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Original Research Article

The association between blood sugar control and hearing impairment in individuals with type 2 diabetes mellitus: a prospective study using otoacoustic emissions as a biomarker

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ABSTRACT

Background: The existing association between hearing impairment and diabetes mellitus (DM) prompted us to investigate the relationship between glycaemic control, as measured by HbA1c levels, and hearing impairment in individuals with type 2 diabetes mellitus (T2DM)**.**
Methods: In this study, we assessed the auditory function of a sample of 100 individuals diagnosed with T2DM, who were aged 30 years or older and had a disease duration of at least 5 years. The evaluation was conducted using distortion product otoacoustic emissions and transient evoked otoacoustic emissions. The criteria for poor glycaemic control were established as HbA1c levels equal to or exceeding 7.5%.
Results: Individuals with a haemoglobin A1c (HbA1c) level of 7.5% or higher exhibited a nearly threefold increased likelihood of developing hearing impairment in comparison to those with lower HbA1c levels. The gender-based observation revealed a stronger association in females, although the observed correlation did not reach statistical significance.
Conclusions: The findings of our study establish a significant association between inadequate management of blood glucose levels and the occurrence of hearing impairment among individuals with T2DM. These results underscore the importance of achieving optimal glycaemic control as a means of preventing hearing impairment in this patient population. Further investigation is required to substantiate these findings through a comprehensive and longitudinal research approach.

Keywords: Blood sugar, Hearing impairment, Type 2 diabetes mellitus, Otoacoustic emissions

INTRODUCTION

Diabetes mellitus (DM) is commonly acknowledged to be linked with hearing impairment, which is likely caused by microvascular and neuropathic complications that affect the auditory nerve and cochlea.[1] Nevertheless, it is imperative to conduct further investigation into the precise mechanisms and contributing factors that underlie this particular relationship.[2,3]

The existing body of research investigating the association between DM and auditory dysfunction has yielded inconclusive results.[2,3] Multiple studies have posited a potential association between the duration of coexisting with DM and the magnitude of hearing loss. However,

divergent findings have been reported by alternative investigations.[2,3] The existing body of evidence is progressively indicating the significance of maintaining optimal glycaemic control in the development of hearing impairment among individuals with DM.[4,5]

The utilisation of otoacoustic emissions (OAEs) has been suggested as a potentially valuable biomarker for the timely identification of auditory impairment in individuals with DM.[6] The cochlea's auditory responses can be measured in an objective manner, potentially allowing for the detection of minor alterations in hearing ability prior to the manifestation of noticeable clinical symptoms. The findings of a study conducted by Sasso FC et al. indicate a notable decrease in OAEs in individuals with T2DM, which underscores the potential value of OAEs in identifying hearing loss at an early stage in this group.[6] Further investigation is warranted considering the intricate relationship between DM and auditory impairment, as well as the potential impact of various factors including the duration of DM, glycaemic control, and coexisting medical conditions. The objective of this study is to examine the correlation between glycaemic control and hearing impairment in individuals diagnosed with T2DM. This will be accomplished by utilising OAEs as a biomarker to evaluate the functioning of the cochlea. The findings derived from this study have the potential to make a valuable contribution towards the advancement of early identification and intervention approaches for hearing loss in this specific demographic.

METHODS

This is a prospective observational study carried out at a tertiary care hospital in Bangalore from January 2021 to December 2022. The study comprised a cohort of 100 individuals diagnosed with T2DM who were at least 30 years of age and had been living with DM for a minimum of 5 years. The study excluded patients with a prior history of noise exposure, ear surgery, or other comorbidities that could impact their hearing.

Measurements

The research assessed hearing loss by utilising OAEs, which are accurate gauges of cochlear function that can identify initial alterations in the hearing before their manifestation in clinical settings. The research examined distortion product otoacoustic emissions (DPOAEs) and transient evoked otoacoustic emissions (TEOAEs) in the ears of all participants. Measurements were carried out with a portable OAE instrument, specifically the Neuroaudio's neuro soft model. DPOAEs were used to assess the performance of the outer hair cells in the cochlea, while TEOAEs were applied to gauge the overall effectiveness of the cochlear system. Hearing impairment was defined as a signal-to-noise ratio (SNR) below 6 dB for either DPOAEs or TEOAEs.

Assessment of glycaemic control was conducted through the utilisation of HbA1c levels, which indicate the mean blood glucose levels within the preceding 3-month period. The criterion for inadequate glycaemic control was established as an HbA1c concentration equal to or exceeding 7.5%. The study subjects' clinical and demographic characteristics were evaluated using descriptive statistics for statistical analysis. The study utilised logistic regression analyses to investigate the correlation between HbA1c levels and hearing impairment while controlling for potentially confounding variables such as age, gender, duration of diabetes mellitus, and medication usage. Subgroup analyses will be conducted to investigate the possibility of effect modification by gender and medication usage. The study's procedures were reviewed and approved by the hospital's Institutional Review Board, indicating that ethical considerations were addressed. In addition, all participants provided written informed consent before participating in the study.

RESULTS

The research involved individuals who were at least 30 years old and had been diagnosed with T2DM for a minimum of 5 years. The study group comprised 100 participants. Participant Demographics: The study population exhibited a mean age of 55.3 years (standard deviation = 7.8), with an age range spanning from 30 to 75 years.

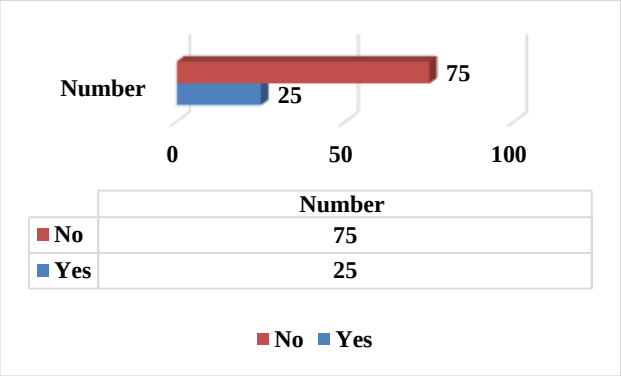

Figure 1: Hearing Impairment among participants.

Participant demographics

The study population exhibited a mean age of 55.3 years (standard deviation=7.8), with an age range spanning from 30 to 75 years. Among the 100 participants, 60 of them (i.e., 60%) were males, and the remaining 40 participants (i.e., 40%) were females.

Clinical characteristics of participants

The average duration of DM was 9.5 years, with a standard deviation of 3.2 years. Of the cohort, a quarter of the subjects (25%) employed insulin to regulate their glycaemic levels, whereas the remaining three-quarters (75%) relied on oral hypoglycaemic agents.

Table 1: Association between HbA1c levels and hearing impairment.

HbA1c Level	N (%) with Hearing Impairment	Odds Ratio (95% CI)
<7.5%	10 (14.3)	1 (Reference)
≥7.5%	15 (31.9)	2.95 (1.12-7.78)

Hearing impairment prevalence in study participants

The study determined that hearing impairment was present when the signal-to-noise ratio (SNR) of either TEOAEs or DPOAEs was less than 6 dB. Twenty-five percent of the people who took part in the research were found to have hearing impairment (Figure 1). According to the study's conclusions, people with HbA1c levels of 7.5% or more had a roughly threefold higher chance of having hearing impairment than people with adequate glycaemic control (Table 1). According to the study's findings, people with DM for at least ten years had nearly three times the likelihood of suffering hearing loss compared to those with DM for less than ten years (p=0.05) (Table 2).

Table 2: Association between DM duration and hearing impairment.

DM Duration (years)	N (%) with Hearing Impairment	Odds Ratio (95% CI)
<10	8 (14.5)	1 (Reference)
≥10	17 (34.0)	2.87 (0.99-8.34)

The statistical analysis performed in the study demonstrated no noteworthy difference in the probability of hearing impairment between male and female participants, with a p value of 0.39 (Table 3). According to the study, there was no statistically significant difference in the probability of hearing impairment between patients who received oral hypoglycaemic agents and those treated with insulin (p=0.91) (Table 4).

Table 3: Association between gender and hearing impairment.

Gender	N (%) with Hearing Impairment	Odds Ratio (95% CI)
Male	17 (28.3)	1 (Reference)
Female	8 (20.0)	0.65 (0.23-1.84)

Based on the study's data, a correlation was observed between hearing impairment and inadequate glycaemic control (HbA1c 7.5%) and a prolonged duration of DM (10 years). The rate of hearing impairment incidence is higher in patients who fall under this category, with 24% experiencing hearing impairment. The text suggests that patients with better glycaemic control and shorter duration of diabetes mellitus have a lower hearing impairment incidence rate, ranging from 5.5% to 10.6% (Figure 2).

The statement emphasises the importance of managing glycaemic control and identifying hearing impairment at an early stage to prevent or manage hearing loss in individuals with diabetes. The study revealed a potential association between HbA1c levels and hearing impairment.

Table 4: Association between medication use and hearing impairment.

Medication Use	N (%) with Hearing Impairment	Odds Ratio (95% CI)
Oral Hypoglycaemics	19 (25.3)	1 (Reference)
Insulin	6 (24.0)	0.94 (0.31-2.84)

Table 5: The relationship between HbA1c and hearing impairment by gender and medication use.

HbA1c Level	Male	Odds Ratio (95% CI)	Female	Odds Ratio (95% CI)2
<7.5%	9	1 (Reference)	1	1 (Reference)
≥7.5%	8	3.09 (0.89-10.71)	7	2.89 (0.66-12.58)

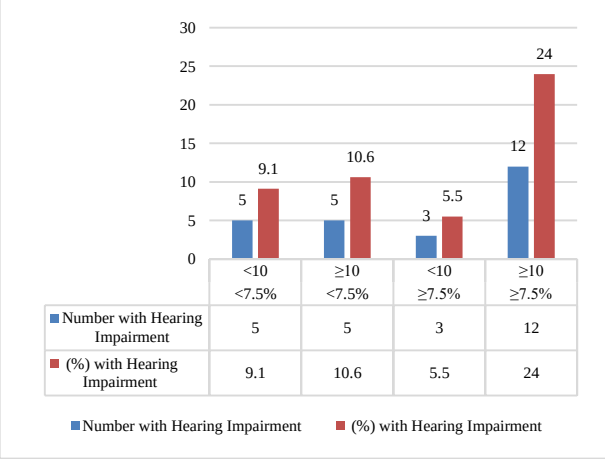

Figure 2: Hearing impairment as a function of Hba1c and diabetes duration.

The strength of this association was observed to be higher in female participants (OR=2.89) than in male participants (OR=3.09); however, this difference was not statistically significant. The study found no notable correlation between the use of medication and HbA1c level on the likelihood of experiencing hearing impairment (Table 5).

DISCUSSION

The demographic characteristics of the study participants align with previous research findings indicating a higher

prevalence of T2DM in males compared to females.[7] This disparity may be attributed to lifestyle factors, including a higher prevalence of tobacco and alcohol consumption among males. The prolonged duration of prediabetes in participants highlights its chronic nature, often requiring long-term management. The use of oral hypoglycaemic medications by a significant proportion of participants suggests their effectiveness in glycaemic control, which is in line with the 2021 guidelines from the American Diabetes Association endorsing the use of oral hypoglycaemic agents.[8,9] The findings of the present study concerning the frequency of hearing impairment among the participants are in line with previous research suggesting a higher prevalence of hearing impairment in individuals with diabetes. A meta-analysis conducted by Horikawa C et al, which analysed 13 studies, concluded that individuals diagnosed with diabetes were significantly more likely to experience hearing impairment compared to those without diabetes.[4] The use of OAEs as a measure of hearing loss in this investigation is consistent with prior research that indicates OAEs can detect initial changes in hearing before they become clinically evident (American Speech-Language-Hearing Association, 2018).[10] The current study found evidence of a connection between inadequate glycaemic control and a heightened vulnerability to hearing impairment, which corroborates the findings of a prior study conducted by Srinivas CV et al. in 2016.[11] The research demonstrated a significant association between uncontrolled diabetes (HbA1c > 8) and sensorineural hearing loss, indicating that elevated blood glucose levels could potentially elevate the risk of experiencing hearing impairment.

Additionally, the research revealed that subjects with a prolonged duration of DM demonstrated a significantly greater odds ratio for experiencing hearing impairment in comparison to those with a shorter duration of DM. The current finding is in line with previous studies conducted by Oh et al and Agrawal et al which identified a relationship between prolonged diabetes duration and increased susceptibility to hearing impairment.[9,13] According to a hypothesis, prolonged exposure to hyperglycaemia could potentially result in impairment of the microvasculature of the auditory system, leading to a decline in auditory function. This has been suggested in previous research. The study results suggest no significant disparity in the probability of hearing impairment between male and female participants. This outcome is consistent with the findings of Gopinath et al.[14] However, earlier research conducted by Helzner et al and Agrawal et al demonstrated more significant hearing loss among males.[15]

The present investigation also scrutinised the association between pharmaceutical consumption and auditory dysfunction and ascertained that there was no noteworthy disparity in the likelihood of auditory dysfunction among subjects who received oral hypoglycaemic agents and those who were given insulin. The current study results are consistent with prior research conducted by Asma et al which did not establish a significant correlation between medication use and hearing impairment in individuals with diabetes.[16]

The present study investigated the potential association between gender, medication use, and HbA1c levels in relation to the likelihood of developing hearing loss. The findings revealed that female participants with HbA1c levels equal to or exceeding 7.5% had a higher odds ratio for developing hearing impairment. However, this difference did not reach statistical significance. These results align with a study conducted by Wang et al. in 2022[17], which suggested a potential correlation between gender, medication use, HbA1c levels, and the likelihood of hearing loss in individuals with diabetes mellitus. Women may be more susceptible to the detrimental effects of diabetes on the risk of hearing loss. The study also indicated that the association between HbA1c level and medication use did not significantly impact the probability of hearing impairment. Further investigation with larger sample sizes is required to explore these potential correlations.

Strengths and limitations

This study uses OAEs as a biomarker to examine the relationship between poor glycaemic control and hearing damage in type 2 diabetics. OAEs can detect hearing impairment with great sensitivity, improving study findings. A well-characterized T2DM sample and careful statistical analysis improved the study's generalizability. It improves the study's validity and clinical relevance. Constraints were; The study's cross-sectional design makes it difficult to prove a causal link between hearing impairment and diabetic control. The study's limited sample size may reduce generalizability and raise type II errors. Age, gender, smoking, and noise exposure could have affected the study's conclusions. The study results may be less accurate and reliable due to this constraint.

CONCLUSION

In conclusion, our study indicates a positive correlation between poor glycaemic control and an increased likelihood of hearing impairment in individuals with type 2 diabetes. Those with a longer duration of diabetes and HbA1c levels above 7.5% are at a higher risk. OAEs have the potential to serve as a biomarker for auditory dysfunction in people with DM. Although no significant difference was observed between male and female participants, it is suggested that there may be an interaction between HbA1c levels and gender. The study did not establish any statistically significant correlation between medication use and the occurrence of hearing impairment. Efficient management of glycaemic control and the early identification of hearing impairment can potentially delay the onset of hearing loss in individuals with diabetes. Our findings underscore the importance of monitoring auditory capacity and comprehensive management of hearing impairment and glycaemic regulation. It is crucial to

implement measures that mitigate the risk of hearing impairment in individuals with diabetes, such as regular hearing screening and strict glycaemic control.

Recommendations

It is recommended to carry out extensive longitudinal investigations to validate and broaden the outcomes, as well as to establish the causal association between glycaemic regulation and auditory dysfunction. It is recommended that future research should incorporate measures to control for potential confounding factors. The objective is to explore the fundamental mechanisms that connect inadequate glycaemic control with hearing impairment, with the aim of identifying potential therapeutic targets. Analysis of the risk factors associated with gender and hearing impairment in patients with diabetes. It is recommended to improve the screening and management of hearing impairment in individuals with diabetes, especially those with longer disease duration or poor glycaemic control.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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