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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:** A hospital-based cross-sectional study was conducted. 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.

Although diabetic retinopathy and sensorineural hearing loss are both recognized complications of type 2 diabetes mellitus, limited evidence exists regarding their direct correlation, particularly within the Pakistani population. Previous studies have insufficiently explored whether worsening diabetic retinopathy severity can serve as an indicator of progressive hearing impairment. Therefore, this study aimed to evaluate the association between different stages of diabetic retinopathy and the severity of sensorineural hearing loss in diabetic patients, while identifying related clinical risk factors such as hypertension, glycemic control, and duration of diabetes.

METHODS

This study was a prospective, cross-sectional study. The formula for comparing two independent means was used to get the study's sample size, taking into account important statistical factors, such as research power (0.84 for 80% power) and the standard normal variate for the significance level (1.96 for a 95% confidence interval). It was calculated that in order to guarantee sufficient statistical power, each group needed at least 150 participants. As a result, the study involved 300 people in total—150 RA sufferers and 150 healthy controls. The Safi Teaching Hospital of Riphah International University in Faisalabad, Pakistan, analyzed the samples from April to August 2023. The hematological and biochemical parameters were compared. Simple random sampling technique was used to enroll the participants. Rheumatoid arthritis patients and healthy controls from the Faisalabad area made up the study population. The American College of Rheumatology's diagnostic and clinical standards were met by the patients. Rheumatoid arthritis and other inflammatory or autoimmune disorders were not present in the participants in the healthy control group, nor had they ever been. Those who had recently undergone major surgery or blood transfusions were nursing or pregnant, had a history of medication use, or had co-occurring medical disorders were among the exclusion criteria. Written, informed consent was taken by each participant. The research protocol was approved by the Research Ethical Committee, Riphah International University, Faisalabad, Pakistan. Reference No. Res/RcRAHS/23/126 to ensure adherence to accepted ethical guidelines. Together with the complete blood count (CBC), the following parameters were measured: erythrocyte sedimentation rate (ESR), rheumatoid factor (RA factor), and c-reactive protein (CRP). In addition, aspartate transaminase (AST), alanine transaminase (ALT), blood urea, creatinine, total bilirubin, direct bilirubin, indirect bilirubin, alkaline phosphatase (ALP), gamma GT (gGT), and anti-CCP tests were performed to assess organ function. Red vacutainers without anticoagulants were used to collect serum samples from fasting subjects while EDTA-containing vacutainers were used for CBC samples. The equipment underwent quality control testing and was calibrated following the manufacturer's instructions. For serum collection For the collection of serum The blood was collected in a sterile test tube, and the serum was separated by centrifuging 5 ml of each sample for 5 minutes at 3500 rpm. Tests were carried out 24 hours after the collection. A hematology analyzer was used to perform a CBC to evaluate several parameters, such as the RBC, WBC, platelet, Hb level, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), Mean corpuscular hemoglobin concentration (MCHC), and DLC. SLECTRA MINI and ROCHE COBAS c 311, were used to measure the levels of RA factor and CRP in plasma or serum. Enzyme-linked immunosorbent assay (ELISA) was

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utilized to identify the existence of antibodies directed against CCP in blood samples. SPSS version 23.0 was used to analyze the data. For every variable, descriptive statistics (mean ± standard deviation) were computed. The means of the RA group and the healthy control group were compared using the independent t-test. Relationships between independent predictors (such as hemoglobin, WBC count, and ESR) and dependent variables (such as CRP and anti-CCP) were investigated using regression analysis. Boxplots were used to depict only statistically significant parameters for better interpretability, and all statistical tests were set at a significance level of $p<0.05$.

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).

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).

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)	–	–

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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]. 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.

This study was limited by its cross-sectional design, single-center setting, relatively small sample size, and short data collection period, which may restrict generalizability and prevent causal inference. Additionally, reliance on hospital-based participants may introduce selection bias, and longitudinal progression of hearing loss could not be assessed. Future multicenter prospective studies with larger, more diverse populations are recommended to confirm these findings, explore underlying pathophysiological mechanisms, and assess whether early auditory screening should be integrated into diabetic retinopathy management protocols.

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 and Drafting: MF
Review and Editing: MF, MAK, ZF, WA

All authors approved the final manuscript and take responsibility for the integrity of the work

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Conflicts of Interest

All the authors declare no conflict of interest.

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