaries of the cochlea (on the lateral wall), and microvascular and neuropathic changes [5].

Diabetic retinopathy (DR) is a microvascular complication of diabetes and one of the important causes of vision impairment in India. Vision impairment from DR is due to diabetic macular edema and non-proliferative DR, and proliferative DR. DR is a highly specific microvascular complication of diabetes and is characterized by abnormal retinal vascular permeability, microaneurysm formation, capillary and arteriolar closure, neovascularization, and associated hemorrhage, scarring, and tractional retinal distortion and detachment [6,7].

Diabetic neuropathy is one of the most common complications that involves both peripheral and autonomic nerves, affecting up to half of all diabetic patients. Hyperglycemia-induced polyol pathways, injury from Advanced Glycation End Products (AGEs), and enhanced oxidative stress have been implicated in its pathogenesis. Peripheral neuropathy in diabetes presents in a number of forms depending on the site, manifesting as sensory, focal/multifocal, and autonomic neuropathies. Diabetic neuropathy has resulted in over 80% of amputations after foot ulceration or injury. It is among the most common, expensive, and disabling complications of diabetes, affecting approximately 30% of hospitalized patients with diabetes and 25% of patients with diabetes in the community [8-10].

Earlier identified as diabetic nephropathy, diabetic kidney disease is defined as diabetes with albuminuria (ratio of urine albumin-to-creatinine ≥30 mg/g), impaired glomerular filtration rate <60, or both and is now acknowledged as the strongest predictor of mortality in patients with diabetes [11]. It is a leading cause of End stage

renal disease (ESRD) affecting ~20–30% of diabetes patients and is associated with increased Cardiovascular (CV) mortality [11]. It affects 10–40% of type 2 DM (T2DM) patients who eventually suffer from kidney failure [11,12].

In India, approximately 63 million people suffer from auditory impairment. Approximately 77 million people are suffering from diabetes. Hence, our research question was "Is there any correlation between SNHL and T2DM?"

The present study is aimed at studying the prevalence of sensorineural hearing loss in patients with T2DM and at finding the relationship between the severity of SNHL and microvascular complications and glycemic status in patients with T2DM.

Aims of the study

1. To study the prevalence of sensory neural hearing loss among T2DM hospitalized patients.
2. To correlate the degree of sensorineural hearing loss and microvascular complication according to age, sexual predominance, duration of disease, and glycemic control (HbA1C).
3. To assess the association between microvascular complications and sensory neural hearing loss among diabetics.

METHODS

Ethical clearance was obtained from the Institutional Ethical Committee (IEC-1060/June 02, 2022) before the commencement of the study. The sampling procedure adopted in this single-centered cross-sectional study was convenience sampling. The study population comprised 101 T2DM patients as cases, and 101 nondiabetics as controls from the P.G. Department of Medicine, SCB Medical College, Cuttack, from July 2022 to January 2023, and were included in the study after considering the inclusion and exclusion criteria, and were thoroughly evaluated after obtaining informed consent. Diabetes patients between the ages of 18 year and 60 year (Criteria for diagnosis OF T2DM as per ADA) and control from the hospital with no diabetes between the ages 18 year and 60 year with fasting plasma glucose <126 or HbA1C <6.4% were included in the study. Patients with a history of childhood, or congenital hearing loss, history of hypothyroidism, history of chronic exposure to noise, history of trauma to the ear, ear discharge and perforated tympanic membrane, history of ototoxic drug in past, history of any sedative or substance abuse, recent ear/nose/throat infection, history of stroke, traumatic brain injury were excluded. After obtaining informed consent from all patients, detailed anthropometric and clinical exams were done and recorded. Fasting blood sugar (FBS), 2 h Post prandial blood sugar (PPBS), HbA1C, Complete blood count (CBC), lipid profile, serum urea, serum creatinine, serum sodium, serum potassium, thyroid function test, and pure tone audiometry were done among both diabetic cases and controls. Urine UACR, funduscopy, and nerve conduction study were done only among diabetic cases. These selected cases and controls were assessed for having sensorineural hearing loss, and only cases were assessed for neuropathy, nephropathy, and retinopathy. The degree of hearing loss is graded based on the degree of decibel (dB) loss as per the World Health Organization [13].

Statistical analysis

The data obtained were coded and entered into a Microsoft Excel worksheet. All statistical analysis was done using Statistical Package for The Social Sciences Software version V21. All nominal data were described as N, %. All continuous data will be described as mean±standard deviation. Proportions for categorical variables are compared using the Chi-square test. Proportions for continuous variables are compared using the Mann–Whitney U-test. For all tests, p≤0.05* is considered statistically significant, and p≤0.001** is considered statistically extremely significant.

RESULTS

The study included 202 subjects comprising 101 type 2 diabetes patients and 101 non-diabetic controls. The majority of cases were in the age group of 31–50 years (61.4%), followed by the age group of 50-60 years (32.7%); also, controls were almost equally divided among different age groups, similar to cases. The p=0.133, which shows the age of cases has been matched with the age of controls. An equal number of males (54–53.5%) and females (47–46.5%) were taken as cases and controls with p=1 (Chi-square test), showing that the gender of cases and controls has been matched.

Unsurprisingly, T2DM subjects had higher mean fasting glucose (183.86±42.31 mg/dL vs. 88.98±8.26 mg/dL, p<0.001**), higher mean 2-h PPBS (270.50±66.16 mg/dL vs. 126.03±14.56 mg/dL, p<0.001**), and higher mean HbA1c (8.93±2.0 vs. 5.22±0.46 p<0.001**) compared to normoglycemic control subjects (Mann–Whitney U-test).

Sixty-eight out of 101 diabetic patients had hearing loss, and the rest 33 were normal. Among 68 diabetic patients who had SNHL, most had a mild degree of 30.7% followed by a moderate degree of 27.7%, severe and profound being 6.9% and 2%, respectively. In comparison, 22 out of 101 non-diabetic controls had SNHL. Overall, prevalence of SNHL is 67.3% among cases in comparison to 21.8% among control. As p<0.001, this is statistically extremely significant (Table 1).

Table 1: Comparisons of the prevalence of SNHL among cases and controls

Hearing loss degree	Cases (%)		Control (%)		p-value
Normal (0–25 dB)	33 (32.7)		79 (78.2)		Chi-square=42.404
Mild (26–40 dB)	31 (30.7)	68 (67.3)	16 (15.8)	22 (21.8)	p≤0.001**
Moderate (41–60 dB)	28 (27.7)		6 (5.9)		
Severe (61–80 dB)	7 (6.9)		0		
Profound (≥81 dB)	2 (2.0)		0		

Chi-Square test, p value < 0.05* is considered statistically significant. p value < 0.001** is considered statistically extremely significant. dB: Decibel

Table 2: Prevalence of degree of SNHL among diabetic cases according to age group

Age group	Degree of hearing loss					
	Normal (%)	Mild (%)	Moderate (%)	Severe (%)	Profound (%)	Total abnormal (%)
≤30 years	1 (16.7)	2 (33.3)	3 (50.0)	0	0	5 (83.3)
31–50 years	27 (43.5)	17 (27.4)	13 (21.0)	4 (6.5)	1 (1.6)	35 (56.5)
51–60 years	5 (15.2)	12 (36.4)	12 (36.4)	3 (9.1)	1 (3.0)	28 (84.8)
Total	33 (32.7)	31 (30.7)	28 (27.7)	7 (6.9)	2 (2.0)	68 (67.3)
	Chi-square=8.6378 p=0.013*					

Chi-Square test, p value < 0.05* is considered statistically significant. p value < 0.001** is considered statistically extremely significant. p=0.013*

The prevalence of SNHL according to age in the cases is shown in Table 2. In our study, as the age of the cases advances, the prevalence of SNHL increases. As the p=0.013* which is statistically significant.

The prevalence of SNHL in diabetic males is 66.70% and in diabetic females is 68.1%. As the p=0.88, it shows that SNHL has no gender predilection in diabetic patients (Table 3).

In the study among T2DM patients and non-diabetic control, hearing loss is more prevalent in both the left and right ears of diabetic patients (Table 4).

The table shows that the proportion of SNHL among diabetes patients with HbA1C between 9.1 and 11 is highest (93.3%) followed by patients with HbA1C more than 11, and the least SNHL was seen among diabetes patients with HbA1C <7. Profound SNHL hearing loss is exclusively found in HbA1C levels more than 11. As the p=0.025* it is statistically significant that the more the HbA1C, the more is the prevalence of hearing loss (Table 5).

A positive correlation was found among diabetic patients with HbA1c and SNHL in the left ear, and this is evidenced by a correlation coefficient of 0.269 (Spearman Rho Correlation). The p=0.007* which is statistically significant. A positive correlation was found among diabetic patients with HbA1c and SNHL in the right ear, and this is evidenced by a correlation coefficient of 0.235. The p=0.018* which is statistically significant (Fig. 1).

The proportion of SNHL among diabetes patients with a duration of diabetes of more than 10 years is the highest. Diabetic patients with <5 years of duration of the disease have the least proportion of SNHL.

A positive correlation was found among diabetic patients with duration of diabetes and SNHL in the left ear, and this is evidenced by a correlation coefficient of 0.308. The p=0.002, which is statistically significant. A positive correlation was found among diabetic patients with duration of diabetes and SNHL in the right ear, and this is evidenced by a correlation coefficient of 0.279. The p=0.005, which is statistically significant (Fig. 2).

The overall prevalence of DR among diabetic patients is 56. 4%. Among 56.4% of cases with retinopathy, 38.6% are mild Non proliferative Diabetic retinopathy (NPDR) followed by 12.9% moderate NPDR, then severe NPDR and PDR had a prevalence of 5% and 2%, respectively (Table 6).

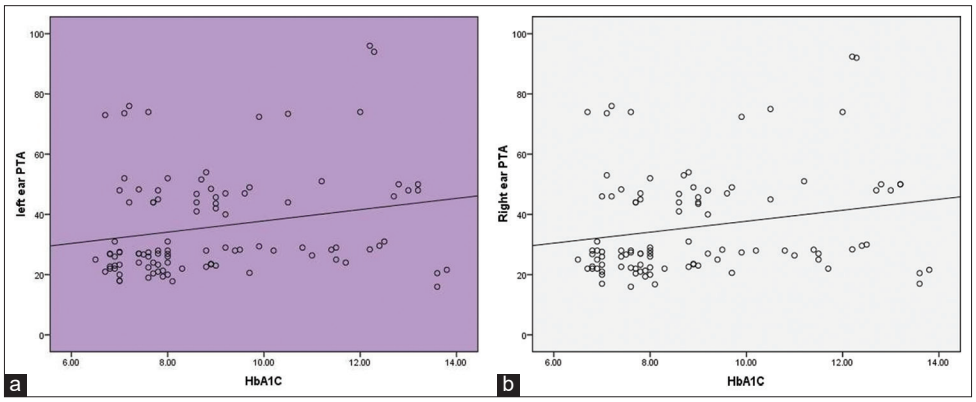

Fig. 1: Correlation between HbA1c and SNHL

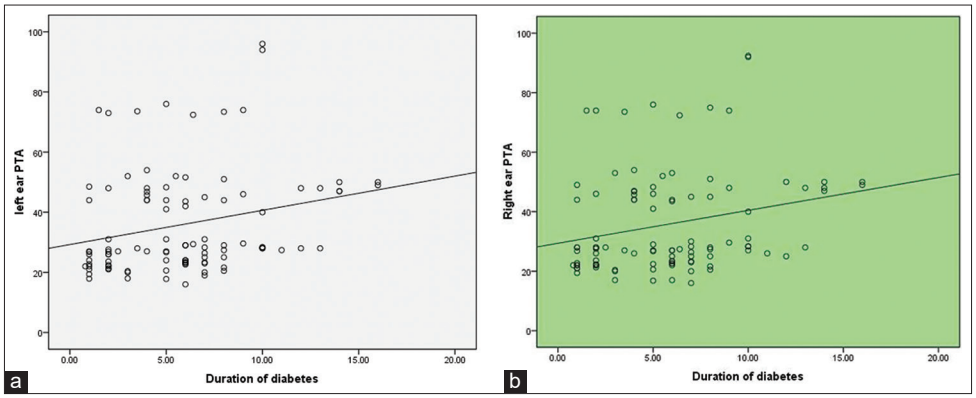

Fig. 2: Correlations between duration of diabetes and SNHL

Table 3: Gender-wise prevalence of degree of SNHL in diabetic cases

Gender	Degree of hearing loss					
	Normal (%)	Mild (%)	Moderate (%)	Severe (%)	Profound (%)	Total abnormal (%)
Male	18 (33.3)	16 (29.6)	16 (29.6)	4 (7.4)	0	36 (66.7)
Female	15 (31.9)	15 (31.9)	12 (25.5)	3 (6.4)	2 (4.3)	32 (67.1)
Total	33 (32.7)	31 (30.7)	28 (27.7)	7 (6.9)	2 (2.0)	68 (67.3)
	Chi-square=0.023 p=0.88					

Chi-Square test, p value < 0.05* is considered statistically significant. p value < 0.001** is considered statistically extremely significant. p = 0.88 (not statistically significant)

In our study, as the age of the cases advances, the prevalence of retinopathy increases. As the p=0.02* which is statistically significant. The prevalence of retinopathy in diabetic males is 53.30% and in diabetic females is 40.40% as the p=0.553 which shows that SNHL has no gender predilection in diabetic patients.

The proportion of DR among diabetes patients with HbA1c between 9.1 and 11 is the highest (80%) followed by patients with HbA1c more than 11, and the least percentage of retinopathy was seen among diabetes patients with HbA1C <7. PDR is exclusively found in HbA1c more than 9.1. As p=0.007* which is statistically significant (Table 7).

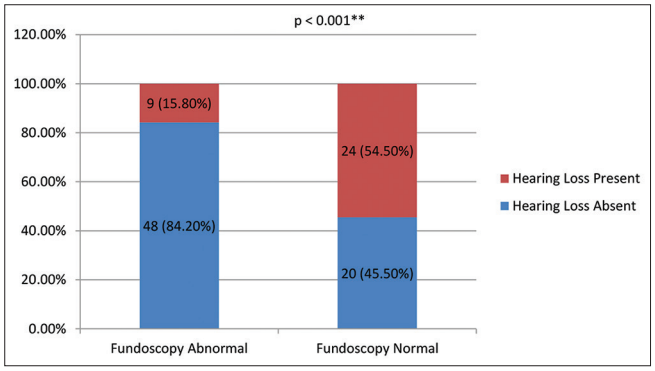

Fig. 3: Correlation between SNHL and retinopathy

Table 4: Comparisons of mean of SNHL (decibel) in both ears among cases and control

Hearing loss (in decibels)	Cases (mean±SD)	Control (mean±SD)	p-value*
Right ear PTA	35.81±17.26	23.80±6.93	<0.001**
Left ear PTA	35.86±17.25	24.01±6.70	<0.001**

<0.001**, *Mann Whitney U Test, p value < 0.001** is considered statistically extremely significant. PTA: Pure tone audiometry. SD: Standard deviation

Among DR patients, 84.20% of patients had hearing loss, with normal hearing in 15.80%. Among diabetic patients without DR, 45.5% of patients show SNHL, with normal hearing in 54.5%. As the p<0.001**, it is statistically extremely significant (Fig. 3).

The overall prevalence of diabetic nephropathy is 43.6% among diabetic patients. The prevalence of microalbuminuria and macroalbuminuria is 38.6% and 5% respectively. Among diabetic nephropathy patients, 86.4% had hearing loss, with normal hearing in 13.6%. Among diabetic patients without diabetic nephropathy, 52.6% of patients show SNHL, with normal hearing in 47.4%. There is a positive correlation between SNHL and diabetic nephropathy (p<0.001**, statistically extremely significant) (Fig. 4).

The overall prevalence of diabetic peripheral neuropathy in diabetic patients is 51.5%, the prevalence of motor axonal neuropathy is 19.8%, followed by motor sensory axonal neuropathy with the same 19.8%, then entrapment neuropathy, motor axonal demyelinating neuropathy, and sensory demyelinating neuropathy have a prevalence of 5.9%, 3.0%, and 2.0% respectively. Among diabetic peripheral neuropathy patients, 78.4% had hearing loss, with normal hearing in 21.6%. Among diabetic patients without peripheral neuropathy, 56% of patients show SNHL, with normal hearing in 44%. The p=0.0163* which is statistically significant (Fig. 5).

DISCUSSION

In our study, the age of cases has been matched with the age of controls. As the prevalence of hearing loss increases with age, as evidenced by Oh *et al*. and Huang and Tang [14,15]; our study subjects were matched according to the age group to minimize the confounding effects of age. In our study, gender distribution in cases was matched with controls (p=1). Our study found the prevalence of SNHL in diabetic males is 66.70% and in diabetic females is 68.1% (p=0.88), suggesting that there is no gender predilection for hearing loss. A similar result had been found in the study conducted by Sharma *et al*. [16].

Unsurprisingly, T2DM subjects had higher mean fasting glucose, 2-h PPBS, and mean HbA1c compared to normoglycemic control subjects. As would be expected, the key pathogenic processes of beta-cell dysfunction and resistance to insulin action were more evident in the

Table 5: Correlations of HbA1c with the degree of hearing loss among diabetic cases

HbA1C	Hearing Loss					
	Normal (%)	Mild (%)	Moderate (%)	Severe (%)	Profound (%)	Total abnormal (%)
6.5–7	10 (55.6)	6 (33.3)	1 (5.6)	1 (5.6)	0	8 (44.4)
7.1–9	17 (34.7)	12 (24.5)	17 (34.7)	3 (6.1)	0	32 (65.3)
9.1–11	1 (6.7)	8 (53.3)	4 (26.7)	2 (13.3)	0	14 (93.3)
>11	5 (26.3)	5 (26.3)	6 (31.6)	1 (5.3)	2 (10.5)	14 (73.7)
Total	33 (32.7)	31 (30.7)	28 (27.7)	7 (6.9)	2 (2.0)	68 (67.3)
	Chi-square=9.3363 p=0.025*					

Chi-Square test, p value < 0.05* is considered statistically significant. p value < 0.001** is considered statistically extremely significant. p=0.025*

Table 6: Prevalence of diabetic retinopathy among diabetic cases according to age group

Age group	Funduscopy					
	Normal (%)	Mild NPDR (%)	Moderate NPDR (%)	Severe NPDR (%)	PDR (%)	Total Abnormal (%)
≤30 years	3 (50.0)	3 (50.0)	0	0	0	3 (50.0)
31–50 years	33 (53.2)	21 (33.9)	5 (8.1)	3 (4.8)	0	29 (46.8)
>50 years	8 (24.2)	13 (39.4)	8 (24.2)	2 (6.1)	2 (6.1)	25 (76.8)
Total	44 (43.6)	37 (38.6)	13 (12.9)	5 (5.0)	2 (2.0)	57 (56.4)
	Chi-square=7.4661 p=0.02*					

Chi-Square test, p value < 0.05* is considered statistically significant. p value < 0.001** is considered statistically extremely significant. p=0.02*

Table 7: Correlations of HbA1c with diabetic retinopathy among diabetic cases

HbA1C	Funduscopy					
	Normal (%)	Mild NPDR (%)	Moderate NPDR (%)	Severe NPDR (%)	PDR (%)	Total Abnormal (%)
≤7	13 (72.2)	5 (27.8)	0	0	0	5 (27.8)
7.1–9	23 (46.9)	21 (42.9)	5 (10.2)	0	0	26 (53.1)
9.1–11	3 (20.0)	4 (26.7)	6 (40.0)	1 (6.7)	1 (6.7)	12 (80.0)
>11	5 (26.3)	7 (36.8)	2 (10.5)	4 (21.1)	1 (5.3)	14 (73.7)
Total	44 (43.6)	37 (38.6)	13 (12.9)	5 (5.0)	2 (2.0)	57 (56.4)
	Chi-square=11.9267 p=0.007*					

Chi-Square test, p value < 0.05* is considered statistically significant. p value < 0.001** is considered statistically extremely significant. p=0.007*

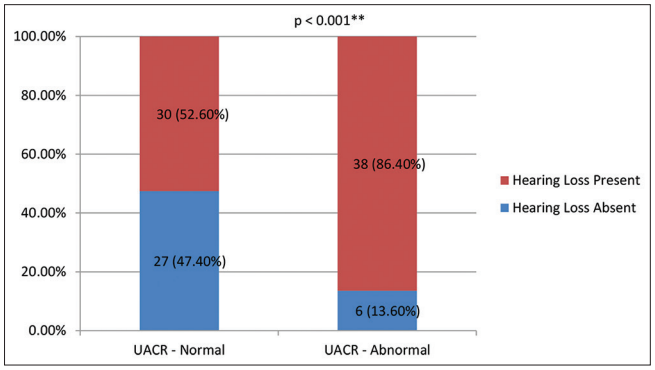

Fig. 4: Correlation between SNHL and diabetic nephropathy

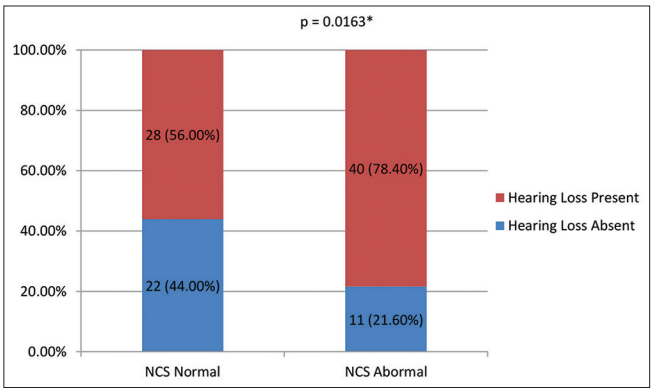

Fig. 5: Correlation between SNHL and diabetic neuropathy

T2DM cohort relative to normoglycemic control subjects.

Our study showed that SNHL was statistically significantly more common in diabetic patients as compared to non-diabetic control. The prevalence of SNHL among diabetics was 67.3% as compared to only 21.8% among non-diabetics, which was statistically extremely significant with a p<0.001**. This result approximates those of Mohapatra *et al.* (58%) [17], Meena *et al.* [18] (58%), Bhaskar *et al.* [19] (78.2%), and Sachdeva and Azim [20] (33.7%) studies. In the study among T2DM patients and non-diabetic control, hearing loss is more prevalent in both ears of diabetic patients. We found that as the age of the cases advances, the prevalence of SNHL increases (p=0.013*). The finding is similar to that of Aziz *et al.* [21], Saini *et al.* [22], and Jankar *et al.* [23].

Our study shows that the proportion of SNHL among diabetes patients with HbA1c between 9.1 and 11 is the highest (93.3%) followed by patients with HbA1c more than 11, and the least SNHL was seen among diabetes patients with HbA1c <7. Profound SNHL is exclusively found in HbA1c levels more than 11. The prevalence of SNHL correlated with the levels of HbA1c among diabetics, suggesting a possible significant association between diabetes and increased hearing loss, which is consistent with the observation made by Kim *et al.* [24] in which they found that the risk of hearing loss increased progressively with increasing HbA1c levels.

The SNHL in diabetes is gradual and progressive; with an increase in the duration of the disease, the prevalence of the SNHL increases. A statistically significant positive correlation was found among diabetic patients with the duration of diabetes and SNHL in the left ear and right ear. This outcome goes in similarity to Mohapatra *et al.* [17], Srinivas *et al.* [25], Ozkurt *et al.* [26], Rajendran *et al.* [27] and Aziz *et al.* [21].

The overall prevalence of diabetic peripheral neuropathy in diabetic patients is 51.5%. This outcome is similar to Pfannkuche *et al.* [28] and Young *et al.* [29].

In our study, we found a positive correlation between SNHL and DR (p<0.001**). The first positive correlation was found in 1961 by Jorgensen and Bush, which showed subjects with proliferative DR were twice as likely to have hearing loss. This outcome is similar to Kurt *et al.* [30]. The relationship between DR and hearing loss has been reported in several studies [14,31].

In our study, there is a positive correlation between SNHL and diabetic nephropathy (p<0.001). There is some study relationship between CKD and SNHL, but there is no study to our knowledge that shows the correlation between diabetic nephropathy and hearing loss.

Our study found a positive correlation between SNHL and diabetic peripheral neuropathy (p=0.0163*). There is a hypothesis that may explain a neuropathic mechanism, involving the auditory nerve, as the underlying cause for the higher prevalence of hearing impairment among diabetes. Despite this, there is only one population-based study that reported the correlation between hearing function and diabetic neuropathy [32]. Similar results have been reported by Ren *et al.* [33]. Hence, our study found a significant correlation between SNHL with DR, neuropathy, and nephropathy. The other factor that had a significant correlation was the duration of diabetes, HbA1C, and age of the patient.

CONCLUSION

This study established that SNHL is common in T2DM, with a high association with microvascular complications such as diabetic peripheral neuropathy, nephropathy, and retinopathy. As the duration of diabetes and level of HbA1C progress, the prevalence of hearing loss is found to get worse, demonstrating that lengthened and sustained exposure to the damaging pathological effects of DM has a tough bearing on hearing impairment. It is imperative to understand the mechanisms core to the pathogenesis of diabetes-associated hearing impairment, which may help provide benefits to ascertain effective interventions or prevention of early hearing dysfunction or loss. In such cases, routine audio-logical evaluation may be carried out to help in early diagnosis of SNHL. Good glycemic control is needed to prevent or delay its progress.

LIMITATION

As in the Indian population, the prevalence of diabetes is on the upper side; a bigger sample size could have thrown more insight on the subject

of SNHL in T2DM. The primary aim of this study was to estimate the prevalence rate and its correlation with microvascular complications. For this reason, merely a single pure-tone audiometry assessment was made. Sequential monitoring of auditory ability in diabetic patients could have helped outline the development of auditory impairment.

AUTHOR'S CONTRIBUTIONS

Dr. Sarata Chandra Singh, Dr. Manoranjan Behera and Dr. Manoranjan Swain contributed equally making the design of the study, literature research, data collection, statistical study, analysis of data, Dr. Bibhu Prasad Behera, Dr. Thakura Soren, and Dr. Tanmaini Das contributed equally to the statistical study, analysis of data, data interpretation, and manuscript writing. The corresponding author is Dr. Bibhu Prasad Behera.

CONFLICTS OF INTEREST

None.

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