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Hearing Evaluation in Type 2 Diabetes Mellitus

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Abstract:
Background: Diabetes mellitus is the most common metabolic disorder prevailing in the current era. With ongoing increase in cases of diabetes there has been a tremendous increase in the complications and consequences associated with diabetes mellitus. The common microvascular complications associated with diabetes are neuropathy, diabetic retinopathy and diabetic nephropathy. Neuropathy in diabetes mellitus can be central and peripheral. An example of central neuropathy is the involvement of the auditory pathway. The otological complaints associated may be commonly manifested as onset of hearing loss. Tinnitus can also be the presenting complaint and can lead to decreased quality of life. There have been multiple studies pertaining to this in order to establish a sound correlation between the two but all have had various conflicting results. Most studies have recorded a relatively higher incidence of sensorineural hearing loss. This study had thus been undertaken to examine the relationship between type 2 diabetes mellitus and hearing loss.

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I. Objectives:

To examine the relationship between type 2 diabetes mellitus and hearing loss, and if found; to determine its type, to find whether it is cochlear or retro cochlear; and to assess a possible relationship, if any between hearing impairment and age, duration of diabetes and metabolic control from the results obtained during the study.

II. Methodology:

Study Design: Hospital-based cross-sectional study
Study Participants: Human
Sample size: 50 patients with Type 2 Diabetes Mellitus
Study time: December 2019 to September 2021

Inclusion criteria:

- Patients with type 2 diabetes mellitus.
- Patients of both sexes between the ages of 30 and 70 are eligible.
- Willing to cooperate with the investigation.

Exclusion criteria:

- History of hearing loss prior to the onset of Diabetes
- Previous history of ear discharge or ear surgery
- Patient with a history of head trauma, radiotherapy and ototoxic drug intake
- Individuals working in occupations that are subjected to loud noises
- Any ear pathology, such as retracted tympanic membrane, perforated tympanic membrane, or tympanosclerosis, is revealed by an otoscopic examination.
- Patients are unwilling to comply with the study.
- Patients with a history of any chronic illness or known neurological
- Patients with no history of smoking

Patients with diabetes mellitus (DM) over the age of 30–70 years in a single group of 50 patients belonging to any gender coming to the ENT Out Patient department.
SAMPLING:

- Sampling Population:

Patients with Diabetes Mellitus ranging in age from 30 to 70 years. A convenient sampling technique was used. Investigations which were conducted in this study were history-taking, otoscopic examination, blood tests (fasting blood sugar, postprandial blood sugar, HbA1c, and serum creatinine).

- Study procedure:

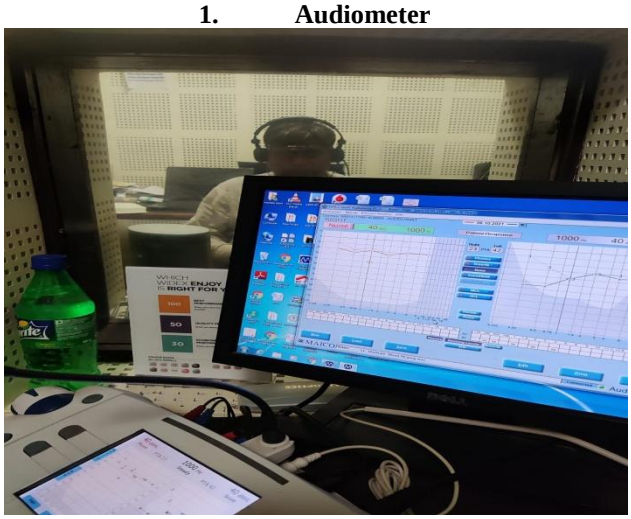
Informed consent was taken from all our OPD patients with Type II diabetes mellitus. Age, gender, weight and history of smoking or alcoholism and history of diabetes or any other chronic illness were recorded. Clinical examinations were performed on the patients to rule out any ear pathology using otoscope. Blood Investigations such as the levels of Fasting Blood Sugar / Post prandial Blood Sugar and HbA1c were carried out. In a performa, the results of the research were noted. Participants also underwent pure tone audiometry and those with results showing SNHL then underwent an additional OAE test and special test of hearing to find out cochlear and retro-cochlear hearing loss.

Hearing loss in these patients was assessed using PTA. In this way, they are exposed to pure tones that can be increased or decreased in intensity in 5 dB steps. The air conduction thresholds of tones of 125, 250, 500, 1000, 2000, 4000, and 8000 Hz were measured, whereas the bone conduction thresholds of tones of 250, 500, 1000, 2000, 4000 Hz were measured. It was depicted graphically as an audiogram graph. For a typical human, there is no A-B gap and air and bone conduction are at 0 decibels.

Air conduction thresholds for high frequencies (1000, 2000, 4000, and 8000 Hz) were then taken into consideration. The A-B gap was calculated to establish the type of hearing loss. Degree of hearing loss was correlated with WHO grading of hearing impairment.

The test was conducted in a soundproof room using a Maico audiometer.

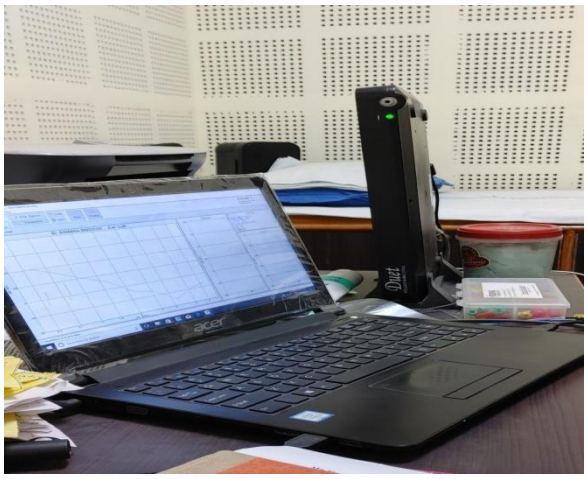
1. Audiometer



SISI test – The short increment sensitivity index test was performed in patients to evaluate cochlear hearing. A continuous tone of 20dB above the threshold is delivered and sustained for about 2 minutes. At every 5 sec tone is increased by 1dB. 20 such blips are delivered to the patient. Patient is asked to indicate the blips heard. Score more than 70% denoted cochlear hearing loss.

Tone decay test – Tone of 4000 hertz is delivered at 5 dB above the hearing threshold of patient for 60 seconds. When the patient stops hearing the intensity of tone is increased by 5 dB. This procedure is then continued till

the patient is able to hear the tone continuously for sixty seconds. More than 25 dB of tone decay is diagnostic of retro cochlear hearing loss.
OAE - The frequencies studied were 0.5 kHz, 1 kHz, 2 kHz, 4 kHz, 6 kHz, and 8 kHz. When the signal-to-noise ratio (SNR) in at least one of the frequencies tested was less than 6 dB, the test was declared abnormal.
When DPOAEs are present and normal in amplitude and configuration, their presence indicates that the cochlear amplifier (i.e., OHC motility) is normal in function. When DPOAEs are absent, their absence indicates that there is some dysfunction in the cochlea.[69]
OAE was performed using HIS DUTE equipment and data was recorded.



2. HIS DUTE Equipment

Parameters for the study were entered into a Microsoft Excel Worksheet Version 2016 spreadsheet. Analysis was done using the data Trial Version 20.0 of the Statistical Package for Social Sciences (SPSS). p value of 0.05 was chosen as the significant level before the investigation began. For data analysis, the following statistical test was used: Chi-square analysis.
Benefits: Appropriate early detection of causal variables for SNHL in diabetics, as well as quick and effective care to prevent or limit consequences.
Risk of study: In previous investigations, no dangers have been identified.
Age and sex were confounding variables. SNHL was outcome variable.

III. Results:

In our study out of 50 diabetes patients , 27(54%) had SNHL and 4(8 %) had mixed hearing loss.

Table 1. Gender wise distribution of Diabetics

Gender	Frequency	Percentage
Male	27	54
Female	23	46
Total	50	100

Table 2. Age wise distribution of Diabetics

Age group	Number of patients	Percentage (%)
30-40	17	34
41-50	8	16
51-60	15	30
61-70	10	20
Total	50	100

Taking into consideration the data in the preceding table, it can be concluded that the majority of diabetes patients in our study (30 percent) were between the ages of thirty and forty, followed by thirty percent among the ages between fifty and sixty. Mean age group in our study was 48 years.
There were a greater number of male patients who had diabetes. Out of 50 patients 27 (54%) were male.

Table 3. Hearing loss type in diabetics

Hearing loss type	Frequency
Normal	19
SNHL	27
Mixed	4

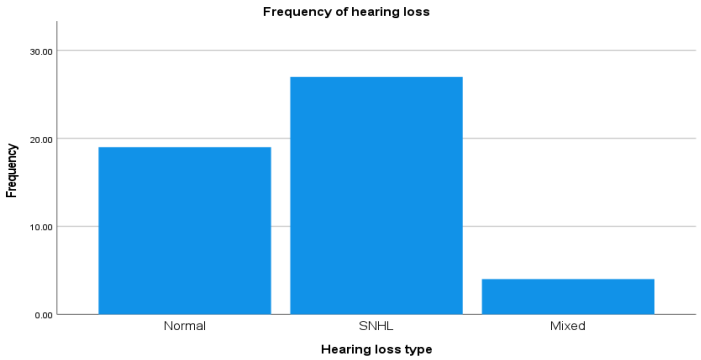


Figure 1

The SNHL group had the highest frequency pattern (54%) (27 out of 30), followed by normal and mixed hearing (38% and 8%) respectively.

Table 4. Frequency of hearing loss based on Pure tone audiogram

Hearing loss (dB)	Right PTA		Left PTA	
	Frequency	Percentage	Frequency	Percentage
Normal	19	38	19	38
Mild	6	12	7	14
Moderate	20	40	15	30
Severe	4	8	8	16
Profound	1	2	1	2
Total	50	100	50	50

PTA of right ear showed maximum number of patients (20 out of 50) having moderate loss followed by 6 patients in mild loss whereas left PTA showed 15 patients in moderate degree followed by 7 in mild category. Mean hearing threshold on right PTA and left PTA was 36.5 dB and 37.48 dB respectively.

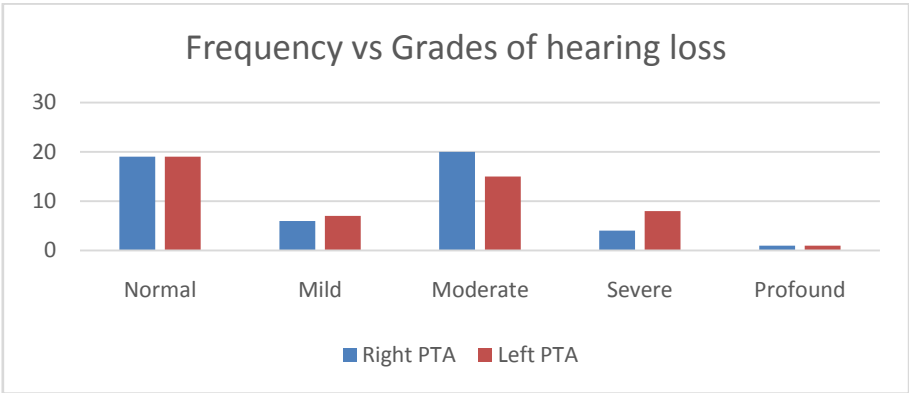


Figure 2.

Table 5. Gender v/s Hearing loss type

Hearing loss type	Male	Female
Normal	8	11
SNHL	16	11
Mixed	3	1

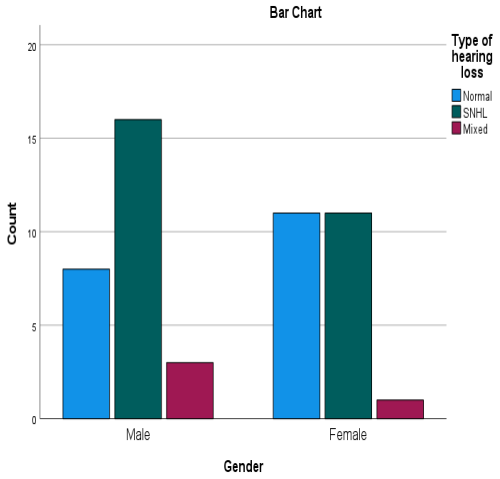


Figure 3

Chi square test	Correlation coefficient	P value
Gender	2.1	0.351

Since p value is 0.351 gender is statistically insignificant.

Table 6. Age v/s Hearing loss type

		Age group			
		30-40	41-50	51-60	61-70
		Count	Count	Count	Count
Hearing loss type	Normal	12	4	3	0
	SNHL	5	3	10	9
	Mixed	0	1	2	1

Chi square test	Value	P value
Age	17.4	0.008

Since p value is less 0.05 is statistically significant. As correlation coefficient is positive there is Strong relation between age of diabetics and hearing loss type.

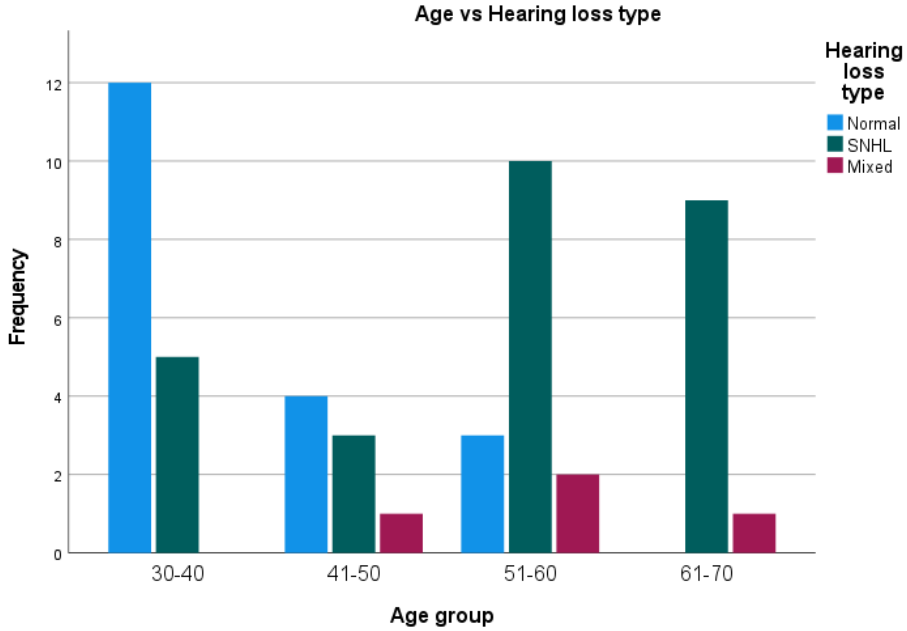


Figure 4
Duration of diabetes v/s type of hearing loss

Table 7.

		Duration of diabetes	
		Less than or equal to 10 years	More than 10 years
		Count	Count
Hearing loss type	Normal	19	0
	SNHL	16	11
	Mixed	4	0

Mean duration of diabetes in our study is 6.66 years

Chi square test	Pearson value	P value
Duration of diabetes	12.1	0.002

Because the p value is 0.002(<0.05), the type of hearing loss and the duration of diabetes have a good correlation. SNHL is common among diabetics, with a prevalence of 16 and 11 among fifty diabetics.

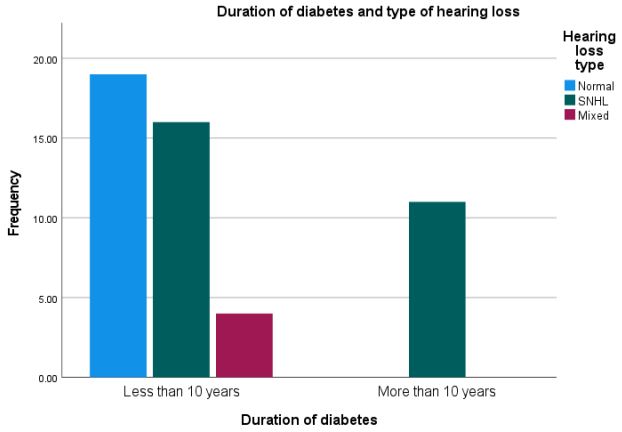


Figure 5.

Duration of diabetes V/s degree of hearing loss[Table 7,8]

Table 7. Right PTA

		Duration of diabetes	
		Less than 10 years	More than 10 years
		Count	Count
Degree of hearing loss	<25 dB	19	0
	26-40 Db	4	2
	41-60 dB	14	6
	61-80dB	1	3
	>80dB	1	0

Table 8. Left PTA

		Duration of diabetes	
		Less than 10 years	More than 10 years
		Count	Count
Degree of hearing loss	<25 dB	19	0
	26-40 Db	5	2
	41-60 dB	9	6
	61-80dB	5	3
	>80dB	1	0

	Pvalue	Pearson chisq coefficient
Right PTA	0.010	13.38
Left PTA	0.040	9.769

With the above results it can be correlated that degree of hearing loss is correlated with duration of diabetes as p value is less than0.05 in both right and left PTA

Table 9. Degree of hearing loss v/s type of hearing loss

Left ear		Degree of hearing loss				
		<25 dB	26-40 dB	41-60 dB	61-80 dB	>80 dB
		Count	Count	Count	Count	Count
Type of hearing loss	Normal	19	0	0	0	0
	SNHL	0	6	13	7	1
	Mixed	0	1	2	1	0

Table 10. Degree of hearing loss v/s type of hearing loss

Right ear		Degree of hearing loss				
		<25 dB	26-40 dB	41-60 dB	61-80 dB	>80 dB
		Count	Count	Count	Count	Count
Type of hearing loss	Normal	19	0	0	0	0
	SNHL	0	5	18	3	1
	Mixed	0	1	2	1	0

	Pearson value	p-value
Left PTA	50.26	<0.001
Right PTA	51.56	<0.001

With a p value of< 0.001, the association between the degree of hearing loss and the type of hearing loss is statistically significant, with SNHL being the most common type of hearing loss (54 percent). Furthermore, the right ear is marginally more significant than the left ear, with a pearson value of 51.56 as opposed to 50.26 for the left ear.

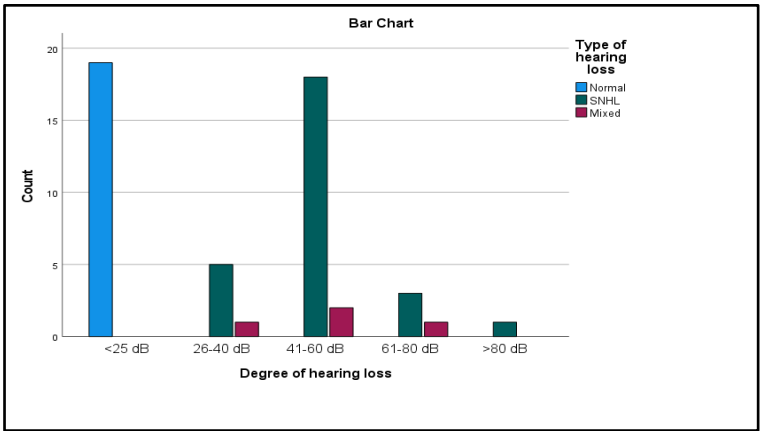


Figure 6.(Right ear)

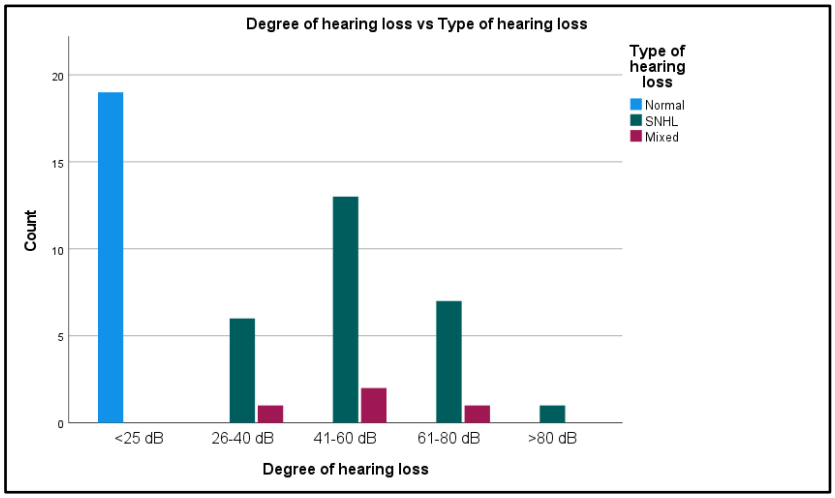


Figure 7(Left ear)

Table 11. Relation of fasting sugar level with hearing loss

		Fasting blood sugar (mg/dl)	
		<126	>126
		Count	Count
Hearing loss	Present	8	23
	Absent	10	9

Pearson chi sq value	P value
3.67	0.055

As p value is more than 0.05 association between Fasting sugar level and hearing loss was insignificant.

Table 12. Post Prandial blood sugar level vs hearing loss

		Post prandial blood sugar (mg/dl)	
		<200	>200
		Count	Count
Hearing loss	Present	5	26
	Absent	11	8

Pearson chisq value	Pvalue
9.44	.002

As p value is less than 0.005 significant association between post prandial sugar level and hearing loss was found. Out of 34 patients who had blood sugar level more than 200 mg/dl, 26 had hearing loss.

Table 13. HbA1c vs Hearing loss

		Hearing loss	
		Present	Absent
		Count	Count
HbA1c level	<5.6	5	11
	5.7-6.4	5	3
	>6.5	21	5

Pearson chi sq value	Pvalue
10.9	0.006

The largest number of patients with HbA1c >6.5 had a mean HbA1c of 8.0. Hearing loss was found in 21 of the 26 patients with HbA1c levels more than 6.5.

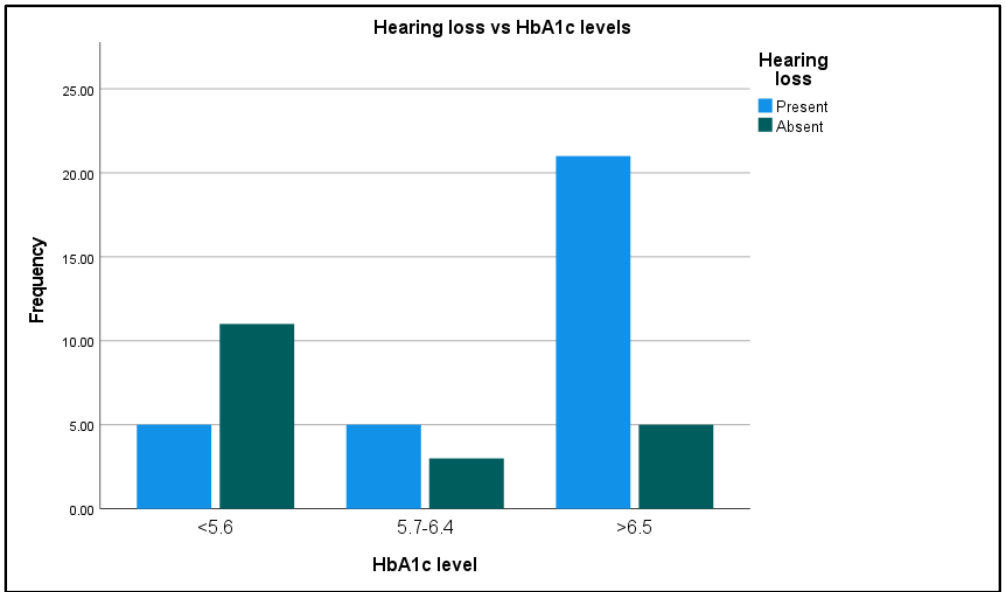


Figure 9

Table 14. Special test of hearing

Type of hearing loss	Number of patients	SISI score	Tone decay test
SNHL	24	70-100%	<25dB
	3	<20%	>25dB
Mixed	4	30-70%	<25 dB

In my study 24 patients had SISI score more than 70 percent which indicates it might be cochlear pathology.

Table 15. OAE

Type of hearing loss	Right EAR		Left EAR	
	Present	Absent	Present	Absent
Normal	N.A	N.A	N.A	N.A
Mixed	1	3	1	3
SNHL	3	24	4	23

OAE was done for patients who had Hearing loss. In right ear 88 % of cases had absent OAE whereas in left ear 85 % of cases had absent OAE.

IV. Conclusion:

In the study conducted it was found that hearing loss in diabetic patients was more common compared to non-diabetic patients and type of hearing loss was Sensorineural hearing loss. Cases predominantly had cochlear type of hearing loss. Maximum number of patients (40%) had moderate type of hearing loss followed by mild type of hearing loss with mean threshold of 36.5 dB in right ear and 37.4 dB in left ear. In diabetics, majority had bilateral hearing loss that is symmetrical, with severity ranging from mild to severe.

Hearing loss in type 2 diabetes mellitus had no significant relation to gender.

With increasing age, the prevalence of hearing loss increases, with the greatest percentage of people affected falling into the age group 51-60 years.

There was positive correlation between duration of diabetes and hearing loss.

Moderate hearing loss was more common in those who had diabetes for longer than 10 years (54%) than in those who had the disease for shorter durations (35%).

Cases with HbA1c levels greater than 6.5 had a greater chance of developing hearing loss. Diabetes patients with inadequate control had a higher hearing threshold. These findings suggest that maintaining a healthy glycaemic control may help prevent diabetes-related hearing loss.

Maximum Cases with blood sugar level more than 200mg/dl had moderate degree of hearing loss. This correlation was found to be significant.

Noncommunicable conditions or diseases, such as smoking, drinking, hypertension, and thyroid disorders, were excluded in order to demonstrate the direct effect of diabetes on hearing loss in our study.

V. Discussion:

The type of hearing loss in diabetic patients, as well as the association between hearing loss in diabetes and age, gender, diabetes duration, and metabolic management, were investigated in our study of 50 diabetic patients.At various frequencies of 1 kHz, 2 kHz, 4 kHz, and 8 kHz, a Pure tone audiogram was recorded using a Maico ma42 and tdh-50 p headphones. Patients underwent OAE test and special tests of hearing(SISI, tone decay test) after analysing the reports of Pure tone audiogram. The WHO categories of hearing impairment were utilised to confirm and classify the degree of hearing loss after the PTA assessed and validated the type and degree of hearing loss.

Sensorineural hearing loss affected 27 of the 50(54%) participants in our study. With such a prevalence rate it can be concluded that hearing loss could be a complication of Diabetes mellitus. Hearing loss in this was found bilateral almost symmetrical SNHL type.

According to Rajendran et al[1], the prevalence of sensorineural deafness among diabetics is 73.3 percent, which is very significant (p = 0.001) when compared to the prevalence of 6.7 percent among controls. Ramlakhan Meena et al[2] did a study at SMS hospital to asses hearing loss in type 2 diabetes mellitus. He evaluated 50 diabetic patients in his study. He reported 58% of cases had SNHL which was more compared to our study. Kakarlapudi V et al[3] found only 13% of cases had SNHL which was very low as compared to our study.

When it came to degree of loss, 20 out of 50 people in our study had moderate hearing loss in their right ear and 15 out of 50 people had moderate hearing loss in their left ear. Furthermore, the right ear is marginally more significant than the left ear, with a pearson value of 51.56 as opposed to 50.26 for the left ear.

Diabetes patients have a 55 percent likelihood of experiencing hearing loss, according to Friedman and colleagues[4]. Weng et al[5] and colleagues assessed 67 diabetic patients for their study and discovered that 44.8 percent of them had substantial hearing loss. According to Ren and colleagues' [6]and Kakarlaupadi et al[3] diabetics have hearing loss that is associated to higher frequencies, resulting in a moderate degree of hearing loss. Elizabeth purchase Helzner et al[7] concluded in his study that 21.3% of diabetic person had low to mid frequency impairment as compared to 9.4% in non-diabetic individuals.

In our study out of 31 patients who had hearing loss 27 patients had Otoacoustic emission absent in right ear whereas in left ear 26 patients showed absent OAE test. Using special test of hearing it was found that 28 out of 31 patients (90.3%) had cochlear type of hearing loss. In a study done by Angela mishra et al[8] it was discovered that the majority of [64 percent] cases had a TDT of 15–20 dB/hl, while the majority of 82 percent of controls had a TDT of less than 5 dB/hl . SISI was less than 70% in 16 (32%) and 47 (94%) subjects in Cases and controls, but 70–100% in 34 (68%) and 3 (6%) subjects in Cases and controls. However, they did special test of hearing in all patients.

All tests done in our study suggest cochlear pathology in diabetic cases. Such high prevalence of absent OAE in our study points towards microangiopathy of cochlea due to poorly controlled diabetes. Patients with microangiopathic endolymphatic sac involvement had significantly greater hearing loss. In diabetic patients with basilar membrane microangiopathy, the percentages of histologically normal hair cells and stria vascularis cells are low.

In contrast to our study Yalda Jabbari[9] evaluated acoustic emission in inner ear in diabetics. He studied 50 diabetic and 50 non diabetic patients. He concluded that disorder OAE was present only in 16 % of cases. He also concluded there was no significant association between OAE in diabetics and non-diabetics individuals.

Fukushima et al[10] hypothesised that cochlear angiopathy and degeneration of the outer hair cells were the most likely causes of deafness in diabetic population.

Erdemerem et al[11] looked at the influence of diabetes on OAE in 40 diabetic patients and found that the amplitude was lower in diabetic patients than in healthy people.

Age

Among the individuals in our study, the age group between 51 and 60 years old was the most adversely affected by hearing loss (p 0.05).

As the patient's age increases, the prevalence of hearing loss increases. This could be a result of the hearing system's structural changes as a person ages. According to a few studies, the risk of microvascular insufficiency due to vasospasm and emboli increases with age.

In a study, Rajendran S, Anandhalakshmi,[12] and colleagues found that the most cases occurred in people aged 40 to 50.

Younger people were more likely to have SNHL, according to Friedman and Cullen A.

Hearing loss was most severe in those aged 41 to 50 years old, according to P C Chamyal's[13]study, which was similar to ours. Eight of the twelve patients between the ages of 41 and 50, suffered from hearing loss.
In his study, Angela Mishra et al[8] found that the frequency of SNHL increases with age. He analysed 50 diabetic patients, of whom 32 percent had SNHL, most of whom were between the ages of 51 and 65.
Gender
In our study a greater number of diabetic males suffered hearing loss, although the it was not statistically significant (p >.05). In my study male are found to be more affected than females. It could be due to exposure to occupational noise and environmental factors.
Diabetic female patients had much higher hearing loss than diabetic male patients, according to Taylor and Irwin[14] (1978). In their study, Hemanth C. et al[15] discovered that females were 1.4 times more affected than males.
Angela Mishra et al[8] did a study in Gandhi medical college between a time period of 2017-2018 to evaluate audiometric results in diabetic person. She studies 50 diabetic patients out of which18(48.6%) male had SNHL and19 (51.35 %) female had SNHL. Similar to our study association between gender and SNHL is statically insignificant.

Duration of diabetes
Twenty diabetics who had been diagnosed for less than ten years reported hearing loss in my study. There is a strong association between diabetes duration and hearing loss because the p value was significant. Eleven persons had diabetes for over ten years, and eight of them had hearing loss as a result of it.

According to our findings, there was a positive relationship between the duration of diabetes mellitus and the degree of hearing loss in our participants. Cases with diabetes for more than 10 years were found to have some degree of hearing loss in the right ear. In our study, cases with a duration of diabetes of more than 10 years had a moderate degree of hearing loss (54%), followed by a severe type of hearing loss (27%). Among cases who had diabetes for less than 10 years, only 35% of cases had moderate hearing loss, followed by 10% of cases with mild hearing loss.

It was observed that 54 percent of patients with diabetes for more than 10 years had moderate type of SNHL in the left ear, whereas only 23 percent of cases with diabetes for less than 10 years had moderate hearing loss. This could be related to the fact that people who have had diabetes for a longer period of time have higher sugar levels in their inner ears, which causes disturbance of the energy-driving mechanism in the inner ear. Diabetes-related hearing loss may be caused by microangiopathy of the cochlear vasculature.
P.C Chamyal[13] studied 30 diabetics patients and 30 control at AFMC Pune and it was concluded there was no relation between hearing loss and duration of diabetes.
Blood sugar
Hearing loss and blood sugar levels were found to have a significant relationship. In our study, 34 of the participants had blood sugar levels greater than 200 mg/dL, and 26 of them suffered hearing loss. Maximum number of patients (19 out of 34) with blood sugar level more than 200mg/dl had moderate type of hearing loss. This signifies poorly controlled diabetes leads to worsening of hearing threshold.
Thimmasettaiahet al.[16] found a link between blood glucose levels and deafness, with the moderate kind of SNHL having the highest incidence in high glucose levels.
In a study similar to ours, P C Chamyal[13]discovered that four out of six individuals with a blood sugar level greater than 200 mg/dl had hearing loss. He came to the conclusion that people with poorly controlled diabetes had a larger likelihood of developing hearing loss than other patients.
Relation with HbA1c level
In our studied we correlated HbA1c levels with hearing loss which showed control of diabetes over past 3 months. Out of 16 patients who had HbA1c levels less than 5.6 only 5 patients had hearing loss whereas 21 out 26 patients having HbA1c level more than 6.5 had hearing loss. As p value less than 0.05 and Pearson chisq value 10.9 this study is significant. It was concluded that in comparison to patients with well-managed diabetes, people with poorly controlled diabetes had a higher hearing threshold. Microangiopathy of the inner ear is the primary cause of this. With an increase in HbA1c, the risk of cochleopathy rises. Glycated haemoglobin levels and cochleopathy are both affected by a lack of glycaemic management.
A study by C.V. Srinivas et al[17] showed that hearing threshold increases with levels HbA1c. In Patients withHbA1c more than 8 prevalence of SNHL more than 85%.
Researchers Ying Shen [18] and colleagues discovered in their study that the degree and type of Sudden Sensorineural Hearing Loss were substantially associated with HbA1c levels, while there was no clear link between a higher HbA1c level and a worse SSNHL prognosis.

Following an investigation of 200 diabetes individuals, Gunjan Dhasmana et al [19] found a statistically significant relationship between hearing loss and HbA1c levels. He discovered that patients with poor metabolic control (HbA1c>7.6) were more likely to suffer from hearing loss, whereas patients with good metabolic control were less likely to suffer from hearing loss.

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