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# "A CLINICAL STUDY TO EVALUATE THE ASSOCIATION OF HBA1C TITRES IN TYPE 2 DIABETES MELLITUS AND SEVERITY OF SENSORINEURAL HEARING LOSS"

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## ABSTRACT

**Background:** Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder associated with several complications, including the underrecognized impact on auditory function. Sensorineural hearing loss (SNHL), particularly at higher frequencies, may be influenced by poor glycaemic control, as reflected by elevated HbA1c levels.

**Objective:** To evaluate the association between HbA1c titres and the severity of SNHL in patients with T2DM.

**Methods:** This cross-sectional observational study was conducted over 12 months at a tertiary care hospital in India, enrolling 70 T2DM patients aged 30–75 years. Patients underwent HbA1c testing and Pure Tone Audiometry (PTA). SNHL severity was categorized using WHO grades, and associations with HbA1c were statistically analyzed using chi-square, Pearson correlation, and ROC analysis.

**Results:** The majority of participants were aged 60–69 years (34%), with moderate or severe SNHL. Poor glycaemic control was common, with 37% of participants having sub-optimal HbA1c levels (7–8.9%) and 37% with poor control (≥9%). The severity of SNHL showed a clear association with glycaemic status: 33% of those with HbA1c < 7%, 54% with HbA1c 7–8.9%, and 100% with HbA1c ≥ 9% had moderate or severe SNHL (**$p < 0.001$**). ROC analysis identified an HbA1c cut-off of 8.7% for predicting moderate SNHL, with good diagnostic accuracy (AUC 0.79, sensitivity 77%, specificity 72%).

**Conclusion:** Poor glycaemic control is significantly associated with increased SNHL severity in T2DM patients. Audiological screening should be integrated into routine diabetic care to detect early hearing impairment.

**Keywords:** Type 2 Diabetes Mellitus, Sensorineural Hearing Loss, HbA1c, Glycaemic control, Pure Tone Audiometry

## INTRODUCTION

Hearing gives us and enriches our day to day life. It helps us to lead our lives happily without any restrictions. Hearing is integral part of speech, it enables us to interact with people, work and earn. Any impairment in hearing will lead to physical, mental and social stress to the person; compromising the work, education, employment opportunities and quality of life. Hearing

loss in adults can be caused by a variety of reasons, including age, genetics, neurological illnesses, vascular causes, metabolic problems, ototoxic medicines, noise, and diabetes mellitus[1] But age-related hearing loss cannot be reversed, it is critical to identify factors that may be avoided.

Sensorineural hearing loss is defined as a bilateral, gradual-onset loss, particularly affecting higher frequencies caused by damage to the inner ear or the nerve pathways from the inner ear to the brain. It is an underrecognized but significant complication of diabetes[2]

Diabetes mellitus is a common non communicable metabolic disease that causes various impairments of the body systems. As diabetes mellitus occurs most commonly in general population, particularly Type 2 diabetes mellitus (T2DM), the effects caused by it on various organs of our body assume greater importance, It is a globally prevalent metabolic disorder with a growing burden in India. Prevalence of diabetes mellitus is increasing worldwide and it is more pronounced in India. According to the estimation, total number of diabetes patients in India is around 40.9 million and by 2025 the number would be around 69.92 million[3]

It is characterized by chronic hyperglycemia due to insulin resistance or inadequate insulin secretion. While complications like neuropathy, nephropathy, and retinopathy are well-known, the impact of T2DM on the auditory system especially sensorineural hearing loss (SNHL)—is gaining attention in recent years.Glycated Hemoglobin (HbA1c) is a non-enzymatic and slow glycolysis product of hemoglobin in the blood that is used to monitor long-term glycemic management in diabetics and to diagnose non-diabetic people[4] HbA1c reflects the average blood glucose concentration over the previous two to three months and is a crucial marker of long-term glycemic control[4] It's also thought to represent the quality of patient follow-up control and suggest the danger of diabetic complications. Although HbA1c is less than 6% in those without diabetes, it can rise to more than 10% in people with uncontrolled diabetes[5] Various mechanisms have been put forward to find causative association such as microangiopathy, oxidative stress, free radical damage, brain stem involvement, precipitates in straia vascularis, spiral ligament, atrophy of spiral ganglion, loss of hair cells, nerve demyelination; but a strong correlation is yet to be proven[6,7] The hurdles in investigating the association between diabetes mellitus and hearing loss are the presence of various confounding factors such as age, hypertension, and occupational noise exposure.

The relationship between diabetes and sensorineural hearing loss has been investigated for more than 150 years although, but there are conflicting results in earlier studies regarding this. Also, there is a lack of sufficient studies establishing a definite correlation between the value of HbA1C and the degree of sensorineural hearing loss. This study is based on the hypothesis that the value of HbA1C correlates with the degree of sensorineural hearing loss in type 2 diabetes mellitus patients So that it will help identify this complication at an early stage and thus decrease morbidity in diabetics. By comparing the audiometric characteristics of the study population, we divided the same into two groups,which lead us to discover a link between HbA1c and Sensorineural Hearing Loss.

## OBJECTIVE

1. To evaluate the association between the severity of sensorineural deafness with poorly controlled diabetes milletus.
2. To evaluate the relation of sensorineural hearing loss with duration of diabetes milletus.
3. To evaluate the result of our study and to compare our data with similarly published studies.

## METHODOLOGY

This was a cross-sectional observational study conducted to evaluate the association between HbA1c levels and the severity of sensorineural hearing loss (SNHL) in patients with type 2 diabetes mellitus (T2DM). The study design enabled data collection at a single time point, allowing analysis of the relationship between glycemic control and hearing status without follow-up.

The study was carried out at Pacific institute Of Medical Sciences,Udaipur,India in the Departments of Otorhinolaryngology and General Medicine over a period of 12 months, from January 2023 to December 2023. This allowed sufficient time for patient recruitment, evaluation, data entry, and analysis. A sample size of 70 diabetic patients was finalized based on prevalence estimates and statistical requirements. This ensured adequate power for detecting significant associations.
Purposive sampling was used. Eligible patients visiting the General Medicine outpatient department were selected consecutively based on inclusion criteria and referred for hearing assessment.
Institutional Ethics Committee approval was obtained. Informed written consent was taken from all participants. Confidentiality was maintained throughout the study, and standard care was provided
After consent, clinical data and HbA1c levels were recorded. Audiological evaluation was done using pure tone audiometry in a soundproof setting, and results were documented systematically.

**Inclusion & Exclusion Criteria**

- Participants aged 30–75 years with T2DM of at least 1year duration were included.
- Patients with ear diseases, ototoxic drug history, neurological disorders, noise exposure, or other comorbidities affecting hearing were excluded.

**Study Groups**

Patients were grouped based on their glycaemic control status as measured by HbA1c levels. Three categories were defined: patients with good glycaemic control (HbA1c < 7%), those with sub-optimal control (HbA1c between 7% and 8.9%), and those with poor glycaemic control (HbA1c ≥ 9%) [8,9]. This stratification enabled a detailed assessment of the relationship between varying levels of chronic hyperglycemia and the severity of sensorineural hearing loss (SNHL). In parallel, hearing loss severity was classified using Pure Tone Audiometry (PTA) in accordance with World Health Organization (WHO) grading criteria. Patients were categorized as having mild (26–40 dB HL), moderate (41–60 dB HL), severe (61–80 dB HL), or profound (>80 dB HL) SNHL [10]. No patient in the study demonstrated normal hearing thresholds (≤25 dB HL). For statistical analysis, hearing loss was further dichotomized into two major categories: SNHL < moderate (mild only) and SNHL ≥ moderate (including moderate, severe, and profound). This categorization facilitated the evaluation of the association between glycaemic control and hearing loss severity across distinct metabolic and audiological profiles observed in patients with Type 2 Diabetes Mellitus.

**Study Parameters**

Parameters assessed included HbA1c levels, hearing thresholds, age,duration of diabetes milletus.Hearing loss was classified using WHO grading based on pure tone audiometry.

**Study Data Collection and Analysis**

Data were collected using a structured case record form. Demographic, clinical, and audiological findings were recorded and cross-verified to ensure accuracy and completeness.
Data were analyzed using SPSS software. Descriptive statistics and tests like chi-square, t-test, and Pearson correlation were used. A p-value <0.05 was considered statistically significant.

## RESULTS

**Table 1. Age Distribution of the Study Population**

| Age Band (years) | n | Percentage (%) |
|---|---|---|
| 30 - 39 | 02 | 2. 85 |
| 40 – 49 | 12 | 17.14 |
| 50 – 59 | 22 | 31.43 |
| 60 – 69 | 24 | 34.29 |
| ≥ 70 | 10 | 14.29 |
| **Total** | **70** | **100** |

Most participants were aged between 60–69 years (approx.34%), followed by 50–59 years (approx.31%). The 40–49 years age group contributed approx. 17% of the cases. Participants aged between 30-39 years accounted for the least proportion (approx.3%) (Table 1).

**Table 2. Duration of Diabetes Milletus**

| Duration(years) | n | Percentage (%) |
|---|---|---|
| 5-9 | 26 | 37.14 |
| 10-14 | 24 | 34.29 |
| ≥ 15 | 20 | 28.57 |
| **Total** | **70** | **100** |

Approximately 63% of participants had lived with T2DM for atleast 10 years,resulting in underlining chronocity of metabolic insult that may culminate in cochlear microangiopathy. Duration showed a moderate positive correlation with HBA1c ($r = 0.32$ , $p = 0.007$) (Table 2)

**Table 3. Glycaemic Control Categories (HbA1c)**

| HbA1c Category | n | Percentage (%) |
|---|---|---|
| < 7 % (Good) | 18 | 26 |
| 7 – 8.9 % (Sub-optimal) | 26 | 37 |
| ≥ 9 % (Poor) | 26 | 37 |
| **Total** | **70** | **100** |

The majority of participants had sub-optimal (37%) or poor (37%) glycaemic control, with equal distribution in both categories. Only 26% of individuals had good glycaemic control (HbA1c < 7%). This indicates a high prevalence of poor glycaemic control among the study population(Table 3).

**Table 4. Severity of Sensorineural Hearing Loss (WHO Grading)**

| SNHL Grade | PTA Range (dB HL) | n | Percentage (%) |
|---|---|---|---|
| Normal | ≤ 25 | 0 | 0 |
| Mild | 26 – 40 | 18 | 25.71 |
| Moderate | 41 – 60 | 28 | 40 |
| Severe | 61 – 80 | 18 | 25.71 |
| Profound | > 80 | 6 | 8.58 |
| **Total** | — | **70** | **100** |

The majority of participants (40%) had moderate sensorineural hearing loss based on WHO grading. Mild and severe hearing loss were observed equally in approx. 26% of individuals each. A smaller proportion (9%) approximately, had profound hearing loss, while no participants had normal hearing(Table 4).

**Table 5. Association Between HbA1c and SNHL Grade**

| SNHL ≥ Moderate | HbA1c < 7 % | HbA1c 7 – 8.9 % | HbA1c ≥ 9 % |
|---|---|---|---|
| Present | 6 | 14 | 26 |
| Absent | 12 | 12 | 0 |
| **Total** | 18 | 26 | 26 |

The table shows that the prevalence of moderate or severe SNHL increases with poorer glycaemic control. Only 33% (6/18) of individuals with good HbA1c (<7%) had moderate or severe SNHL. This increased to 54% (14/26) in those with sub-optimal HbA1c (7–8.9%) and 100% (26/26) in

those with poor HbA1c (≥9%), indicating a strong association between poor glycaemic control and severity of SNHL (Table 5).

**Table 6. ROC Analysis for HbA1c Cut-off Predicting Moderate SNHL**

| Metric | Value |
|---|---|
| Area Under Curve | 0.79 |
| Optimal Cut-off (HbA1c) | 8.7 % |
| Sensitivity | 77 % |
| Specificity | 72 % |
| Youden Index | 0.49 |

The ROC analysis shows that HbA1c has good predictive ability for moderate or severe SNHL, with an AUC of 0.79, indicating acceptable discrimination. An optimal HbA1c cut-off of 8.7% provides 77% sensitivity and 72% specificity, with a Youden Index of 0.49, suggesting this cut-off balances both true positive and true negative rates reasonably well(Table 6).

## DISCUSSION

This study confirms a strong association between poor glycaemic control and the severity of sensorineural hearing loss (SNHL) in patients with type 2 diabetes mellitus (T2DM). More than half of the participants exhibited moderate or severe SNHL, with the highest prevalence observed in the 60–69 years age group, suggesting that both advancing age and diabetes-related metabolic disturbances contribute to cochlear dysfunction. .In another Indian study by Pemmiah KD and Srinivas DR. [11], a statistically significant correlation was found between HbA1c levels and SNHL at higher frequencies (2000 Hz and 4000 Hz), suggesting that hyperglycemia might affect cochlear structures responsible for high-frequency hearing [11].

Similar trends were reported by Quines and Gloria (2023) [12], who found that T2DM patients with HbA1c above 8.3% had significantly greater SNHL severity due to poorer auditory function compared to those with better glycemic control patients. Our identification of 8.7% as the optimal HbA1c cut-off for predicting moderate SNHL closely mirrors their findings. The observed dose-response relationship between HbA1c and hearing thresholds further supports the hypothesis of glycaemic-driven cochlear injury.

A population-based analysis by Li M et al [13] also supported this relationship. Using large-scale data, the study found that diabetics with poor glycemic control (HbA1c ≥14.0%) had a significantly higher risk of developing SNHL than those with better control. This effect was most pronounced in older adults, further stressing the compounding impact of age and glycemic status [13].Kaur G and Srivastava SP [14] reiterated that SNHL is more prevalent among diabetics than in non-diabetics, and the degree of hearing loss correlates with the duration of diabetes and elevated HbA1c levels, implicating microangiopathy as a possible mechanism [14].

Another analytical study by Jyoti et al. (2021) [15] found SNHL in 73% of diabetic patients versus only 16% in controls, with severity increasing in poorly controlled diabetics. Their study strengthens the idea that SNHL is a prominent yet overlooked diabetic complication [15].

Kumar et al. (2023) [16] reported a moderate positive correlation between HbA1c and PTA thresholds, consistent with our result. Additionally, our logistic regression analysis showed that every 1% increase in HbA1c raised the odds of severe SNHL by 60%, reinforcing findings by Srinivas et al. (2016) [17], who emphasized the impact of chronic hyperglycaemia and long-standing diabetes on auditory health.

Vybhavi et al. (2024) [18] also observed a high SNHL prevalence (70.7%) in diabetics and highlighted that hearing loss severity correlated with both glycaemic control and diabetes duration. Our findings are similar, as approx. 63% of participants had lived with diabetes for over 10 years, and this chronicity likely contributed to microvascular damage in the cochlea. Tiwari and Mudhol (2018) [19] also documented SNHL in 76.8% of diabetic subjects and noted a significant

correlation with both HbA1c levels and duration of disease. Their work advocates for including auditory evaluations in routine diabetic care .

A similar study by Kumar S [20] demonstrated that 84.7% of diabetic patients with SNHL had HbA1c levels above 7%, and a significant number had levels above 8%, underlining the link between poor glycemic status and severe SNHL [20].

The ROC analysis in our study yielded an AUC of 0.79, indicating good predictive accuracy of HbA1c for moderate SNHL. This supports its clinical use as a screening threshold in diabetic populations.

Our study corroborates existing evidence that poor glycaemic control, increasing age, and longer diabetes duration are significant risk factors for SNHL. These findings advocate for integrating audiological screening into routine diabetes care to identify early hearing impairment and reduce the burden of undiagnosed auditory disability in this high-risk group.

## CONCLUSION

This study establishes a strong association between poor glycaemic control and the severity of sensorineural hearing loss (SNHL) in patients with type 2 diabetes mellitus. The risk of moderate or severe SNHL significantly increased with rising HbA1c levels, with all individuals having HbA1c ≥ 9% exhibiting significant hearing loss. An HbA1c cut-off of 8.7% demonstrated good predictive accuracy for moderate SNHL. These findings highlight the importance of routine audiological screening in diabetic patients, especially those with poor glycaemic control, to enable early detection and management of hearing impairment.

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