SENSORINEURAL HEARING LOSS IN PATIENTS WITH DIABETES MELLITUS: CLINICAL EVALUATION

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Abstract: This study aims at unravelling the characteristics of SNHL in DM and its relation to age, sex, duration ,family history, type of anti diabetic medication and control of DM.A total of 200 cases, 150 type 2 diabetic patients and 50 non diabetic(controls) cases between the age group of 20-55years were enrolled in the study. FBS and PPBS and HbA1c of all the subjects were done and later subjected to PTA. Bilaterally symmetrical graph were observed for both cases andcontrols. 81.3%diabetics showed significant high frequency SNHL and only 58% of non-diabetic individuals showed high frequency SNHL, in an age group of 50-55years, suggesting age related changes. Low and midfrequencies also showed increased incidence of SNHL among diabetics when compared to control group. Four frequency PTA threshold averages of 150 diabetic individuals were divided among Goodmann’s (1965) classification of hearing loss, and it was seen that, 21.3% individuals showed slight hearing loss, 14.7% had mild SNHL and 2% had moderate SNHL. Mean age group among diabetic group was 45.21 and that of controls were 42.52. It was seen that that as age progresses, the incidence of hearing loss among diabetics is more with higher incidence in the 41-50years and 51-55 years group age group. Female diabetics had more preponderance to SNHL than males in our study. As duration of diabetes increases, the predisposition to SNHL also increases. It was concluded that Type 2 diabetic subjects had a higher hearing threshold than the healthy controls. The diabetics showed significant high frequency, bilateral, mild to moderate sensorineural hearing loss as compared to controls of similar age. As the duration of diabetes increases the hearing threshold for all frequencies also increases, suggesting microangiopathy of cochlear vessels. Therefore the auditory and metabolic health of diabetic patients is to be more carefully followed up by health care professionals to diminish comorbidities among them and improve their quality of life.

Keywords: Sensorineural hearing loss (SNHL), diabetes mellitus (DM), pure tone audiometry(PTA).

I. Introduction
Hearing is one of the most important among the five senses gifted to mankind. It plays an important role in the development of speech, communication and cognitive, emotional and social development of a human being. Being an hearing impaired puts a step backward in the overall development of the child. Thus it is very 1,2 essential to identify this impairment in early stages and treat effectively. Hence hearing impairment is not a trivial consideration. Diabetes mellitus is a common non-communicable metabolic disorder of multiple etiologies characterized by chronic hyperglycemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action or both[2]. Diabetes is a chronic and potentially disabling disease which is reaching an epidemic proportion in many parts of the world. It is a major and growing threat to global public health. The vast majority of cases of diabetes fall into two broad categories: those having little or no endogenous insulin secretory capacity (Insulin Dependent Diabetes Mellitus) or type 1 DM and those who retain endogenous insulin secretory capacity but have a combination of insulin resistance and an inadequate compensatory insulin secretory response(Non-Insulin...
Dependent Diabetes Mellitus or Type 2 DM)[2,3]. The prevalence of diabetes mellitus and its adverse health effects have increased more rapidly in South Asia than in any other region of the world [4]. Furthermore, DM is associated with several complications, which include retinopathy, nephropathy, and neuropathy (both peripheral and autonomic). The risk for atherosclerotic vascular disease is also increased in persons with DM. The risk for microvascular and neuropathic complications is related to both duration of diabetes and severity of hyperglycemia [4]. In patients with DM all the cells of the body are exposed to high levels of plasma glucose but it is observed that symptoms of complication are arising only in few cell types. This may be because many of such complications are unrecognized or only particular cells are affected by hyperglycemia. The sense organ of hearing- the organ of corti has complex components and arrangement which makes it a potential target for hyperglycemic damage. Microangiopathy is the basic lesion and is considered to be the most important factor in long term complication of diabetes [5]. Microangiopathic changes in retina, skin and renal vessels are very well documented. As microangiopathy affects almost all parts of the body, its effect on the vessels of the inner ear may lead to impairment on hearing.

Diabetes mellitus is a multisystem disorder with abnormally high blood glucose level. It is a disease known since ages. It is said that 1 in 8 individuals is a diabetic. It affects almost all the systems in the body to its severity if left uncontrolled. Likewise, diabetes affects hearing by damaging the inner ear structures. The effect of diabetes mellitus on hearing is 2,3,4 known since 1857, when Jordao first showed hearing loss in a patient with incipient diabetic coma.

The typical hearing loss pattern in diabetics is progressive, bilateral sensorineural hearing loss affecting the 1.3 higher frequencies. But rarely, there are incidences where sudden onset, sensorineural hearing loss affecting 2,5 lower frequencies are also noted. The type of hearing impairment noted, is similar to that of presbyacusis, but those affected show a greater decrease in hearing than one would expect at that age. Hence this case control study aims to find out whether diabetes mellitus causes hearing loss, and if so then its relation to age of patient, sex of patient, duration of diabetes, family history of diabetes, control of diabetes and type of medication taken.

II. Materials And Methods
This case control study was done from October2012 to October 2014 after ethical committee clearance from the institution. A total number of 200 patients, of which 150 patients less than 55 years, diagnosed to be type 2 DM for more than 2 years, attending the out patient departments of ENT & General Medicine, at Justice K S Hegde Charitable Hospital, has been enrolled in this study. 50 were controls, who matched in all respects with the cases except in having diabetes. Written informed consent was taken from all. Inclusion criteria were patients with Diabetes Mellitus on treatment, <5 years, diagnosed with DM for more than 2 years. Exclusion criteria included Patients with middle ear pathology, history of noise exposure and ototoxic drug intake, hearing Loss caused by Inner ear pathologies like Meniere’s disease, Acoustic neuroma and age > 55 years.

Detailed history including age, gender, duration of diabetes mellitus, type of diabetes and previous medical history were noted. Detailed systematic examination to rule out any diabetic complications was done and complete ENT examination with emphasis on Otological examination and Tuning fork test is done to know the hearing status of the patient.

Then the patient is subjected to the following investigative procedures.- HbA1C (<6.5%), Fasting blood sugar(<110mg/dl) and Random blood sugar. Pure Tone Audiometry done usingGrason-Stadler GSI 61 - Dual channel clinical audiometer The air conduction testing was done using TDH 50P supra aural headphones across test frequencies in the order of 1KHz, 2KHz, 4KHz, 8KHz, 1K Hz, 500Hz and 250Hz. Bone conduction thresholds were estimated using Radioear B 71 bone vibrator. Thresholds were tracked to estimate for each of the frequencies if and only if 2/3 correct response was observed. Masking was done to prevent participation of the non test ear whenever necessary.

<table>
<thead>
<tr>
<th>Degree of hearing loss</th>
<th>Hearing loss range (dB HL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>−10 to 15</td>
</tr>
<tr>
<td>Slight</td>
<td>16 to 25</td>
</tr>
<tr>
<td>Mild</td>
<td>26 to 40</td>
</tr>
<tr>
<td>Moderate</td>
<td>41 to 55</td>
</tr>
<tr>
<td>Moderately severe</td>
<td>56 to 70</td>
</tr>
<tr>
<td>Severe</td>
<td>71 to 90</td>
</tr>
<tr>
<td>Profound</td>
<td>91+</td>
</tr>
</tbody>
</table>

Data management and statistical assessment was done using students „T“ test for comparing tests and controls of categories of age, frequencies-250Hz, 500Hz, 1KHz, 2KHz, 4KHz, 6KHz, 8KHz,
PTA average, Low and High frequency average. And age, duration, gender, family history and medication was done using Chi Square Test. P Value of <0.05 was considered statistically significant. SPSS statistics 20 software was used for the assessment.

III. RESULTS
This descriptive study included a total of 140 patients presenting with diabetes mellitus during the study period. In this study 58.27% of the patients were males and 41.43% were females. The male to female ratio was 1.41:1. The commonest age group was 40 to 50 years comprised of 55% of patients followed by 20 to 30 years (24.29%) and 31 to 40 years (20.71%). The mean age of the study population was 39.85±9.25 years. In the present study maximum (75%) patients presented with duration of 5 years or less. In the remaining, the duration was 6 to 10 years (18.57%), 11 to 15 years (5%) and more than 15 years (1.43%). The mean duration of the study population was 4.91±3.44 years. Family history of diabetes was present in 32.86% of the patients. In this study, the prevalence of SNHL in patients with diabetes mellitus was found to be 40%. In the present study the severity of hearing loss was minimal in 20%, mild in 14.29%, moderate and moderately severe in 2.86% each (Table 1).

Table 1: Severity of hearing loss

<table>
<thead>
<tr>
<th>Severity</th>
<th>Distribution (n = 140)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>84</td>
<td>60.00</td>
<td></td>
</tr>
<tr>
<td>Minimal</td>
<td>28</td>
<td>20.00</td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>20</td>
<td>14.29</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>4</td>
<td>2.86</td>
<td></td>
</tr>
<tr>
<td>Moderate to Severe</td>
<td>4</td>
<td>2.86</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>140</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

In this study 36.59% of the males had SNHL compared to 44.83% of females but the difference was statistically not significant (p=0.327). In the present study the prevalence of SNHL increased with age that is 55.84% of patients aged between 41 to 50 years had hearing loss compared to 11.76% of patients who were aged between 20 to 30 years. This difference was statistically significant (p<0.001). Patients aged between 31 to 40 years had 31.03% hearing loss (Table 2).

Table 2: Association of age with SNHL

<table>
<thead>
<tr>
<th>Age group(years)</th>
<th>SNHL</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>No</td>
<td>%</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>56</td>
<td>40.00</td>
<td>84</td>
</tr>
</tbody>
</table>

In this study the prevalence of SNHL was high had duration of 5 years or less (33.33%). This in those patients who presented with duration of more difference was statistically significant (p=0.009) (Table than 10 years (77.78%) while it was less in those who 3).

Table 3: Association of duration of diabetes with SNHL

<table>
<thead>
<tr>
<th>Duration (Years)</th>
<th>SNHL</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>%</td>
<td>No</td>
</tr>
<tr>
<td>5 or Less</td>
<td>35</td>
<td>33.33</td>
<td>70</td>
</tr>
<tr>
<td>6 to 10</td>
<td>14</td>
<td>53.85</td>
<td>12</td>
</tr>
<tr>
<td>&gt;10</td>
<td>7</td>
<td>77.78</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>56</td>
<td>40.00</td>
<td>84</td>
</tr>
</tbody>
</table>

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IV. Discussion
The relationship between diabetes mellitus and hearing loss has been debated for many years. Jordao in 1857 published a case report of a diabetic patient with hearing loss. Edgar in 1915 was the first to report a high-frequency sensorineural hearing loss (SNHL) in a diabetic patient. The typical hearing loss in diabetics is 1,3 progressive, bilateral sensorineural hearing loss affecting the higher frequencies. In this case control study the occurrence of sensorineural hearing loss in diabetic patients was compared with those of non-diabetics. It has been discussed under the following headings.

1. Characteristics of SNHL among Diabetics and Non Diabetic
In our study, there were total number 150 patients diagnosed with type 2 DM between the age of 20-55 and 50 non diabetic age matched controls. Frequencies 250Hz, 500Hz, 1Khz, 2Khz, 4Khz, 6Khz, 8Khz were tabulated and PTA averages were calculated for low(250Hz, 500Hz), mid (500Hz, 1Khz, 2Khz, 4Khz) and high(6Khz, 8Khz) frequencies for both cases and control group. In a study by Rajendra et al shows that the diabetics had a 73% incidence of deafness when compared to the non-diabetics of the
same age group. Friedman et al. showed a 55% incidence of hearing loss in diabetic patients. Kakarlapudi et al. found that hearing loss was more common in diabetic patients (13.1% prevalence) than the control non diabetic healthy subjects. Weng et al. noted that among the 67 diabetic subjects examined, 44.8% of them had profound hearing loss.

In our study, the incidence of SNHL (4 frequency PTA avg.) among diabetics was 38% which is similar to above studies. Many studies suggested that diabetes causes hearing loss. Many have tried to identify the cause and based on their conclusions, the probable mechanisms are microangiopathy of the inner ear, neuopathy of the cochlear nerve, a combination of both, outer hair dysfunction and disruption of endolymphatic potential. The tissue effects of diabetes are thought to be related to the polypyl pathway, where glucose is reduced to sorbitol. Sorbitol accumulation is implicated in neuropathy by causing a decrease in myo inositol content, abnormal phosphoinositide metabolism and decrease in Na+ K+ ATPase activity. Makishima and Tanaka (1971) observed severe atrophy of the spiral ganglion in the basal and middle turns of the cochlea in diabetic patients with sensorineural hearing loss. They also observed that 8th nerve showed changes of myelin degeneration with fibrosis of perineurium. Jorgensen (1961) observed thickening of the walls of the vasa nervorum of 8th nerve, leading to acoustic neuropathy. Wackym and Linthicum (1986) observed microangiopathic changes in the endolymphatic sac, striavascularis and basilar membrane. Van den Ouweland et al. observed a mutation in mitochondrial tRNA in a small subset of patients with maternally inherited diabetes with sensorineural hearing loss. Lisowska et al. demonstrated abnormalities of outer hair cell function and abnormal auditory brain stem responses in patients with diabetes. Fukushima et al. concluded that Type 2 Diabetes results in changes in cochlea, such as significant atrophy of striavascularis & otic loss in basal turn, which likely results in hearing loss.

In our study, among the diabetics 82.3% showed significant SNHL in high frequencies (4KHz, 6KHz and 8KHz) while only 58% of non diabetic individuals showed high frequency SNHL, that too observed in individuals of 50-55 years age group, suggesting age related changes. Low (250,500Hz) and mid (500Hz, 1KHz, 2KHz, 4KHz) frequencies also showed increased incidence of SNHL among diabetics when compared to control group. Four frequency PTA threshold averages of 150 diabetic individuals were divided among Goodmann’s (1965) classification of hearing loss, and it was seen that, 21.3% individuals showed slight hearing loss, 14.7% had mild SNHL and 2% had moderate SNHL. This result was in concordance with previous studies.

But Fangchao Ma et al. and Friedman et al. observed the strongest association of hearing loss at lowest frequency at 500 Hz.

Gibbin and Davis found a statistically significant incidence of type II tone decay in the overall group of diabetics at 2000Hz. According to Frisina et al. the greatest deficit of hearing in the diabetics tended to be at low frequencies. Vaughan et al. suggest that diabetic patients 60 years old or younger may show early high frequency loss similar to early presbyacusis. Our study reports that the incidence of sensorineural deafness is increased in diabetics. The hearing loss is a progressive, bilateral, sensorineural deafness which affects predominantly the higher frequencies. The decrease in hearing acuity is similar to presbyacusis but those affected show a hearing loss greater than could be expected at that age.

2. Age Distribution

The mean age in Group A was 45.21 and group B was 42.52. There were 10 patients in the 21-30 years age group, of which none had hearing loss. In the 31-40 age group, there were total of 28 patients, out of which 8 had hearing loss and 20 patients had normal hearing. 73 patients in the 41-50 year age group, of which 25 had hearing loss and 48 had normal hearing. 51-55 year group had 39 patients of which 24 had hearing loss and 15 with normal hearing. Obtained P value of <0.001 was statistically significant. It was noted that as age progresses, the incidence of hearing loss among diabetics is more.

In the study by Diniz and Guide which reported higher Prevalence of hearing loss among patients with older age it means in addition to diabetes age also plays an important role in hearing loss. A study by Donald et al. indicated that the patient with < 50 years of age, has lower risk of hearing loss.

Our study showed increased incidence of SNHL in 50-55 age group which correlates with above study. Friedman et al. showed a 55% incidence of hearing loss in diabetic patients. Kakarlapudi et al. found that hearing loss was more common in diabetic patients (13.1% prevalence) than the control non diabetic healthy subjects. Weng et al. noted that among the 67 diabetic subjects examined, 44.8% of them had profound hearing loss. Our study correlates with the above studies, on comparing the PTA average of cases and control group, it is seen that 57 out of 150 diabetes mellitus patients had SNHL and none from the control group had hearing loss.

3. Gender Distribution

According to Cullen and Cinnamond, male patients with diabetes had worse hearing than female patients with diabetes. They
surmised that this may have been due to occupational noise exposure. However, Taylor and Irwin observed that female patients with diabetes had significantly greater hearing loss than male patients with diabetes. Most studies in the literature reported no differences between the sexes. Our study correlates with the Taylor and Irwin study, with higher incidence of SNHL in females compared to males.

4. Duration of DM
Some studies state that the hearing threshold increases with increase in duration of diabetes 3,23,28 Type 1,2,15 mellitus. While others state that there is no relation between hearing threshold and diabetes mellitus. The increase in hearing threshold is attributed to microvascular angiopathy occurring in capillaries of striovascularis which make these vessels thicker than normal. These changes can occur in vessels supplying 4 other parts of auditory system as well. In our study, it was noted that, there was increase in hearing threshold with increase in duration of diabetes mellitus which was correlating with the studies done by Virteniemil et al. *Celik et al* and Fangcha MA et al.

5. Family History
The relation between family history of diabetes and sensorineural hearing loss was evaluated. This was studied to know any genetic factor of diabetes that might influence on the occurrence of sensorineural hearing loss. Diabetics with a positive family history do not have any variation in hearing threshold levels. In our study, 46/150 diabetic patients had no family history of diabetes, of which 17 had hearing loss. And 104/ 150 diabetics had positive family history, of which 40 had hearing loss. It was seen that family history of diabetes had no effect on predisposition to SNHL in diabetes which was similar to the study conducted by Cullen et al.

6. Control of Diabetes
Occurrence of sensorineural hearing loss in diabetics depends on the control of the disease. Most of the studies have stated that a better control of diabetes delays or prevents the onset of sensorineural hearing loss in 1,2,4 that person. But different studies have used different parameters of diabetic control to analyse the result. The blood sugar levels, FBS and PPBS dictate the control of diabetes and they have a highly significant variation in 1 higher frequencies but insignificant variation in low frequencies. Glycated hemoglobin (HbA1C) is also one of the indicator for control of diabetes. But its elevated levels were not systematically associated with increased thresholds of hearing. Thus, direct evidence that poor 3 metabolic control in diabetes causing sensorineural hearing loss remains to be proven. According to study done by Rajendra et al, the control of diabetes did not show any significance in the incidence of hearing loss in the diabetic group. In the present study, control of DM was assessed using HbA1c value which summarizes the average control of blood sugar level for past 3 months. There were 124 out of 150 (82.7%) uncontrolled diabetics, of which 49(39.5%) cases had SNHL and 26(17.3%) controlled diabetics, of which 8(30.7%) had SNHL. This proves that there is no relation between control of diabetes and onset of sensorineural hearing loss. This also shows that diabetes might cause some specific changes in the inner ear that may not be attributable to the microvascular changes of diabetes.

7. The Prevalence Of Hearing Loss According To The Type Of Anti Diabetic Medication
In our study, of the 150 diabetic patients, majority ie 101(67.3%) were on oral hypoglycaemic medication, of which 39(38.6%) showed hearing loss. 28/150(18.8%) were on insulin injection, of which 9(32.14%) had hearing loss, 15(10%) were on both insulin and OHA of which 7(46.6%) had SNHL. 5(3%) cases were on diet control of which 1(20%) had SNHL. P value of 0.522 is insignificant. Study done by Taziki Mohammad H et al indicates that diabetic patient on Insulin therapy do not loose their hearing ability. Also a study by Chon et al indicated that the control of diabetes with insulin can have a better prognosisfor hearing loss, for diabetic patients. But no correlation was found between type of anti diabetic medication taken and hearing loss in our study probably due to the lesser number of patients on insulin medication in the study group.

8. Association Of SNHL With Other Complications Of DM
According to the study conducted by Harkare, et al Diabetics with one or more complications had high incidence of sensorineural hearing loss (60 patients out of 67) than those without diabetic complications (14 patients out of 33). Kurienet al also found that patients without complications had relatively lower level of sensorineural hearing loss as compared to patients with diabetic complications. Taylor and Irwin reported that almost 70% of their adult diabetics had hearing impairment. This occurred more commonly when retinopathy was present. Parving in his study of 20 patients with diabetic microangiopathy did not find correlation between hearing impairment and angiopathy as well as neuropathy.

In our study, out of 150 cases 24 cases were associated with one or more complications of DM like retinopathy, neuropathy,
nephropathy and ketoacidosis and all those cases were associated with SNHL, indicating strong association, which is similar to the above studies.

V. Conclusion
Type 2 diabetic subjects had a higher hearing threshold than the healthy controls. The diabetics showed significant high frequency, bilateral, mild to moderate sensorineural hearing loss as compared to controls of similar age. As the duration of diabetes increases the hearing threshold for all frequencies also increases, suggesting microangiopathy of cochlear vessels. Glycemic status and family history had no significant correlation with hearing loss while female diabetic showed preponderance to SNHL. Therefore the auditory and metabolic health of diabetic patients is to be more carefully followed up by health care professionals to diminish comorbidities among them and improve their quality of life.

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