ORIGINAL ARTICLE

# A clinical study of age related hearing loss among diabetes patients

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**Abstract**

**Background:** Age related hearing loss is one of the most common chronic health conditions affecting the elderly people. With aging, risk of presbycusis and diabetes increases. Our study aims at evaluating auditory dysfunction in patients with diabetes mellitus aged above 50 years as compared to non-diabetic patient. We also tried to find the relation between duration of diabetes and severity of hearing loss and whether HbA1c and blood sugars levels affected the type and severity of hearing loss. **Materials and Methods:** A cross-sectional study on 106 patients with type 2 diabetes mellitus and 90 non-diabetic patients with age and sex matched (controls) was carried out during November 2011 to October 2013. All patients were evaluated for hearing loss by subjecting to pure tone audiometry and blood investigations like glycated hemoglobin, fasting and postprandial blood sugars and serum creatinine levels. **Results:** A prevalence of 73% hearing loss was seen in diabetics. The degree of hearing loss increased with age. There was bilateral progressive sensory neural hearing loss with right sloping curve in both diabetics as well as controls but with significantly ($P < 0.001$) higher loss in diabetics (at 4 KHz and 8 KHz). A significant relationship between duration of the diabetes, HbA1c and severity of hearing loss was observed. **Conclusion:** Diabetes mellitus was associated with higher hearing loss compared to presbycusis and hearing threshold was seen to affect all frequencies, but significantly the higher frequencies in diabetics. As duration of diabetes increased, the severity also increased. Poorer the HbA1c, more severe was the hearing loss.

**Keywords:** Presbycusis, Pure tone audiometry, SNHL, Type 2 diabetes mellitus

## Introduction

Age-related hearing loss is one of the most common health conditions affecting individuals aged 65 years and older.[1]

In 1857, Jardao proved that diabetes mellitus causes hearing loss.[2] Previously, various studies have shown that diabetes mellitus causes hearing loss, but a confirmed cause-effect relationship between the two has not yet been established.

Our study tries to confirm the cause-effect relationship between diabetes mellitus and hearing loss.

### Aims of study

- To evaluate occurrence of auditory dysfunction in patients with type 2 diabetes patients aged above 50 years and compare the same with age matched control groups
- To study the relation between the degree of hearing loss, the duration and severity of type 2 diabetes mellitus
- To evaluate hearing loss and pattern in controlled and uncontrolled diabetes mellitus.

## Materials and Methods

A cross-sectional study on 106 diabetic and 90 non-diabetic patients without any comorbidity, aged 50 years and above,

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**Access this article online**

Quick Response Code:

Website: www.indianjotol.org

DOI: 10.4103/0971-7749.146930

attending Diabetology and ENT department at our hospital during December 2011 to October 2013 were evaluated for hearing loss.

Prior informed written consent was taken from all the subjects participating in the study. Ethical clearance was obtained from the Institution for conducting the study.

We included diabetic patients aged >50 years with/without hearing loss and non-diabetic controls who were age and sex matched without any comorbidities.

We excluded patients <50 years, with middle ear pathology, known cause of sensorineural hearing loss (congenital hearing loss, Meniere's disease, Labyrinthitis, temporal bone fracture, syphilis, meningitis), patients with history of ototoxic drug intake, hypertension, cardiac diseases and renal failure.

A complete history regarding hearing loss, duration and any associated symptom was taken. A detailed history regarding diabetes, its duration, treatment was taken. Further otological examination, tuning fork tests and other vestibular function testings were done.

All patients underwent pure tone audiometry by Hughson-Westlake method.

The minimum threshold was identified at all frequencies 250, 500, 1000, 2000, 4000 and 8000 Hz, in air conduction whereas only till 4000 Hz in bone conduction. The patients were grouped into different age groups 50-60 years, 61-70 years, 71-80 years, 81-90 years and >90 years in both cases and controls. The average pure tone threshold was taken at low (250 Hz, 500 Hz and 1000 Hz) and high frequencies (2000 Hz, 4000 Hz and 8000 Hz) and then the minimum difference was calculated between diabetic and non-diabetic males as well as females. Further, the average threshold was compared between both the genders in diabetic and non-diabetic groups. These groups were further divided into fasting blood sugar, FBS <110 mg/dl and FBS > 110 mg/dl/post-prandial blood sugar PPBS <140 mg/dl and PPBS >140 mg/dl. The HbA1c was classified into (<7% good, 7%-8% Fair, >8% poor) glycemic control. Serum creatinine levels was classified into (<1.5 mg/dl and >1.5 mg/dl).

The severity of hearing loss was graded according to the World Health Organization (WHO).

| | | |
|---|---|---|
| A | Normal | 0-25 dB |
| B | Mild | 26-40 dB |
| C | Moderate | 41-55 dB |
| D | Moderately severe | 56-70 dB |
| E | Severe | 71-90 dB |
| F | Profound | >90 dB |

## Results

The incidence of sensorineural hearing loss (SNHL) among diabetics was 73.58%, whereas in non-diabetics, it was 61.1% and incidence of hearing loss increased subsequently (as seen in Table 1) as the age progressed in both diabetics and non-diabetics, but with higher loss in diabetic group.

There was 63% incidence of hearing loss in <10 years of duration of diabetes as compared to 85% in >10 years of duration. Further, as duration progressed the severity of hearing loss also increased in most of the cases. We observed that most of the patients in <10 years had normal (32.2%) or mild (22.5%) with few moderately severe (16%) or severe (9%) hearing loss. However, diabetics of >10 years and <15 years had mild 30% (6 cases) or moderate 40% (8 cases), with only few normal hearing (3 cases). But, patients with >15 years duration, the sample size was less and there was equal distribution of patients in all degrees of hearing loss.

## Discussion

Diabetes mellitus is one of the most common metabolic disorder, which affects both the older as well younger individuals and is associated with hearing impairment.

Diabetes mellitus is known to cause [Table 2] bilateral progressive SNHL.[3,4] With aging, both hearing loss as well as risk of diabetes increases.[3] But hearing loss seen in these patients would be similar to that of presbycusis but with more severe losses and early onset than expected by aging alone.[3] As a result, it is difficult to distinguish whether hearing loss in diabetes is due to normal process of aging or due to biochemical and the vascular abnormalities associated with diabetes.

**Table 1: Age-wise distribution of hearing loss among diabetics and non-diabetics**

| Age | SNHL (D) | Incidence (D) (%) | SNHL (ND) | Incidence (ND) (%) |
|---|---|---|---|---|
| 50-60 | 24 | 66.6 | 6 | 40 |
| 61-70 | 25 | 71.42 | 14 | 42.42 |
| 71-80 | 25 | 86.2 | 26 | 83.87 |
| 81-90 | 4 | 66.6 | 7 | 100 |

SNHL: Sensorineural hearing loss; ND: Non Diabetics

**Table 2: Duration of diabetes and severity of hearing loss**

| Degree of hearing loss | Incidence (%) in >10 years | Incidence (%) in <10 years |
|---|---|---|
| Mild | 30 | 22.5 |
| Moderate | 40 | 17 |
| Moderately severe | <5 | 9 |
| Severe | 10 | 10 |

Most of the reported studies have shown diabetes to affect the hearing threshold in both young and elderly diabetics and in that some studies have shown higher frequencies being affected more than lower or mid frequencies.[5-8] Whereas other studies have reported it to affect all the frequencies[4] and some only in lower frequencies.[9]

The two important factors seen in diabetics which affect hearing are: Diabetic angiopathy and neuropathy.

## Diabetic angiopathy

Diabetes mellitus causes increased rate of triglyceride production due to insulin resistance. There is endothelial proliferation and accumulation of glycoproteins, with thickening of the capillary vessels in basement membranes.[10-12] This results in impaired nutrient transportation through these thickened vessels resulting in decreased blood flow through narrowed vessels leading to secondary degeneration of vestibulocochlear nerve.

## Diabetic neuropathy

Activation of polyol pathway, causes accumulation of sorbital within the neurons thereby reducing the myoinositol content and Na+/K + ATPase activity intracellularily leading to osmotic damage and swelling.[4]

Protein kinase C is implicated in increased production of cytokines, regulation of vascular permeability, flow, and increased synthesis of basement membranes which is seen to increase in diabetes.[13]

In addition to increased formation of advanced glycation products in collagen, DNA also contributes to tissue damage leading to cellular hypertrophy and hyperplasia.[14]

Our study showed a prevalence rate of 73.58% among the type 2 diabetes mellitus and 60% in controls. This was similar to study by Malucelli *et al.,* (76.6%),[15] Rajendran *et al*., (73.3%).[16] But there are studies which shows low prevalence rates as well.[8,17]

There was bilateral progressive SNHL with most of them having mild to moderate or moderately severe hearing loss among diabetics. However, a significant difference was noted at higher frequencies mainly 4 KHz and 8 KHz between diabetics and pure presbycusis [Tables 3 and 4]. This was consistent with the study results as that found in Mitchell *et al*.[18]

Other studies which have reported higher frequencies being affected more in diabetics are Bainbridge and Hoffman *et al*.,[19] Rajendran *et al.,*[16] and Cullen and Cinnamond.[5] In contrast, Irwin and Taylor reported lower and mid frequencies being affected more.[9] Axelsson[6] has showed no significant relation between the two.

Diabetes mellitus was associated with early onset of hearing loss similar to that of presbycusis. However, presbycusis

**Table 3: PTA comparison diabetic and non-diabetic males**

| Age | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|
| (D) 50-60 | 27 | 30.67 | 37 | 43.67 | 52.33 | 59.33 |
| (ND) 50-60 | 22.63 | 25.18 | 32.18 | 38.81 | 40.45 | 45.36 |
| *P* value | 0.04 | 0.03 | 0.03 | 0.02 | 0.001* | 0.001* |
| (D) 61-70 | 39.4 | 42.25 | 43.65 | 53.75 | 61.25 | 72 |
| (ND) 61-70 | 35.25 | 38.25 | 45.25 | 51.75 | 52 | 60.75 |
| *P* value | 0.07 | 0.08 | 0.05 | 0.23 | 0.008* | 0.001* |
| (D) 71-80 | 2.86 | 48.57 | 53.21 | 61.07 | 69.28 | 78.92 |
| (ND) 71-80 | 31.74 | 35.89 | 49.09 | 51.58 | 53.04 | 62.6 |
| *P* value | 0.01 | 0.003 | 0.08 | 0.01 | 0.006* | 0.001* |
| (D) 81-90 | 65.53 | 73.33 | 78.56 | 88.23 | 91.67 | 96.67 |
| (ND) 81-90 | 52.46 | 55.35 | 65.08 | 74.54 | 78 | 83 |
| *P* value | 0.003 | 0.001 | 0.01 | 0.008* | 0.007* | 0.002* |

PTA: Pure tone average; ND: Non Diabetics *: *P* value <.005 as significant

**Table 4: PTA comparison diabetic and non-diabetic females**

| Age | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|
| (D) 50-60 | 28.04 | 32.6 | 36.95 | 41.52 | 43.86 | 56.23 |
| (ND) 50-60 | 36.25 | 37.5 | 43.75 | 47.5 | 50 | 53.25 |
| *P* value | 0.03 | 0.02 | 0.004* | 0.03 | 0.009* | 0.06 |
| (D) 61-70 | 26 | 28.33 | 36 | 45.67 | 51 | 56.33 |
| (ND) 61-70 | 20.55 | 23.66 | 25.88 | 28.22 | 32.22 | 37.22 |
| *P* value | 0.02 | 0.008 | 0.001 | 0.0001* | 0.0001* | 0.0001* |
| (D) 71-80 | 40.35 | 44.28 | 51.07 | 54.28 | 65.35 | 77.14 |
| (ND) 71-80 | 36.87 | 39.12 | 46.45 | 51.87 | 52.5 | 63.75 |
| *P* value | 0.04 | 0.03 | 0.04 | 0.08 | 0.01* | 0.009* |
| (D) 81-90 | 74.67 | 84.5 | 90 | 92.5 | 96 | 100 |
| (ND) 81-90 | 70 | 75 | 79.59 | 84.86 | 87.38 | 90 |
| *P* value | 0.03 | 0.001* | 0.004* | 0.01 | 0.03 | 0.01 |

PTA: Pure tone average; ND: Non Diabetics *: *P* value <.005 as significant

patients developed hearing loss, which was slow and increased progressively with the age. Both these conditions were known to have a similar pattern of hearing loss with diabetes having slightly higher loss. The difference in pure tone average (PTA) seen in different age groups in diabetics varied from 5-30 dB. Severity of hearing loss also increased with aging.

These results were similar to that of various other studies done in the past.[17,20-23] However, studies by Mitchell *et al.,*[18] and Horikawa *et al*., showed that difference in hearing threshold remained consistent and not much of significant changes were seen as age progressed.

We observed higher incidence (85%) of hearing loss in patients with longer duration of diabetes (>10 years) [Table 2]. However, in patients with >15 yrs of duration no significant result was seen probably due to a relatively less sample size.

Further as duration progressed the severity of hearing loss also increased in most of the cases. Few studies including Mitchell *et al.,*[18] had shown significant relation between duration of diabetes and the hearing loss. However, contradicting results was seen in a number of studies where no association between both was observed.[5,6,8,26]

A high incidence of hearing loss (83%) was noted in patients with blood sugar >110 mg/dl [Tables 5 and 6] as compared to 60.2% in <110 mg/dl. Also patients with high FBS and PPBS levels had more severe hearing loss (either moderate, moderately severe to severe hearing loss) [Figures 1 and 2]. In contrast, patients within the normal blood sugar levels had either normal to mild or moderate hearing loss. Panchu[23] and Sharma *et al.*,[15] also showed strong association between blood sugar levels and severity of hearing loss.

Our study showed a positive relation between HbA1c and severity of hearing loss. Patients with poor glycemic (>8%) control had higher hearing loss (89%). Also the severity seemed to increase with the poor glycemic status. Most of the cases were moderately severe (26%) or moderate (21%) hearing loss. On the other hand, patients with good glycemic control had either normal (40%) or mild (30%) with few moderate (20%) hearing loss [Table 7 and Figure 3].

Studies by Panchu[23] and Pemmaiah *et al.*,[15] showed HbA1c had a strong association with hearing loss. Similarly, Sumathi *et al.*, concluded in their study that poorer the glycemic status, more severe was hearing loss. However, some studies have shown no correlation between glycemic control and hearing loss.[8]

There was no correlation between serum creatinine and hearing loss in our study [Table 8]. Only one study by Kakarlapudi *et al.*, reported a strong association between serum creatinine levels and hearing loss.[8] This association could be attributed to severe hyperglycemia resulting in activation of polyol pathway and accumulation of sorbital within the neurons thereby reducing the myoinositol content and Na+/K+ ATPase activity.

**Table 5: FBS and severity of hearing loss**

| Inference | Total subjects | FBS (%) | |
|---|---|---|---|
| | | <110 | >110 |
| A | 28 | 18 (36) | 10 (17) |
| B | 27 | 15 (30) | 12 (21) |
| C | 24 | 9 (18) | 15 (26) |
| D | 14 | 4 (8) | 10 (17) |
| E | 10 | 02 (4) | 8 (14) |
| F | 03 | 01 (2) | 02 (3) |
| Total | 106 | 49 | 57 |

FBS: Fasting blood sugar

**Table 6: PPBS and severity of hearing loss**

| Inference | Total subjects | PPBS group (%) | |
|---|---|---|---|
| | | <140 | >140 |
| A | 28 | 16 (35) | 12 (19) |
| B | 27 | 14 (31) | 13 (21) |
| C | 24 | 08 (17) | 16 (26) |
| D | 14 | 04 (8) | 10 (16) |
| E | 10 | 3 (6) | 7 (11) |
| F | 03 | 00 | 03 (4) |
| Total | 106 | 45 | 61 |

PPBS: Post-prandial blood sugar

**Table 7: HbA1c and severity of hearing loss**

| Inference | Total subjects | HbA1c grading (%) | | |
|---|---|---|---|---|
| | | <7 | 7-8 | >8 |
| A | 28 | 15 (50) | 8 (26) | 5 (10) |
| B | 27 | 8 (26) | 10 (33) | 9 (19) |
| C | 24 | 6 (20) | 8 (26) | 10 (21) |
| D | 14 | 1 (3) | 1 (3) | 12 (26) |
| E | 10 | 0 | 2 (6) | 8 (17) |
| F | 3 | 0 | 1 (3) | 2 (4) |
| Total | 106 | 30 | 30 | 46 |

HbA1c: Glycated Hemoglobin

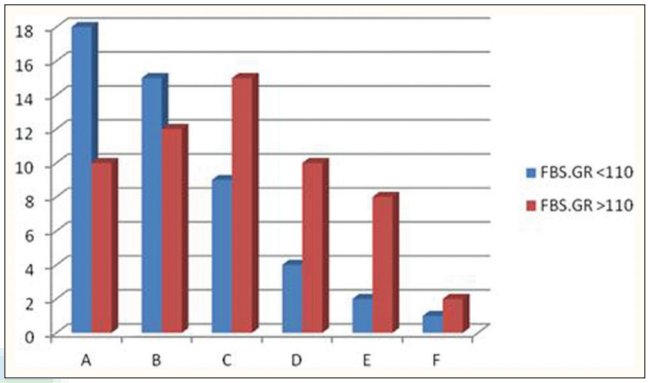


**Figure 1:** Correlation between fasting blood sugar and severity of hearing loss

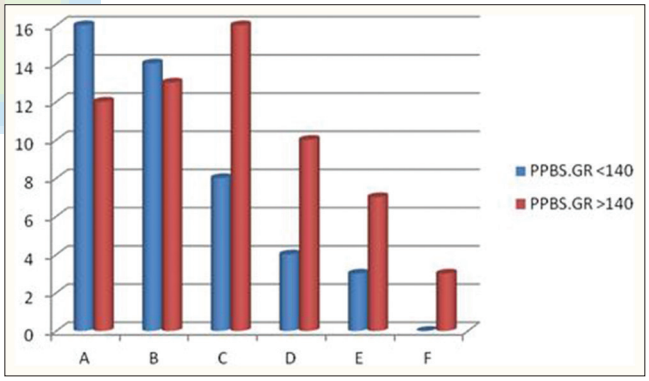


**Figure 2:** Correlation between post prandial blood sugar and severity of hearing loss

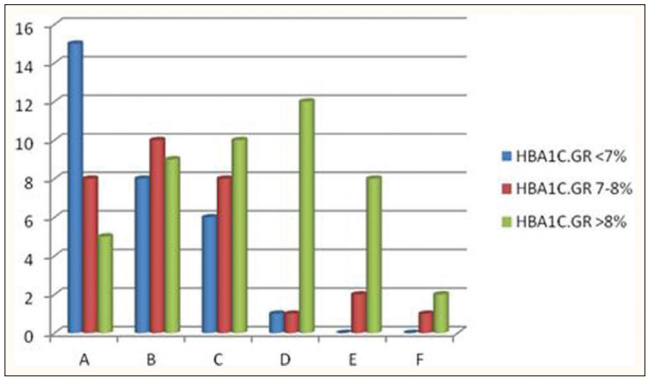


**Figure 3:** Correlation between HbA1c and severity of hearing loss

Our study did not show much significant difference between both the genders in diabetic as well as Non diabetic group in relation to hearing loss [Tables 9 and 10]. Similarly, Axelsson and Fagerberg[6] as well as Colonel and Chamyal[21] also showed no gender difference in their studies. However, few studies have showed male preponderance.[24-26] Irwin and Taylor[9] and Rajendran *et al.*,[16] observed females having higher affliction for hearing loss compared to males.

Diabetic males had significantly higher hearing loss compared to controls. Also at various frequencies, hearing loss seem to affect all frequencies with a higher loss in diabetics compared to non-diabetics, more so in higher frequencies (4 KHz and 8 KHz) at all age groups except at 71-80 and 81-90 years where it was consistent in all frequencies [Table 3].

Similarly, diabetic females had slightly higher loss compared to non-diabetics. In various age groups, diabetic females had slightly higher loss compared to non-diabetic females (except at 50-60 years). The difference in hearing loss was more marked in the high frequencies (at 60-70 years and 70-80 years), but in other age groups it was almost constant [Table 4].

In younger age groups the difference varied from 5-11dB at low frequencies whereas at high frequencies it was 13-19 dB.

**Table 8: Serum creatinine and severity of hearing loss**

| Inference | Total subjects | Sr. Creatinine (%) | |
|---|---|---|---|
| | | <1.5 | >1.5 |
| A | 28 | 26 (29) | 2 (10) |
| B | 27 | 21 (24) | 6 (31) |
| C | 24 | 20 (23) | 4 (21) |
| D | 14 | 9 (10) | 5 (26) |
| E | 10 | 8 (9) | 2 (10) |
| F | 3 | 3 (3) | 0 |
| Total | 106 | 87 | 19 |

**Table 9: Average PTA comparison between males and females of diabetic group**

| Age in years | PTA average in males (D) | PTA average in females (D) | Difference in dB loss |
|---|---|---|---|
| 50-60 | 33.03 Db | 36.405 dB | 2-3 dB |
| 61-70 | 47.63 Db | 36.17 dB | 10 dB |
| 71-80 | 53.72 dB | 50.55 dB | 4-6 dB |
| 81-90 | 85.073 Db | 89.25 dB | 4-6 dB |

PTA: Pure tone average; dB: Decibels

**Table 10: Average PTA in males and females among Non-diabetic group**

| Age in years | PTA average in males (ND) | PTA average in females (ND) | Difference in dB loss |
|---|---|---|---|
| 50-60 | 30.27 dB | 36.983 dB | 2-3 dB |
| 61-70 | 42.516 dB | 35.085 dB | 10 dB |
| 71-80 | 46.09 dB | 42.93 dB | 4-6 dB |
| 81-90 | 66.66 dB | 69.33 dB | 2-4 db |

PTA: Pure tone average; ND: Non Diabetics

However, in higher age groups, the difference was almost constant in all frequencies with 7-12 dB.

Studies by Rajendran *et al.*,[16] Cullen and Cinnamond[5] showed maximum difference in hearing loss at high frequencies. A difference of 5-30 dB in hearing threshold was seen between the diabetics and non-diabetics, but was more prominent at 4 KHz and 8 KHz.

The possible reason why high frequency sounds were affected more was, due to accelerated atherosclerosis, thickening of basement membrane, which decreases blood flow to cochlea, mainly to the basal and middle turn leading to cell degeneration and loss of high frequency hearing sounds.

## Conclusion

Prevalence of hearing loss was high in type 2 diabetic patients. Bilaterally symmetrical progressive SNHL with right sloping curve was seen in both diabetic as well as non-diabetics, with hearing loss noted at all frequencies, but significantly in higher frequencies in diabetics. Hearing threshold increased linearly with increase in age. No significant difference was seen in hearing threshold between diabetic males and females. However, a significant relationship was observed between HbA1c, blood sugar levels and severity of hearing loss. The severity increased as the duration of diabetes increased.

Our study successfully determined the prevalence and hearing threshold, along with the effects of diabetes on hearing in older individuals.

We identified a positive correlation between elevated blood sugar levels and HbA1c levels with hearing loss when compared to controls.

We also found that the hearing loss affected all the frequencies, but the higher frequencies were affected more when compared to control.

To our knowledge, very few studies have compared so many variables in a single study.

However, certain conclusions with respect to attributability and confounding factors are beyond the scope of this study. It is felt strongly that larger studies with less variables and more randomized must be done to evaluate the relation between diabetes and hearing loss.

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**How to cite this article:** Krishnappa S, Naseeruddin K. A clinical study of age related hearing loss among diabetes patients. Indian J Otol 2014;20:160-5.

**Source of Support:** Nil. **Conflict of Interest:** None declared.