

A STUDY ON EFFECTS OF DIABETES MELLITUS ON AUDITORY SYSTEM

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Abstract

Background and aims: Auditory dysfunctions in diabetes are known but are difficult to identify. Role of clinical tests and routine audiological tools are still to be established in early detection of diabetes-related auditory complication. The study aims to establish a link between diabetes and auditory dysfunction and assess the role of clinical examination and audiological investigations as a sensitive indicator of auditory dysfunctions in diabetics. **Material and Methods:** The auditory functions of 100 diabetic patients and 100 non-diabetics were assessed by clinical otological examination including free-field hearing and pure tone audiometry (PTA) in this descriptive study. The data for diabetic and non-diabetic groups and effect of age on auditory functions were analyzed with suitable statistical tests using SPSS 2.0 software with an error margin of 10%. **Results:** The demographical variables were comparable in both groups. The results showed a decline in free field hearing, which are further adversely affected by duration of diabetes and patient's age. Overall pure tone thresholds were not significantly higher in diabetics, however the thresholds were higher in diabetics in older age groups. The hearing loss appears at an early age in diabetics but gradually becomes indistinguishable from age-related hearing loss. **Conclusions:** The auditory dysfunction can be linked to diabetes. It is usually not detectable at earliest stages with routine clinical and audiological tests but the clinical tests and pure tone audiometry can have a utility in monitoring the auditory dysfunction.

key words: Diabetes mellitus, hearing loss, pure tone audiometry, neuropathy, auditory dysfunction, hyperglycemia

Background and aims

Diabetes Mellitus (DM) is among the oldest recognized diseases, with dramatic rise in prevalence over past few decades. The epidemic is mainly contributed by Type 2 DM with almost 90% of cases [1,2]. The diabetes-induced complication of

auditory system can be cochlear, retrocochlear or combined with proposed pathophysiological mechanisms like microangiopathy, neuronal degeneration, neuropathy and free radical damage [3,4]. The studies conducted so far to analyze the relation between diabetes and hearing loss, have suggested varying and incongruous results. Despite

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of clear linkage of DM with other complications, there are still voids in establishing its relationship with auditory dysfunction [5].

The aim of this study was to establish a link between diabetes and auditory dysfunction and assess the role of clinical examination and audiological investigations as a sensitive indicator of auditory dysfunctions in diabetics.

Material and Methods

This study is a descriptive comparative study with an error of margin 10% including a population of 100 patients diagnosed with DM, without any subjective hearing related complaints and receiving outpatient or inpatient care at a Tertiary Care hospital between 2014 and 2016. The control population comprised of 100 age and sex matched non-diabetic subjects. Exclusion criteria were: history of exposure to loud noise, intake of ototoxic drugs, chronic smoking, severe head injury, neoplastic diseases, family history of deafness, anatomical defects in the ear or conductive hearing loss of any etiology. Diabetic patients were metabolic controlled as determined by Hb1AC with a cut off of <7% and without complications like diabetic retinopathy, neuropathy or nephropathy. Approval of ethical committee was obtained and all patients were informed about the study in a language they understand and written consent was taken prior to any study procedure.

Clinical otological examination (including free field hearing) was carried out for all individuals participating in the study. Otoscopic examination of all patients was within normal limit. Free field hearing was done in sound treated room with pre-recorded numbers presented at a distance of 600 cm with contra-lateral masking, and gradually decreasing distance if patients do not hear and repeats the number. The distance at which the subject repeats at least 50% of presented words, was recorded for both conversational and forced whisper separately. Pure tone audiometry for air and bone

conduction was performed using Alps international-AD 2100 digital audiometer at frequencies 500, 1000, 2000 and 4000 Hz.

Study objectives: The present study was carried out to identify a link between diabetes and auditory dysfunction and to assess the role of clinical examination and audiological investigations to serve as sensitive indicators of deterioration of auditory functions in patients of diabetes mellitus.

Sample size calculation: The sample size was calculated by using statistical formula for sample size for estimation of difference between proportions, with proportion of subjects having Sensorineural Hearing loss among Diabetics as 74% and proportion of subjects having Sensorineural Hearing loss among Non-Diabetics as 7% with an alpha-error level of 10% and a power of 90% [6].

Statistical analyses: Statistical analyses were performed on the per-protocol population. Statistical testing was performed at a significance level of $\alpha=0.05$. Adjusted means and corresponding two-sided 90% confidence intervals (CI) were calculated. The data are presented as mean \pm standard deviation (SD) values and suitable statistical methods were applied. Statistical analyses were performed using IBM SPSS v2.0 software.

Results

The demographic details of the two groups were comparable and not statistically significant between the two groups. There were 100 subjects in each group, with mean age of the diabetic group 50.47 years (yrs) (range 19 -79 yrs) and mean age of the non diabetic group 47.88 yrs (range 20 -76 yrs). In the diabetic group, 5 subjects were younger than 30 yrs of age, 49 were in between 31 to 50 yrs and 46 were greater than 50 yrs, while in the non-diabetic group 9 subjects were younger than 30 yrs of age, 52 were in between 31 to 50 yrs. and 36 were more than 50 yrs old. Mean fasting and post-

prandial blood glucose level in the diabetic group was 155.65 mg/dl (range 77-361 mg/dl) and 222.86 mg/dl (range 121-501 mg/dl).

The free field hearing test showed that the mean distance for hearing conversational voice was 574.50 centimeter (cm) in the diabetic group and 589.00 cm in the non-diabetic group, the difference being statistically significant (p=0.001). The mean distance for hearing forced whisper was 537.00 cm in the diabetic group and 559.50 cm in the non-diabetic group. These results suggest higher mean

hearing threshold for hearing forced whisper in diabetic group, but the results were not significant (p=0.051). On age subgroup analysis in diabetic patients and non-diabetic population, there was a statistically significant decrease in free field hearing with advancing age for conversational voice in diabetics as compared to non-diabetic population. However, the results were not clinically significant as the difference of distance in both groups was not easily appreciable during clinical testing ([Table 1](#)).

Table 1. Free Field Hearing: Conversational voice and forced whisper [in cm] according to age subgroups.

Age group (yrs)	Group	No. of subjects	Conversational voice		P-value	Forced whisper		P -Value
			Mean	SD		Mean	SD	
≤ 30	DM	5	600.00	0.00	0.999	600	0	0.999
	Non DM	9	600.00	0.00		600	0	
31- 50	DM	49	593.88	28.05	0.020*	579.59	51.69	0.553
	Non DM	52	600.00	0.00		584.62	41.26	
> 50	DM	46	551.09	77.74	0.029*	484.78	133.37	0.158
	Non DM	39	571.79	66.25		516.67	106.19	

*Statistically significant

Table 2. Free Field Hearing: Conversational voice and forced whisper [in cm] according to the duration of diabetes.

Duration of Diabetes Mellitus	Conversational voice			Forced Whisper		
	Mean	SD	P-value	Mean	SD	P-value
≤ 5 years	581.82	52.16	< 0.001*	554.55	90.26	< 0.001*
5 - 10 years	580.95	50.55		538.10	112.52	
> 10 years	526.92	87.44		446.15	142.07	

*Statistically significant

When results for free field hearing in diabetic patients were compared according to the duration of diabetes, it was observed that an increase in the duration of diabetes significantly affects free field hearing of both conversational and forced whisper ([Table 2](#)).

The pure tone audiometry (PTA) is an important test done routinely in otological examination. The PTA thresholds for air and bone conduction for diabetic patients were higher in all frequencies as compared to non-diabetics ([Table 3](#)), but the differences were not significant.

On comparison of mean PTA thresholds in diabetic patients according to the duration of diabetes, it was observed that air conduction and bone conduction thresholds increase with duration

of diabetes, the results being statistically significant (Table 4). All frequencies were affected significantly with the increase in the duration of diabetes.

Table 3. Pure Tone Audiometry: Air and bone conduction threshold.

Frequency In Hz	Group	AC		BC	
		Mean (Range)	P Value	Mean (Range)	P value
500	DM	11.53 (0.0 -50)	0.592	8.98 (0.0-50)	0.308
	Non DM	11.05 (0.0 -40)		8.13 (0.0-30)	
1000	DM	13.43 (0.0 -60)	0.639	10.95 (0.0-55)	0.187
	Non DM	12.95 (0.0 -45)		9.70 (0.0-35)	
2000	DM	16.18(5.0 -65)	0.420	12.20 (0.0-55)	0.238
	Non DM	15.23 (0.0 -50)		10.93 (0.0-45)	
4000	DM	19.20 (5.0 -75)	0.620	14.77 (0.0-60)	0.271
	Non DM	18.50(0.0 -60)		13.32(0.0-50)	
Average	DM	15.08(3.7 -62.5)	0.545	11.72(0.0-55)	0.227
	Non DM	14.43 (2.5 -46.25)		10.52(0.0-40)	

Table 4. Pure Tone Audiometry: Air and bone conduction thresholds according to the duration of diabetes.

Frequency in Hz	Duration of Diabetes Mellitus	Air conduction dB	P-value	Bone conduction dB	P-value
500	≤ 5 years	9.70	< 0.001*	7.05	< 0.001*
	5 - 10 years	11.90		9.40	
	> 10 years	20.19		18.08	
1000	≤ 5 years	11.44	< 0.001*	8.98	< 0.001*
	5 - 10 years	13.33		11.43	
	> 10 years	23.65		20.19	
2000	≤ 5 years	14.20	< 0.001*	10.38	< 0.001*
	5 - 10 years	16.43		12.74	
	> 10 years	25.77		20.58	
4000	≤ 5 years	16.48	< 0.001*	12.26	< 0.001*
	5 - 10 years	20.95		16.07	
	> 10 years	30.19		25.38	
Average	≤ 5 years	12.95	< 0.001*	9.66	< 0.001*
	5 - 10 years	15.65		12.41	
	> 10 years	24.95		21.06	

*Statistically significant

When the PTA thresholds were compared according to the age sub-groups (less than 30 yrs, 31 -50 yrs and more than 50 yrs) for both diabetic patients and non-diabetic controls, it was observed

that the PTA thresholds of air and bone conduction were slightly higher in the diabetic group for all frequencies (Table 5 and Table 6). However, the results were significant for both air conduction and

bone conduction only in the age group 31 -50 yrs. 50 yrs. it was significant only for air conduction at for all frequencies and for the age group older than 4000 Hz.

Table 5. Pure Tone Audiometry: Bone conduction thresholds according to age subgroups.

Frequency in Hz	Group	Age group (< 30)		P-value	Age group (31 - 50)		P-value	Age group (> 50)		P-value
		PTA BC			PTA BC			PTA BC		
		No. of subjects	Mean		No. of subjects	Mean		No. of subjects	Mean	
500	DM	5	4.50	0.834	49	5.26	0.021	46	13.42	0.434
	Non DM	9	4.17		52	3.99		39	14.55	
1000	DM	5	5.00	0.855	49	7.09	0.003	46	15.71	0.258
	Non DM	9	5.28		52	4.66		39	17.44	
2000	DM	5	5.50	0.718	49	7.65	0.023	46	17.77	0.405
	Non DM	9	5.00		52	5.67		39	19.29	
4000	DM	5	6.00	0.894	49	9.34	0.004	46	21.50	0.144
	Non DM	9	5.83		52	6.15		39	24.59	
Mean	DM	5	5.25	0.873	49	7.33	0.002	46	17.10	0.260
	Non DM	9	5.07		52	5.12		39	18.97	

Table 6. Pure tone audiometry: Air conduction thresholds according to age subgroups.

Frequency in Hz	Group	Age group (< 30)		P-value	Age group (31 - 50)		P-value	Age group (> 50)		P-value
		PTA AC			PTA AC			PTA AC		
		No. of subjects	Mean		No. of subjects	Mean		No. of subjects	Mean	
500	DM	5	7.50	0.694	49	7.70	0.022	46	16.03	0.214
	Non DM	9	6.94		52	6.54		39	18.01	
1000	DM	5	8.50	0.745	49	9.03	0.046	46	18.64	0.126
	Non DM	9	8.06		52	7.55		39	21.28	
2000	DM	5	10.50	0.131	49	11.28	0.012	46	22.01	0.105
	Non DM	9	8.33		52	8.94		39	25.19	
4000	DM	5	10.00	0.747	49	13.52	0.017	46	26.25	0.033
	Non DM	9	9.44		52	10.67		39	31.03	
Mean	DM	5	9.13	0.353	49	10.38	0.010	46	20.73	0.079
	Non DM	9	8.19		52	8.43		39	23.88	

Discussions

Diabetes has emerged as an epidemic of non-communicable disease in the present century. This

study communicates the contribution of diabetes toward causing auditory dysfunction in otherwise asymptomatic individuals on the basis of clinical examination and pure tone audiometry.

It was reported that the prevalence of sensorineural hearing loss (SNHL) in diabetes is 13.1%, compared to 10.3% in non-diabetics [7]. Previous studies have found that the auditory thresholds were significantly elevated, however no statistically significant elevation of auditory thresholds were detected when analysis was done with various age groups in consideration [8,9]. However, there are a few studies, which suggest no clinical reduction in hearing function in diabetic patients compared to controls on basis of pure tone audiometry [10,11].

In this study, the hearing acuity was clinically assessed by free field hearing test with conversational voice and forced whisper. The main drawback of this technique for assessment of hearing acuity is lack of standardisation, which makes the results less reproducible. A normal person can hear whisper at a distance of 6 to 7 meters and loud speech at 20 meters [12].

In the present study, hearing was assessed at a maximum distance of 600 cm. The results indicated a decline in free field hearing according to the duration of diabetes and age of the patients. Similar results of significant speech perception deficit in diabetes were obtained by Bajaj et al. [13].

The pure tone audiometry is a subjective test, which can determine the minimum hearing sensitivity of hearing at a specific frequency. The results of various studies conducted in patients with diabetes to assess hearing have yielded diverse results. In the present study, the PTA air conduction thresholds for 500, 1000, 2000 and 4000 Hz were marginally higher in the diabetic group compared to non-diabetic group, without statistically significant differences for any frequency. Similar results were obtained for bone conduction thresholds. However, diabetes was found to significantly affect hearing in the age group 31 to 50 yrs. where both air and bone conduction thresholds for all frequencies were significantly higher in diabetes compared to controls. When hearing thresholds of diabetic

patients were compared on the basis of diabetes duration, it was found that PTA thresholds increase in all frequencies with increase in duration of diabetes. Similar to the results of this study, Karabulut et al. [14] found that PTA thresholds were significantly higher in patients with diabetes. However, Kamble et al. [9] could not find any statistically significant correlation when analyzing according to age groups, despite significantly elevated PTA thresholds. Dalton et al. [15] compared age adjusted pure tone threshold of Diabetic patients with controls and found no reduction in hearing and no significant effect of diabetes duration.

These results are indicative of the fact that diabetes related auditory dysfunctions have a gradual onset, thus not appearing in the very young age groups. With advanced age, the auditory changes become indistinguishable from auditory dysfunction caused by other etiologies like presbycusis.

In view of diverse result from the studies on the subject; it is essential to carry out standardization of results before implementation into routine clinical practice. Hence, studies with large sample size and probably multicentric studies are required on the subject.

Conclusions

In the present study an effort was made to study the effects of diabetes on auditory function, in relation to age and duration of diabetes. The results of the study suggest that diabetes have a definite and adverse effect on the auditory system, which usually goes unnoticed. While the investigations like pure tone audiometry can detect hearing loss, they are not suitable for early detection and prevention of auditory dysfunction. PTA evaluation appear to be less sensitive in detecting early subtle changes produced by diabetes and therefore has limited utility as a screening tool. However the usage of PTA as a routine monitoring tool can

detect diabetes related deterioration of hearing earlier.

The present study concludes that the diabetics are at definite risk of developing auditory dysfunction. It is recommended that all newly

diagnosed diabetic case should undergo a complete audiological evaluation on diagnosis and a regular follow up for the early detection of damage to auditory functions.

REFERENCES

1. **Mohan V, Sandeep S, Deepa R, Shah B, Verghese C.** Epidemiology of type 2 diabetes: Indian scenario. *Indian J Med Res* 125: 217-230, 2007.
2. **Wild S, Roglic G, Green A, Sicree R, King H.** Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 27: 1047-1053, 2004.
3. **Maia CAS, Campos CAH.** Diabetes mellitus as etiological factor of hearing loss. *Braz J Otorhinolaryngol* 71: 208-214, 2005.
4. **Xipeng L, Ruiyu L, Meng L, Yanzhuo Z, Kaosan G, Liping W.** Effects of diabetes on hearing and cochlear structures. *J Otol* 8: 82-87, 2013.
5. **McDermott D, Konrad-Martin D, Austin DF, Griest S, Mcmillan GP, Fausti SA.** The link between diabetes and hearing loss. *The ASHA Leader* 14: 5-6, 2009.
6. **Rajendran S, Anandhalakshmi, Mythili B, Viswa R.** Evaluation of the incidence of sensorineural hearing loss in patients with type 2 diabetes mellitus. *Int J Biol Med Res* 2: 982-987, 2011.
7. **Kakarlapudi V, Sawyer R, Staecker H.** The effect of diabetes on sensorineural hearing loss. *Otol Neurotol* 24: 382-386, 2003.
8. **Panchu P.** Auditory acuity in type 2 diabetes mellitus. *Int J Diabetes Dev Ctries* 28: 114-120, 2008.
9. **Kamble NM, Mankar VR.** Identifying diabetic parameters in cochlear mechanics and models. *International Journal of Engineering Research* 3: 521-525, 2014.
10. **Lisowska G, Namyslowski G, Morawski K, Strojek K.** Early identification of hearing impairment in patients with type 1 diabetes mellitus. *Otol Neurotol* 22: 316-320, 2001.
11. **Salvinelli F, Miele A, Casale M et al.** Hearing thresholds in patients with diabetes. *Internet Journal of Otorhinolaryngology* 3: 1-6, 2003
12. **Sokolova L, Myalovitska O, Krylova V, Ilyash T, Melnyk V.** Cranial nerve pathology. In: *Neurology*. Sokolova L (Ed), Nova Knhya Publishing House, Vinnytsia, pp. 60-63, 2012.
13. **Bajaj G, Puthuchery S, Bhat J, Ranjan R.** Effect of type II diabetes on speech perception in noise. *International Journal of Innovative Research* 3: 50-54, 2014.
14. **Karabulut H, Karabulut I, Dagli M et al.** Evaluation of outer hair cell function and medial olivocochlear efferent system in patients with type II diabetes mellitus. *Turk J Med Sci* 44:150-156, 2014.
15. **Dalton DS, Cruickshanks KJ, Klein R, Klein BE, Wiley TL.** Association of NIDDM and hearing loss. *Diabetes Care* 21: 1540-1544, 1998.