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Assessing the Correlation between Hearing Loss and Diabetic Retinopathy Severity in Patients at A Tertiary Care Hospital in Pakistan

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ABSTRACT

Diabetes frequently results in sensorineural hearing loss (SNHL), although little is known about its root causes and risk factors. **Objectives:** To evaluate the association between the severity of diabetic retinopathy and sensorineural hearing loss in patients with type 2 diabetes mellitus. **Methods:** Data were collected from 150 patients with type 2 diabetes between June and August 2024. Participants were recruited via consecutive sampling. Audiological assessments were conducted using pure-tone audiometry, and the severity of diabetic retinopathy was graded by the Early Treatment Diabetic Retinopathy Study scale. Statistical analysis was performed using the Kruskal-Wallis test to assess the association between diabetic retinopathy severity and sensorineural hearing loss. **Results:** 33.3% of participants had normal hearing, while 37.3% had mild sensorineural hearing loss, 20% had moderate sensorineural hearing loss, and 9.3% had severe sensorineural hearing loss. Hypertension prevalence increased with DR severity ($p=0.002$), and a longer duration of diabetes was associated with more severe retinopathy ($p<0.001$). Significant differences were found in albumin, creatinine, and HbA1C levels ($p<0.05$), indicating worsening metabolic control with disease progression. sensorineural hearing loss severity showed a significant correlation with retinopathy stages ($\chi^2=25.47$, $p<0.001$), with the highest prevalence of severe sensorineural hearing loss in proliferative diabetic retinopathy. **Conclusions:** It was concluded that this study demonstrates a significant association between diabetic retinopathy severity and sensorineural hearing loss, with increased sensorineural hearing loss severity in more advanced stages of diabetic retinopathy.

INTRODUCTION

One of the main causes of blindness and disability among diabetics is diabetic retinopathy. Despite advances in diabetes management, diabetic retinopathy (DR) remains a significant public health concern, particularly in low- and middle-income countries like Pakistan. According to estimates, approximately 5% of people with diabetes have a severe form of the condition, while 25% of those with diabetes mellitus have diabetic retinopathy [1, 2]. According to a recent meta-analysis, among Iranian patients with type 2 diabetes mellitus (T2DM), the prevalence rate of retinopathy was 37.8% (95% CI: 32.8%, 43.0%) [3]. Diabetic retinopathy (DR) is divided into two types: proliferative diabetic retinopathy (PDR), which develops with additional retinal ischemia and is characterized by the growth of new blood vessels on the retina and posterior surface of the vitreous, and non-proliferative diabetic retinopathy (NPDR), which is characterized by micro-aneurysms, retinal hemorrhages,

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cotton-wool spots, or venous beading. While DR primarily affects vision, growing evidence suggests that similar microvascular and neuropathic mechanisms may also contribute to hearing loss in diabetic patients [4]. Hearing loss is a prevalent condition that can affect people of all ages and has a significant negative impact on their quality of life. Over 1.5 billion people, or 20% of the world's population, are currently thought to be affected by hearing loss. Of these, over 430 million have moderate or greater hearing loss in their better hearing ear. By 2050, that number is predicted to increase to over 700 million [5]. There are three types of hearing loss: mixed, sensorineural, and conductive. Chronic exposure to loud noises is one of the main causes of sensorineural hearing loss (SNHL). Nevertheless, genetic predisposition, specific drugs, and illnesses including diabetes mellitus (DM) and hypertension (HTN) are other contributing variables [6]. High blood sugar levels are a typical sign of diabetes mellitus, resulting in complications including diabetic retinopathy (DR) and neuropathy. Damage to the blood vessels of the retina leads to DR, which directly or indirectly impairs vision. On the other hand, neuropathy is damage to the nerves that can result in impairments in motor and sensory abilities. According to earlier studies, diabetic patients with retinopathy had a higher chance of acquiring SNHL [7]. Another prevalent medical condition that can raise the risk of SNHL is hypertension which directly affects the blood vessels and nerve fibers in the inner ear [8, 9]. Despite existing literature on diabetes-related complications, the relationship between the severity of diabetic retinopathy and the degree of hearing loss remains inadequately explored, particularly in the Pakistani population. In Pakistan, both diabetic retinopathy and hearing loss are common conditions that significantly impact independence, function, and quality of life. However, the extent to which the severity of DR correlates with hearing impairment remains unclear.

This study aims to assess the degree of hearing loss at different stages of diabetic retinopathy.

METHODS

This hospital-based cross-sectional study analysed data from patients with diabetes mellitus (DM) at Jinnah International Hospital, Abbottabad, Pakistan. Data collection was carried out over three months (June 2024 to August 2024). Ethical approval was taken from the Institutional Review Board (IRB), IRB number JIHA-EYE-01-2024. The sample size was calculated using a significance level of 0.05, power of 80%, and an anticipated SNHL prevalence rate of 70.4% using Open Epi software [10]. 150 patients were recruited via random sampling methods from ophthalmology clinics and referrals by primary care physicians and internists within the medical centre. Written informed consent was obtained from each patient before participation. The study followed the principles outlined in the Declaration of Helsinki. Patients aged ≥18 years, with a confirmation of DM according to the criteria set by the American Diabetes Association and any grade diabetic retinopathy (DR) following the criteria set by the Early Treatment Diabetic Retinopathy Study (ETDRS) scale, were included [5,6]. Exclusion criteria encompassed patients with a history of ear surgery, use of hearing aids, known non-DM-related causes of hearing loss, or retinal vein or artery occlusions. The demographic and medical history included age, gender, DM duration, hypertension (HTN) status, and severity of retinopathy (no DR, mild non-proliferative DR, moderate non-proliferative DR (NPDR), severe NPDR, proliferative DR) according to ETDRS scale, were included [5, 6]. Audio-logical assessments were performed in a soundproof closed area using a standardised audiometer by a qualified audiologist. Pure-tone audiology was conducted at different frequencies from 0.5 to 8 kHz, and the mean hearing threshold for each ear was measured by adding all the values of the threshold at 500, 1000, 2000, 4000, and 8000 Hz and dividing by five. Sensorineural hearing loss (SNHL) was grouped as normal, mild, moderate, or severe according to the criteria set by the World Health Organization. Only cases with SNHL were considered, and patients with mixed or conductive hearing loss were excluded. The worst ear of each patient was evaluated, and SNHL was correlated with the eye with the most severe retinopathy. Data were analysed using SPSS version 24.0, version 28.0 (IBM Corp., Armonk, NY). Descriptive statistics summarised the clinical and demographic characteristics of the study population. The association between retinopathy severity and SNHL was assessed using the Kruskal-Wallis non-parametric test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

This study included 150 participants with type 2 diabetes, with a male-to-female ratio of 56% to 44%. Regarding diabetic retinopathy (DR), 26.7% of the participants had no DR, 16% had mild non-proliferative DR (NPDR), 17.3% had moderate NPDR, 9.3% had severe NPDR, and 30.7% had proliferative DR. Among the participants, 33.3% had normal hearing, 37.3% had mild sensorineural hearing loss (SNHL), 20% had moderate SNHL, and 9.3% had severe SNHL (Table 1).

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Table 1: Distribution of Diabetic Retinopathy Severity and Sensorineural Hearing Loss (SNHL) by Gender

Category	Severity	Male n (%)	Female n (%)	Total n (%)
Diabetic Retinopathy	No DR	22 (14.7%)	18 (12.0%)	40 (26.7%)
	Mild NPDR	10 (6.7%)	14 (9.3%)	24 (16.0%)
	Moderate NPDR	14 (9.3%)	12 (8.0%)	26 (17.3%)
	Severe NPDR	8 (5.3%)	6 (4.0%)	14 (9.3%)
	Proliferative DR	30 (20.0%)	16 (10.7%)	46 (30.7%)
	Total	84 (56.0%)	66 (44.0%)	150 (100%)
Sensorineural Hearing Loss	Normal Hearing	28 (18.7%)	22 (14.7%)	50 (33.3%)
	Mild SNHL	30 (20%)	26 (17.3%)	56 (37.3%)
	Moderate SNHL	18 (12%)	12 (8%)	30 (20%)
	Severe SNHL	8 (5.3%)	6 (4%)	14 (9.3%)
	Total	84 (56.0%)	66 (44.0%)	150 (100%)

Among participants with no diabetic retinopathy (DR), 10.7% had normal hearing, while 8%, 3.3%, and 1.3% had mild, moderate, and severe sensorineural hearing loss (SNHL), respectively. For mild non-proliferative DR (NPDR), 5.3% showed normal sense of hearing, 6.7% showed slight SNHL, 3.3% showed modest SNHL, and 1.3% showed severe SNHL. In moderate NPDR, 4.0% had normal hearing, 8% had mild SNHL, 4% showed moderate SNHL, and 1.3% had severe SNHL. Among severe NPDR cases, normal hearing was observed in 1.3%, while 2.7%, 1.3%, and 0.7% had mild, moderate, and severe SNHL, respectively. Proliferative DR showed the highest proportions of SNHL, with 8% having normal hearing, 13.3% mild SNHL, 8% moderate SNHL, and 7.3% severe SNHL (Table 2).

Table 2: Distribution of SNHL Assessment with Diabetic Retinopathy Severity

Retinopathy Severity	Normal Hearing n (%)	Mild SNHL n (%)	Moderate SNHL n (%)	Severe SNHL n (%)	Total n (%)
No DR	16 (10.7%)	12 (8%)	5 (3.3%)	2 (1.3%)	35 (23.3%)
Mild NPDR	8 (5.3%)	10 (6.7%)	5 (3.3%)	2 (1.3%)	25 (16.7%)
Moderate NPDR	6 (4%)	12 (8.0%)	6 (4.0%)	2 (1.3%)	26 (17.3%)
Severe NPDR	2 (1.3%)	4 (2.7%)	2 (1.3%)	1 (0.7%)	9 (6.0%)
Proliferative DR	12 (8%)	20 (13.3%)	12 (8%)	11 (7.3%)	55 (36.7%)
Total	44 (29.3%)	58 (38.7%)	30 (20%)	18 (12%)	150 (100%)

The prevalence of hypertension significantly increased with retinopathy severity (p=0.002), with 88.2% of patients in the Severe NPDR/PDR group having hypertension. The duration of diabetes was significantly longer in patients with more severe retinopathy (p<0.001), with the Severe NPDR/PDR group having an average of 18.4 years of diabetes. The analysis revealed significant differences in albumin (p=0.04), creatinine (p=0.01), and HbA1C (p<0.001) levels across retinopathy stages, indicating worsening metabolic control with disease progression. Hearing loss severity showed a significant correlation with retinopathy stages ($\chi 2=25.47$, p<0.001). Patients with Severe NPDR/PDR had the highest prevalence of moderate (29.4%) and severe (35.3%) hearing loss, while those with No DR predominantly had no hearing loss (61.7%) (Table 3).

Table 3: Demographic, Clinical Characteristics, and Hearing Loss Severity Across Retinopathy Stages

Variables	No DR (n=81)	Mild NPDR (n=52)	Moderate NPDR (n=25)	Severe NPDR/PDR (n=17)	Median (IQR)	χ^2	p-Value
Age (Years)	59.6 ± 8.0	61.5 ± 6.9	62.4 ± 10.4	58.8 ± 8.4	60 (55–65)	3.42	0.33
Albumin (g/dL)	4.2 ± 0.8	4.2 ± 0.5	4.3 ± 0.7	3.7 ± 0.9	4.2 (3.9–4.4)	8.13	0.04*
Creatinine (mg/L)	7.3 ± 34.3	1.0 ± 0.2	11.2 ± 40.3	1.2 ± 0.4	1.0 (0.9–1.2)	10.72	0.01**
HbA1C (%)	7.2 ± 1.6	8.1 ± 1.7	8.0 ± 2.0	8.9 ± 1.8	8.0 (7.1–9.0)	18.65	<0.001**
Hypertension n (%)	25 (30.9%)	34 (65.4%)	18 (72.0%)	15 (88.2%)	60 (50–70)	14.39	0.002**
Duration of Diabetes (Years)	12.5 ± 6.4	14.2 ± 6.1	16.3 ± 7.2	18.4 ± 8.1	13 (10–15)	22.61	<0.001**
No Hearing Loss n (%)	50 (61.7%)	15 (28.8%)	5 (20.0%)	2 (11.8%)	0.0 (0.0–1.0)	–	–
Mild Hearing Loss n (%)	20 (24.7%)	20 (38.5%)	7 (28.0%)	4 (23.5%)	1.0 (1.0–2.0)	25.47	<0.001**
Moderate Hearing Loss n (%)	8 (9.9%)	12 (23.1%)	8 (32.0%)	5 (29.4%)	2.0 (1.0–3.0)	–	–
Severe Hearing Loss n (%)	3 (3.7%)	5 (9.6%)	5 (20.0%)	6 (35.3%)	3.0 (2.0–3.0)	–	–

Data are presented as mean ± standard deviation, n (%), or median (interquartile range). Statistical analysis was performed using the Kruskal-Wallis test, with χ^2 and p-values reported. Significant differences are indicated by *(p<0.05) and **(p<0.01).

DISCUSSION

In 1990, an estimated 158.8 million people worldwide had diabetes, a number that surged to 459.9 million (6.18% of the global population) by 2019 [11]. It is a metabolic disease that has a major impact on health because it doubles or triples the risk of heart attacks and strokes [12], is one of the main reasons for renal failure [13], and results in DR, which is a major reason of blindness due to the growth of retinal vessels [14]. Diabetes may also be associated with other morbidities, such as sensorineural hearing loss. SNHL was more common in diabetics than in non-diabetics of the same age and sex, according to several studies [15]. Uncertainty surrounds the precise mechanism by which hyperglycemia may cause SNHL. SNHL linked to diabetes mellitus is thought to be caused by the microvascular alterations and inflammation linked to this metabolic disorder, which may also impact the auditory system and cause cochlear microangiopathy, articular vascular degeneration, and loss of cochlear outer hair cells [16].

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Since microvascular alterations are the cause of both diabetic retinopathy and sensorineural hearing loss, the current study aims to investigate the association between the degree of DR and the occurrence of sensorineural hearing loss and its severity. Our findings showed a strong correlation of the severity of DR with the evaluation of sensorineural hearing loss. Specifically, it was discovered that those with comparatively more severe DR were more prone to have worse hearing test scores. Patients who had more severe DR or moderate non-proliferative diabetic retinopathy were more likely to have moderate SNHL or worse, which was clear from the data. Similarly, Alizadeh *et al.*, AM *et al.*, and Carlson *et al.*, observed a direct relationship between the progression of DR and hearing impairment, further supporting our findings [1, 17, 18]. A significant relationship was also found between age and hearing loss level. This result is consistent with earlier studies that indicated a high correlation between hearing loss and age. According to Lin *et al.*, systematic review and meta-analysis, the prevalence of hearing loss rises with each decade of life [19]. In a similar vein, a different study conducted by Wasano *et al.*, discovered that the prevalence of hearing loss rose dramatically with age, peaking in people over 80 [20]. To avoid or lessen the effects of age-related hearing loss, these findings emphasize the significance of routine hearing tests and hearing protection measures for older people. A notable finding in our study was the strong correlation between hypertension (HTN) and SNHL severity. This suggests that HTN may be an independent risk factor for hearing loss, consistent with Abraham *et al.*, who highlighted the vascular contributions of hypertension to cochlear dysfunction. Furthermore, SNHL severity tended to increase with the duration of HTN, reinforcing the hypothesis that chronic vascular stress exacerbates auditory impairment [21]. The number of years the patient had diabetes may have been underestimated because the duration of diabetes was determined from the year of diagnosis. However, this computed DM length and DR severity showed a strong correlation in the multinomial cumulative logit model. A review of the literature revealed conflicting and inconsistent findings; whereas some studies found no significant link [22], others identified a favourable correlation between DM duration and SNHL severity [23, 24]. To confirm these findings and understand the reasons behind the connection, longer-term studies are needed. Despite the limitations, current research provides a useful understanding of the link between diabetic retinopathy and hearing loss and more research is required to explore this further and find ways to prevent or reduce hearing loss in people with diabetic retinopathy.

CONCLUSIONS

It was concluded that this study underscores a significant association between DR severity and SNHL, with proliferative DR (PDR) emerging as a strong predictor of hearing impairment. Male gender, advancing age, longer diabetes duration, and hypertension were also identified as independent risk factors for worsening SNHL. Notably, for every additional year of age, the likelihood of severe SNHL increased by 9.2%.

Authors Contribution

Conceptualization: MAK
Methodology: MAK, ZF, WA
Formal analysis: AQ, KF
Writing review and editing: MF

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

The authors declare no conflict of interest.

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