International Journal of Otorhinolaryngology and Head and Neck Surgery
Sachdeva K et al. Int J Otorhinolaryngol Head Neck Surg. 2018 Mar;4(2):499-507
http://www.ijorl.com
pISSN 2454-5929 | eISSN 2454-5937

Original Research Article

DOI: http://dx.doi.org/10.18203/issn.2454-5929.ijohns20180714

Sensorineural hearing loss and type II diabetes mellitus

Kavita Sachdeva, Saima Azim*

Department of Otorhinolaryngology and Head Neck Surgery, Netaji Subhash Chandra Bose Medical College, Jabalpur, M.P., India

Received: 26 November 2017
Accepted: 01 January 2018
Accepted: 04 January 2018

***Correspondence:**
Dr. Saima Azim,
E-mail: saimakhan.gmcbhopal@gmail.com

ABSTRACT

Background: The association between Hearing loss and diabetes, first mentioned by Jardao in 1857, had been under continuous research since then; giving both positive and negative results. This study aims to explore the relationship of hearing loss with type II DM and also to evaluate the impact of glycemic control over degree of hearing loss.
Methods: 92 patients with type II DM were enrolled in this study, audiometrically evaluated and compared with equal number of age and sex matched non-diabetic controls. Apart from audiological tests, haematological tests like FBS, PPBS, HbA1c, serum creatinine and cholesterol were carried out to assess glycemic control.
Results: It was observed that 31 (34%) of the diabetic patients had mild to moderate sensorineural hearing loss, while only 12 (13%) of the control group suffered from the same, which is statistically significant ($p<0.05$). Among these 31 patients, 19 (61%) patients had uncontrolled diabetes (HbA1c >8.5) and 12 (39%) had higher creatinine levels (>2.5 mg/dl). Higher frequencies (4 and 8 kHz) were found to be affected more, both in case and control groups. Low stapedial reflex thresholds were observed in 14% patients of case group and 5.4% of the controls. Speech discrimination scores were not significantly different. Otoacoustic emission showed outer hair cell dysfunction in 85% cases and 66% controls.
Conclusions: There is a strong correlation between diabetes mellitus and hearing threshold levels especially at higher frequencies. Long duration and uncontrolled diabetes has more implications over hearing threshold. Since the pattern of hearing loss in diabetes and presbycusis is similar, it may be said that hearing level with ageing is significantly impaired earlier in diabetic patients as compared to general population.

Keywords: Sensorineural hearing loss, Diabetes, Presbycusis, Glycemic control, Audiometry, Speech discrimination score, Otoacoustic emission

INTRODUCTION

According to WHO statistics, updated on February, 2017- Over 5% of the world's population, that makes to be 360 million people suffer from hearing loss (328 million adults and 32 million children). Among these, one third of them are above 65 years of age, prevalence being maximum in South Asia, Asia pacific and sub-Saharan Africa. Furthermore, WHO also suggests that half of all the cases of hearing loss are preventable.[1]

The association between hearing loss and diabetes mellitus was first mentioned in 1857 by Jardao, which came to light due to the presence of hearing loss in a patient of diabetic coma.[2-5] However, this relationship was first documented 7 years later, in 1864, bringing forward the link between hyperglycemia and hearing loss.[5-7] Since then, lot many researches have been done to establish this association. Axelson and Sigroth in 1978, stated no relationship between hearing loss and Diabetes; so did Harner in 1981.[8,9] However, studies done on effects of diabetes on auditory functions have concluded

that diabetes mellitus has a negative effect on hearing; the prevalence varying from 13.1% (according to Kakarlapudi, USA) to 60% (according to Pathak et al).[10,11] The pathogenesis of hearing loss in Diabetes has been explained on the basis of mitochondrial DNA mutation, neuropathy, and microangiopathy.[12]

Given this scenario of increasing incidence of preventable hearing loss and the indefinite results of association between diabetes and hearing loss, present study aims to explore the linkage between hearing loss and diabetes mellitus, and certain factors associated with it like, glycemic control, presence of diabetes related complications, serum creatinine, and serum cholesterol.

METHODS

In the present prospective study conducted for a period of 2 years (February 2015 to January 2017) at NSCB Medical College, Jabalpur. 184 individuals were enrolled and divided into two groups-

Group 1 (cases): 92 individuals suffering from Type II Diabetes Mellitus visiting diabetic clinic or ENT OPD were included.

Group 2 (controls): 92 normal subjects who were age and sex matched with the case group were included.

Subjects with external or middle ear pathology, and those with other systemic illnesses like hypertension, Thyroid disorders were excluded. The only difference in cases and controls being presence and absence of type II diabetes mellitus respectively. Peripheral neuropathy (Vibration sense) was examined with help of 128Hz Tuning fork over medial malleolus.

Prior informed consent was signed by all the participants enrolled as per guidelines and standards of research using human beings. The study was given approval by the Institutional Ethics Committee (IEC), Jabalpur.

Audiological evaluation was done which included pure tone audiometry from 300 to 8000 Hz, immitance audiometry including tympanogram and acoustic reflex, otoacoustic emissions, speech discrimination score, tone decay test and short increment sensitivity index.

Further the diabetic cases were examined for presence of Diabetes related complications (cardiomyopathy, nephropathy, neuropathy and retinopathy) and also evaluated for glycemic control on the basis of FBS, PPBS, HbA1c and urine sugar and albumin. Serum creatinine and total serum cholesterol was also done to look for associations.

The variables used for comparison were treated using two sample test of probability and statistical significance was attributed when p value was <0.05.

RESULTS

Cases included 92 diabetic patients with mean age of 58.5 years (range: 42-74years) and male:female ratio of 1.6:1 (57 males and 35 females). Controls were normal individuals (without any metabolic disorder) who were age and sex matched, average age being 59.1 years (range: 40-74) with male:female ratio of 1.8:1 (59 males and 33 females).

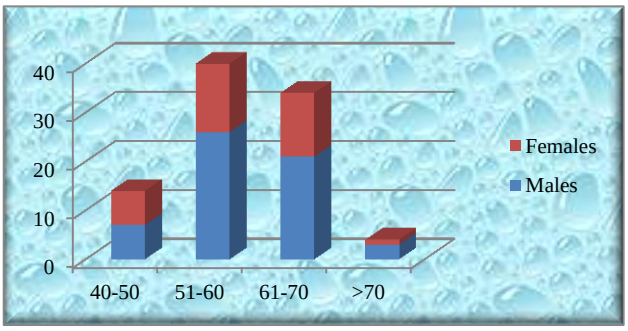

Figure 1: Age and sex distribution of patients with diabetes.

Maximum numbers of patients were found in the age group of 51-60 years. Females were more as compared to males in the younger age group 40-50 years (ratio of 1:1) than in the older group of >70 years (M:F=3:1).

When the case and control groups were compared with each other, significant differences were found in terms of several auditory measurements of both right and left ears. The diabetics demonstrated higher pure tone thresholds than the non-diabetic subjects at all frequencies, although these differences were higher at higher frequencies >3000 Hz.

Audiological evaluation

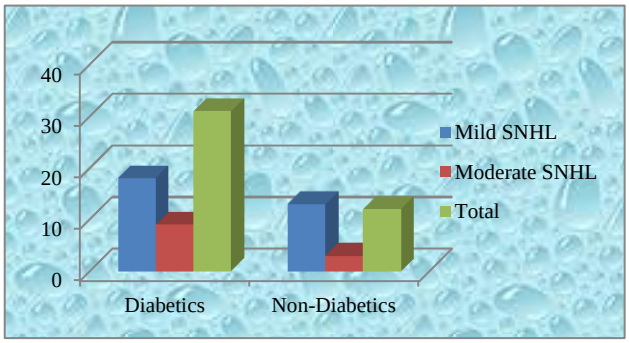

Figure 2: Sensorineural hearing loss in diabetics and non-diabetic controls as assessed by pure tone audiometry.

Among the diabetics, 33.7% (31) of the patients were found to be suffering from mild to moderate sensorineural hearing loss while in the control group, 13% (12) suffered from the same, p value being 0.009, which is significant.

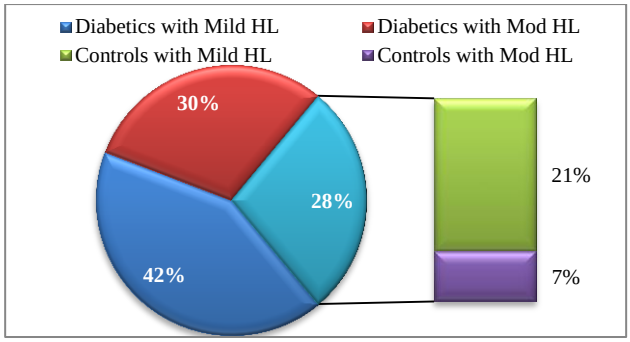

Figure 3: Severity of hearing loss in cases and controls.

It was observed that among all the subjects of hearing loss 72% belonged to the diabetic group and only 28% were from the non-diabetic group, ratio being 2.6:1, (p=0.00004) which is highly significant. Also, the severity of hearing loss was found to be less in the control group (21% mild and 7% moderate SNHL) as compared to the diabetic patients (42% mild and 30% Moderate SNHL).

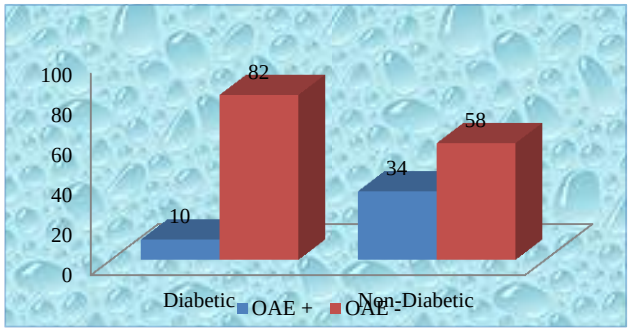

Figure 4: Association of OAE with Diabetes induced hearing loss.

Among all 184 subjects (cases+controls), 140 had outer hair cell dysfunction resulting in absent Otoacoustic emissions. Amongst the patients with absent OAE, 58.6% (82) belonged to the diabetic group and 41.4% (58) to the non-diabetic group (p=0.00003), which is highly significant. Hence, diabetes mellitus is seen to have a negative effect on outer hair cell function.

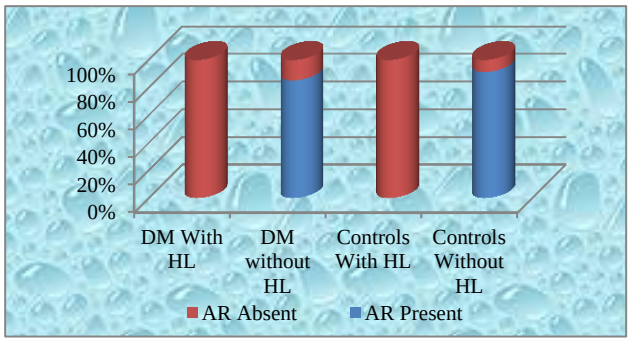

Figure 5: Relation of diabetes induced HL with acoustic reflex test.

We can see that in all the patients with hearing loss Acoustic reflex is absent. So, to find out whether diabetes affects acoustic reflex or not; subjects without hearing loss were compared with results as seen in Table 1.

Table 1: Number of diabetics and non-diabetics with absent acoustic reflex test.

	Diabetics with normal hearing	Non-diabetics with normal hearing	Total	P value
AR -	**9**	**7**	**16**	**0.479**

P value being 0.479 (>0.05), this value is insignificant.

Hence, from this p value and the above bar diagram, if presence or absence of acoustic reflex is co-related; it can be said that acoustic reflex is related to presence or absence of hearing loss rather than diabetes. So, we can say that acoustic reflex is absent in patients with hearing loss and diabetes does not affect acoustic reflex per se.

All the subjects included in this study had normal 'A' type tympanogram, showing normal middle ear compliance.

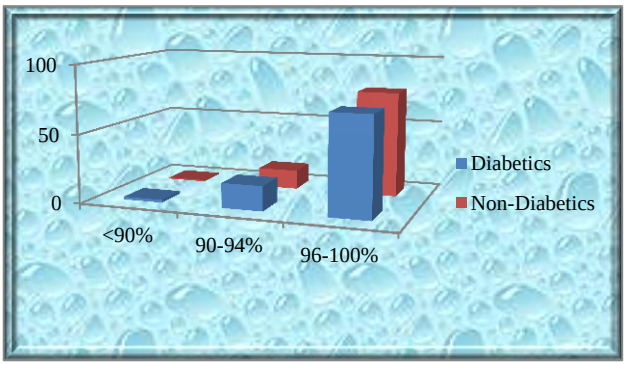

Figure 6: Relation of diabetes induced hearing loss with SDS.

Among all the ranges of Speech discrimination score, no significant differences were found between diabetics and control groups (all p>0.05). Speech discrimination scores in all the patients were essentially normal >90%, irrespective of presence or absence of hearing loss. This shows that hearing loss in both diabetes and presbycusis are similar in nature, not involving retrocochlear pathology.

In all the subjects taken into this study (both cases and controls) showed negative tone decay test (<10 dB), indicating either cochlear or conductive pathology.

100% of the patients with hearing loss (both among cases and controls) had Short increment sensitivity index between 70-100% showing that both age related hearing loss and diabetes induced hearing loss are essentially cochlear in nature.

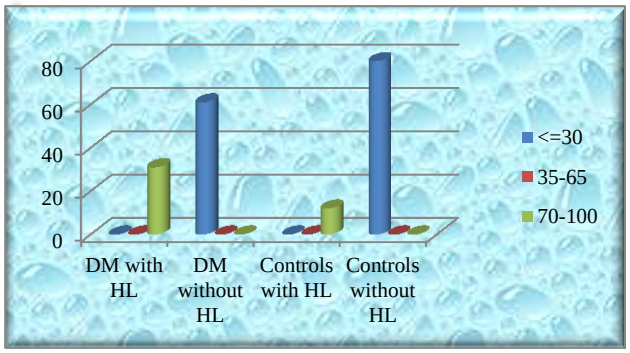

Figure 7: Relation of diabetes induced HL with SISI score.

Relation of hearing loss with duration and severity of diabetes mellitus

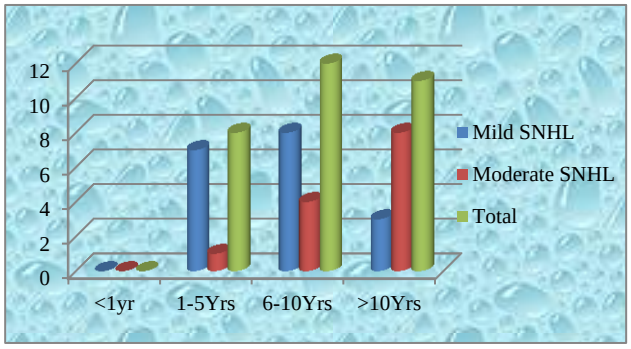

Figure 8: Relation of diabetes induced hearing loss with duration and severity of diabetes.

It is very evident from graph number 8, that as the duration of diabetes increases, the prevalence as well as the severity of hearing loss increases.

Among all the 31 diabetic patients with hearing loss, 74.2% of them had history of diabetes for more than 5 years, p=0.001, which is significant.

Maximum number of patients (44%) lie in the group of 6-10 years of diabetic history.

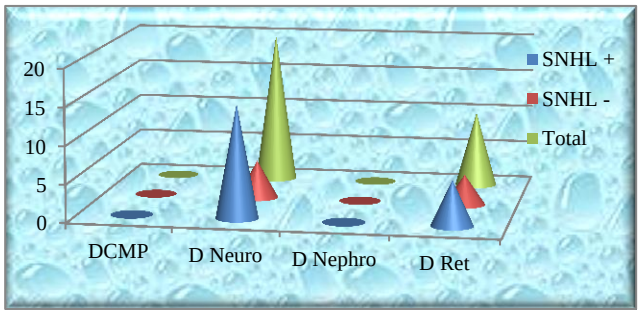

Figure 9: Association of hearing loss with diabetes related complications.

Among all the diabetic patients taken into this study, 30 (32.6%) were suffering from chronic complications of diabetes. Among these, 70% had sensorineural hearing loss (p=0.0019) which is very significant.

Seen individually, co-relation of sensorineural hearing loss was seen with diabetic neuropathy (p=0.0075). 75% of the patients with neuropathy (peripheral neuropathy and diabetic foot ulcers) also suffered from hearing loss.

60% of the patients of diabetic retinopathy also suffered from hearing loss (p=0.371), which is not found to be significant.

None of the patients taken into this study were suffering from diabetic cardiomyopathy or Nephropathy.

Hence, according to present study, hearing loss in diabetics has significant association with diabetes neuropathy.

A fasting blood sugar level of <100 mg/dL is considered normal according to WHO guidelines. Value between 101-125 mg/dL is considered prediabetes. Diabetic individuals are asked for better control over their blood sugar levels keeping FBS below 100 mg/dL.

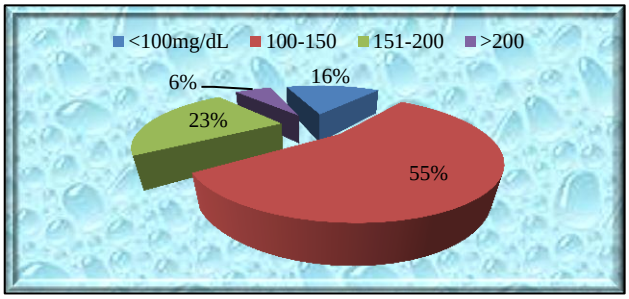

Figure 10: Diabetic patients with hearing loss and FBS.

From the above pie diagram, it can be seen that only 16% of the diabetic patients with hearing loss had good glycemic control, rest 84% had uncontrolled diabetes (p value 0.029). Maximum patients (55%) had their FBS between 100-150 mg/dL.

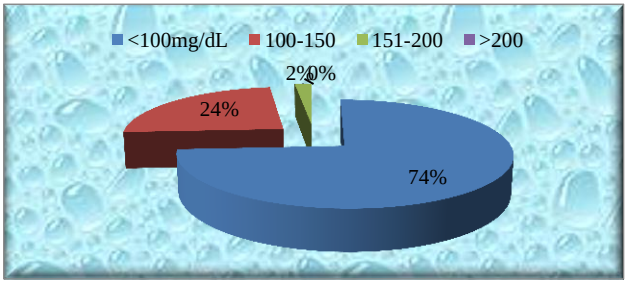

Figure 11: Diabetic patients without hearing loss and FBS.

Among diabetic patients who did not have any hearing loss, 74% had FBS within normal limits and none having >200 mg/dL. Hence, it is very clear that deranged fasting glucose predisposes to hearing loss.

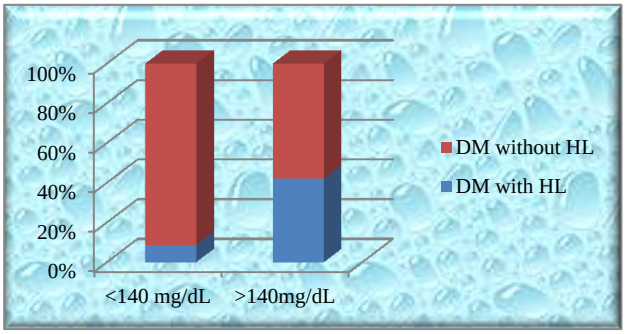

Figure 12: Relation of diabetes induced HL with PPBS.

Post prandial blood sugar after 2 hours of meal should be <140 mg/dL according to WHO normal standards.

Among all patients with uncontrolled diabetes (PPBS >140 mg/dL), number being 69, 42% of them suffered from hearing loss (p=0.0611) which is insignificant. Among 31 patients with hearing loss, only 2 of them (6%) had normal PPBS (<140 mg/dL), p value being 0.02*10^-6, which is highly significant.

From above values, it can be interpreted that high post prandial blood sugar does not predispose to hearing loss but keeping it inside normal range certainly prevents it.

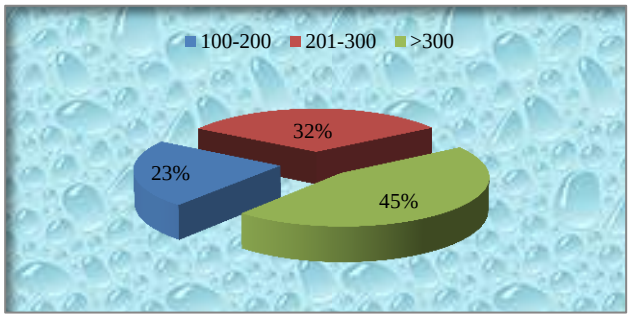

Figure 13: PPBS of diabetic patients with hearing loss.

45% (14 out of 31) of the diabetic patients with hearing loss had PPBS above 300 mg/dL, while only 1.6% (1 out of 61) of the diabetic patients without hearing loss had the same.

PPBS was not found to be significantly related to Diabetes induced hearing loss when cut off was taken to be 140 mg/dL, but if the same was taken to be 200 mg/dL (p=0.0011) or 300 mg/dL (p=0.000002), the value was significant. Hence, it can said that diabetes increases the risk of hearing loss when PPBS is more than 200 mg/dL and significantly increases when the same is more than 300 mg/dL.

Table 2: Relation of diabetes induced HL with PPBS (range).

PPBS (mg/dL)	DM with HL	DM without HL	Total	P value
100-200	7	58	65	
201-300	10	2	12	0.0011
>300	14	1	15	0.000002
Total	31	61	92	

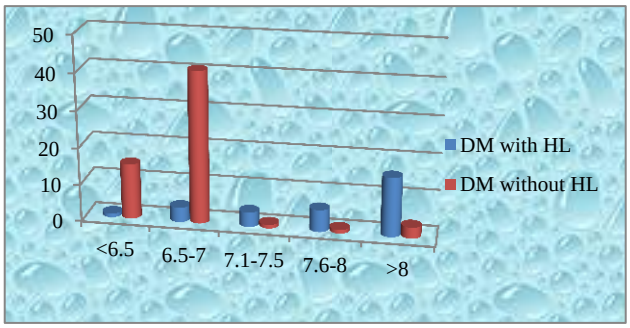

Figure 14: HbA1c levels and diabetes induced hearing loss.

It is observed from the graph that as the percentage of Glycosylated Hb increases, incidence of hearing loss in diabetic patients increases accordingly. Maximum number of patients with hearing loss (51.6%) were found to have HbA1c levels >8% (p=0.00002) signifying uncontrolled Diabetes mellitus.

According to WHO recommendations for HbA1c levels, the value should be 6.5% and below. Taking that into consideration:

93.5% of the diabetic patients with hearing loss had deranged HbA1c according to WHO norms giving a highly significant p value of 0.006*10^-9. Hence, glycosylated Hb is strongly related to diabetes induced hearing loss.

Among all the diabetic patients with presence of sugar in urine, 89.6% (26 out of 29) of them were found to be suffering from sensorineural hearing loss (p value 0.02*10^-7). This is highly significant.

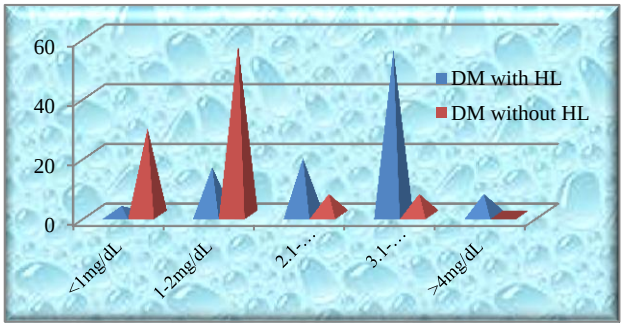

Figure 15: Relation of diabetes induced HL with serum creatinine levels.

Table 3: HbA1c levels (high and low).

HbA1c Levels	≤6.5	>6.5	Total	P value
Diabetic pts with HL	2	29	31	0.0069*10^-9

Table 4: Relation of diabetes induced HL with urine sugar and albumin.

Urine sugar and albumin		DM with HL	DM without HL	Total	P value
Sugar	Present	26	3	29	0.02*10^-7
	Absent	5	58	63	
	Total	31	61	92	
Albumin	Present	10	4	14	0.0233
	Absent	18	60	78	
	Total	31	61	92	

Table 5: Relation of diabetes induced hearing loss with serum creatinine (high and low).

Serum creatinine	DM with HL	DM without HL	Total	P value
≤1.2 mg/dL	1	46	47	
>1.2 mg/dL	30	15	45	0.0016
Total	31	61	92	

Table 6: Relation of diabetes induced HL with total serum cholesterol

Serum cholesterol	DM with HL	DM without HL	Total	P value
<200 mg/dL	20	51	71	
>200 mg/dL	11	10	21	0.757
Total	31	61	92	

Table 7: Comparison of indicators of control of diabetes: arranged in descending order of significance.

Significance	Indicators	P value
Significant	1. HbA1c	0.006*10^-9
	2. Urine sugar	0.02*10^-7
	3. PPBS >300 mg/dL	0.02*10^-4
	4. Serum creatinine	0.00003
	5. Duration of diabetes	0.0001
	6. Diabetic complications	0.0019
	7. Albuminurea	0.0233
	8. FBS	0.029
Not Significant	9. PPBS >140 mg/dL	0.0611
	10. Serum total cholesterol	0.757

71.4% (10 out of 14) of the diabetic patients with hearing loss suffered from albuminurea, p value 0.023, which is significant. Hence, it can be concluded from all the parameters that uncontrolled diabetes has higher incidence of hearing loss and also the severity of hearing loss is more.

We can see that most of the diabetic patients with hearing loss had serum creatinine levels in the higher range (maximum within 3-4 mg/dL). It is observed that diabetes related hearing loss is directly proportional to serum creatinine levels. 75.8% of the diabetic patients with hearing loss had serum creatinine levels above 2 mg/dl (p value 0.00003), which is significant. Maximum number of patients (55%) of diabetes related hearing loss had serum creatinine levels between 3-4 mg/dL.

Talking in terms of standard values and taking normal serum creatinine levels as 1.2 mg/dL, among all the diabetic patients with hearing loss (31), 97.7% (30) had abnormally high creatinine levels giving a p value of 0.0016, which is significant.

From the above data, it is clear that 52% of the patients with diabetes have high serum cholesterol and rest 48% did not (p value 0.757). This value is insignificant.

Hence, according to this study, total serum cholesterol has no affect on diabetes induced hearing loss.

From the above table, it is evident that strongest indicator of diabetes induced hearing loss is glycosylated Hb followed by glycosurea, PPBS >300 mg/dl, serum creatinine, duration of diabetes, diabetes related complications, albuminuria and fasting blood glucose in descending order.

Total serum cholesterol and PPBS cut off if taken at 140 mg/dL had no significance.

DISCUSSION

In the present study, diabetic patients were found to have significantly higher prevalence of sensorineural hearing loss when compared to non-diabetic control subjects (p value 0.0009). 33.7% of the diabetic patients had mild to moderate sensorineural hearing loss, and 13% of the control subjects suffered from the same. Also, the severity of hearing loss was found to be less in the control group (18% mild and 3% moderate SNHL) as compared to the diabetic patients (46% mild and 33% moderate SNHL).

Differences in thresholds were found at all frequencies, although they were greater at higher frequencies (>3000 Hz). This is in concordance with other authors stating that there is approximately a 5 to 30 dB difference in hearing thresholds across all frequencies, but more pronounced at 4 to 8 kHz.[9,10,13,14] A study done by Brainbridge et al in USA from 1999 to 2004 on 5140 subjects, reported that diabetic individuals had reduced hearing at all frequencies but greater degrees above 2000 Hz.[15] Cayonu et al, stated that although there were significant differences at 0.5 and 1 kHz, the differences were most pronounced at 2, 4, and 8 kHz.[16] However, in contrast to these studies, Tay et al reported higher incidence of hearing loss in diabetes mellitus at lower and middle frequencies ($p<0.001$).[17]

In the present study, out of 31 diabetic patients with hearing loss, 23 (74.2%) had history of diabetes for more than 5 years (p value 0.001), indicating that long term diabetes has higher chances of developing auditory symptoms. Also, with increasing duration of diabetes, the severity of hearing loss was found to be higher. Most of the studies stating a positive co-relation between diabetes and hearing loss have also stated that diabetes of longer duration shows higher prevalence of hearing loss. Thimmasettaiah et al in their study done in Bangaluru, stated that diabetes of more than 5 years duration were found to have more hearing impairment (79%) as compared to freshly detected diabetics (42%).[18] Pemmaiah and Srinivas found that among 47 patients who had diabetes for more than 10 years, 29 patients (61.7%) showed at least mild hearing loss.[19] In contrast to this, Allesandra et al (Brazil) in their article published online in January 2017 stated that there is no association between the duration of diabetes and hearing thresholds was observed after adjusting for age, gender, and hypertension.[20]

Amongst the patients with absent OAE, 58.6% (82) belonged to the diabetic group and 41.4% (58) to the non-diabetic group (p value 0.00003), which is highly significant. Hence, according to this study, Diabetes definately affects the function of outer hair cells. Dabrowski, in his study found decreased amplitude or lack of OAEs in both type 1 and type 2 diabetes.[21] A study by Sasso et al on type II diabetic patients showed that these patients had higher rate of compromised e-OAE than healthy individuals.[22] These observations indicate an increased prevalence of impaired function of the cochlea in patients with diabetes. However, Agarwal et al, in their study in 2013 found OAEs affected in 30% of the diabetic subjects, and co-related outer hair cell dysfunction with degree of hearing impairment rather than with diabetes.[23]

In present study, all the patients whether diabetics or non-diabetics with hearing loss had absent Acoustic reflex. Hence, it can be stated that acoustic reflex is absent in patients with hearing loss and diabetes does not affect acoustic reflex per se. Also, Tone Decay test was found to be negative in all subjects, irrespective of presence or absence of diabetes or hearing loss. Snashall found excessive tone decay at 8,000 Hz in two out of nine diabetic subjects, and this was found to be significant when compared with a normal group of 19 subjects tested at this frequency, concluding that excessive adaptation at threshold is to be expected at 8,000 Hz in diabetic subjects.[24]

No significant differences were found between diabetics and control groups in terms of speech discrimination score (all $p>0.05$). This is in concordance with most studies stating that Speech discrimination scores are generally seen not to be significantly different in diabetic patients.[10,18,25] However, in studies showing negative relation between diabetes and hearing loss stated that some patients had a few abnormal findings, such as high frequency pure tone loss, impaired speech discrimination ability, and abnormally decreased stapedial reflex thresholds.[8] This is in contrast to the findings of present study.

All the patients with hearing loss, whether diabetic or non-diabetic showed SISI score above 70%, while the rest showed below 30%.

In the light of audiological evaluation of diabetic and non diabetic controls in this study which shows bilateral sensorineural type of hearing loss, normal tympanograms and acoustic reflex tests, negative tone decay test, normal speech discrimination scores and high SISI scores, the broad inference that can be drawn is that diabetes induced hearing loss is essentially cochlear in nature. All the patients of presbycusis in this study are also showing

similar audiological findings. Hence, it may be said that Diabetes basically accelerates the senile changes occurring at the level of cochlea, thus increasing the prevalence of hearing loss in them. Hence, the term diabetic otopathy given by Dabrowski.[21] Other studies also indicate a reduction in auditory acuity, which is similar to that shown in presbycusis, is greater than expected for the age, in elderly and diabetic patients.[4] After age 60, the difference in hearing loss between diabetics and non-diabetics was reduced.[4]

It was observed in this study that hearing loss is more common in patients with diabetes related complications (p value 0.0019). Maximum co-relation of sensorineural hearing loss was seen with Diabetic Neuropathy (Peripheral neuropathy and diabetic foot ulcers). Also, glycemic status had significant correlation with hearing loss that may be explained by diabetic microangiopathy of the inner ear. Strongest co-relation was found with deranged glycosylated Heamoglobin (p value 0.006*10^-9). PPBS cut off, if taken at 140 mg/dL was not significant (p value 0.0611), however taking the same at 200 mg/dL (p value 0.0011) or 300 mg/dL (p value 0.000002) was certainly significant. Significant relation was also found with glycosurea (p value 0.02*10^-7), serum creatinine (p value 0.00003) and albuminurea (p value 0.0233) in decreasing order of strength. However, total Serum Cholesterol had no significant relationship (p value 0.757). Other studies also came up with similar results.[11,19,26] Dalton et al found weak association between NIDDM and hearing loss, but at same time also stating that auditory symptoms were more common in patients with NIDDM and nephropathy as compared to those with NIDDM and no nephropathy.[27]

CONCLUSION

In the present study, it was found that the patients with Type 2 diabetes had a higher hearing thresholds than the healthy controls. The patients with diabetes showed significant bilateral, mild-to-moderate Cochlear type of SNHL of gradual onset which affects predominantly the higher frequencies (>3000Hz). The decrease in hearing acuity was found to be similar to presbycusis, but greater than that expected for the age. Uncontrolled Diabetes and those suffering from other complications of it, have higher chances of developing hearing loss than those maintaining a good glycemic control. The glycemic status having significant correlation with hearing loss may be explained by diabetic microangiopathy of the inner ear. Thus, maintaining good metabolic control can prevent vascular injury and complications associated with diabetes.

Hence, all the patients of Diabetes mellitus, along with other tests for glycemic status, should undergo regular hearing assessment as auditory symptoms might be an early indicator of impending systemic complications.. Also, the long term diabetics should be counselled along the lines of maintaining a good glycemic control in order to avoid these complications.

To sum up, the higher prevalence of hearing impairment in patients with diabetes indicates the need for early screening for auditory organ involvement in these patients.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. WHO: Deafness and hearing loss. http://www.who.int/mediacentre/factsheets/fs300/en/. Accessed on 10 February 2017.
2. Fowler PD, Jones NS. Diabetes and hearing loss. Clin Otolaryngol Allied Sci. 1999;24(1):3-8.
3. Lisowska G, Namysłowski G, Morawski K, Strojek K. Cochlear dysfunction and diabetic microangiopathy. Scand Audiol Suppl. 2001;(52):199-203.
4. Vaughan N, James K, McDermott D, Griest S, Fausti S. A 5-year prospective study of diabetes and hearing loss in a veteran population. Otol Neurotol. 2006;27(1):37-43.
5. Louise Ziani de David, Marcele Machado Finamor,Ceres Buss. Possible Hearing Implications Of Diabetes Mellitus: A Literature Review. vol.17 no.6 São Paulo Nov./Dec. 2015.
6. Lisowska G, Namysłowski G, Morawski K, Strojek K. Early identification of hearing impairment in patients with type 1 diabetes mellitus. Otol Neurotol. 2001;22(3):316-20.
7. Doroszewska G, Kazmierczak H. Hyperinsulinemia in vertigo, tinnitus and hearing loss. Otolaryngol Pol. 2002;56(1):57-62.
8. Axelsson A, Sigroth K, Vertes D. Hearing in diabetics. Diabetes and Sensineural hearing Loss. Otology Acta Otolaryngol. 1978;356:3–21.
9. Harner SG. Hearing in adult-onset diabetes mellitus. Otolaryngol Head Neck Surg. 1981;89:322–7.
10. Kakarlapudi V, Sawyer R, Staecker H. The effect of diabetes on sensorineural hearing loss. Otol Neurotol. 2003;24(3):382–6.
11. Pathak NA, Rokade VV, Shinde KJ. Screening of auditory acuity in patients with type 2 diabetes mellitus. 2017;23(2):67-70.
12. Akbar. Exploring the association between diabetes mellitus and hearing loss: Genetic mutation, neuropathy and microangiopathy. Academic J. 2016;11(14):147-52.
13. Huang YM, Pan CY, Gu R. Hearing impairment in diabetics. Chin Med. 1992;105:44–8.
14. Celik O, Yalcin S, Celebi H, Oztürk A. Hearing loss in insulindependent diabetes mellitus. Auris Nasus Larynx. 1996;23:127–32.

15. Bainbridge KE, Hoffman HJ, Cowie CC. Diabetes and hearing impairment in the United States: audiometric evidence from the National Health and Nutrition Examination Survey, 1999 to 2004. Ann Intern Med. 2008;149(1):1–10.
16. Cayonu M, Capraz M, Acar A, Altundağ A, Salihoğlu M. Hearing loss related with type II diabetes mellitus in an elderly population. J Int Advanced Otol. 2014;10(1):72-5.
17. Tay HL, Ray N, Ohri R, Frootko NJ. Diabetes mellitus and hearing loss. Clin Otolaryngol. 1995;20:130-4.
18. Thimmasettaiah N, Shankar R, Ravi GC, Reddy S. A one year prospective study of hearing loss in diabetes in general population. Transl Biomed. 2012;3:2.
19. Pemmaiah KD, Srinivas DR. Hearing loss in diabetes mellitus. Int J Collab Res Intern Med Public Health. 2011;3(10):725–31.
20. Samelli AG, Santos IS, Moreira RR, Rabelo CM, Rolim LP, Bensenõr IJ, et al. Diabetes mellitus and sensorineural hearing loss: is there an association? Baseline of the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). Clinics São Paulo Jan. 2017;72:1.
21. Dabrowski M. Disorders of hearing in diabetes mellitus, 2014. Available at: http://dx.doi.org/10.14496/dia.7105378814.8 in a book. Accessed on 20 January 2016.
22. Sasso FC, Salvatore T, Tranchino G, Cozzolino D, Caruso AA, Persico M, et al. Cochlear dysfunction in type 2 diabetes: A complication independent of neuropathy and acute hyperglycemia. Metabolism: Clinical Experimental. 1999;48(11):1346–50.
23. Agarwal AC, Pujary K, Ganapathy K, Balakrishnan R, Nayak DR, Hasan F. Pure tone audiometry and otoacoustic emissions for the assessment of hearing loss in diabetic patients. Indian J Otol. 2013;19(1):13-7.
24. Snashall SE. Békésy audiometry and tone and reflex decay tests in diabetics. Arch Otolaryngol. 1977;103(6):342-3.
25. Cullen JR, Cinnamond MJ. Hearing loss in diabetics. J Laryngol Otol. 1993;107:179–82.
26. Lerman-Garber I, Cuevas-Ramos D, Valdés S. Sensorineural Hearing Loss-A Common Finding in Early-Onset Type 2 Diabetes Mellitus. Endocrine Practice. 2012;18(4):549-57.
27. Dalton DS, Cruickshanks KJ, Klein R, Klein BE, Wiley TL. Association of NIDDM and hearing loss. Diabetes Care. 1998;21(9):1540-4.

Cite this article as: Sachdeva K, Azim S. Sensorineural hearing loss and type II diabetes mellitus. Int J Otorhinolaryngol Head Neck Surg 2018;4:499-507.