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ORIGINAL ARTICLE

Spectrum of Ocular Manifestations among Patients with Chronic Kidney Disease: A Hospital-Based Observational Study

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ABSTRACT

Background: *Chronic kidney disease (CKD) is associated with systemic vascular, metabolic, and inflammatory abnormalities that may adversely affect ocular health. This study assessed the spectrum and frequency of ocular manifestations among patients with CKD and their distribution according to CKD stage.* ***Methods & Materials:*** *A hospital-based observational study was conducted among 180 adults with CKD stages 3a–5 attending a tertiary care hospital. Sociodemographic, clinical, and laboratory data were collected, followed by comprehensive ophthalmological examination. Ocular manifestations included cataract, dry eye disease, glaucoma, hypertensive retinopathy, diabetic retinopathy, diabetic macular edema, and optic nerve/optic disc abnormalities. Best-corrected visual acuity (BCVA) was recorded in logMAR. Associations were assessed using chi-square tests and one-way ANOVA.* ***Results:*** *The mean age was 54.7 ± 11.7 years, and 104 (57.8%) participants were male. Overall, 109 (60.6%) patients had at least one ocular manifestation. Cataract was the most common finding (33.3%), followed by hypertensive retinopathy (26.7%), dry eye disease (25.0%), and diabetic retinopathy (20.0%). The prevalence of any ocular manifestation increased significantly from 37.1% in stage 3a to 80.0% in stage 5 CKD (p<0.001). Mean BCVA deteriorated progressively from 0.12 ± 0.14 logMAR in stage 3a to 0.42 ± 0.31 logMAR in stage 5 (p<0.001). Ocular manifestations were significantly associated with age ≥60 years, diabetes, hypertension, and CKD duration ≥5 years. Among patients with diabetes, 36 (43.9%) had diabetic retinopathy; however, its severity was not significantly associated with CKD stage (p=0.168).* ***Conclusion:*** *Ocular abnormalities were common among patients with CKD and increased substantially with advancing disease stage. Routine ophthalmological assessment may support early detection and management of ocular morbidity in CKD.*

Keywords: *Chronic kidney disease; ocular manifestations; cataract; diabetic retinopathy; hypertensive retinopathy; dry eye disease; visual acuity; glaucoma.*

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INTRODUCTION

Chronic kidney disease (CKD) is a major global health problem characterized by persistent abnormalities of kidney structure or function and progressive loss of renal function resulting in considerable systemic morbidity, impaired quality of life, and increased mortality [1]. The eye, namely the retina and choroid, is highly susceptible to the vascular, metabolic, inflammatory, and hemodynamic abnormalities associated with CKD because of its extensive and delicate microvascular network [2-4]. Patients who have chronic kidney disease have an increased risk of developing visual impairment and various ocular disorders, including retinopathy, cataract, macular abnormalities, and other retinal and ocular changes [5]. Visual impairment in chronic kidney disease may occur from multiple interacting factors, including diabetes, hypertension, anemia, uremia, and microvascular dysfunction [3]. Changes in the retina and choroidal microvasculature have been associated with declining renal function, signifying a close relationship between ocular and renal microvascular disease [2,6]. These changes may represent generalized endothelial dysfunction and microvascular injury that occurs during the progression of renal disease. Involvement of the ocular surface has also been observed, including altered tear dynamics and tear protein profiles in patients with chronic renal failure [7]. Several hospital-based investigations have revealed diverse ocular abnormalities in adult and pediatric patients with CKD, underscoring the importance of regular and systematic ophthalmic assessment in this population [8,9]. Further, recent advances in retinal imaging and deep-learning technologies have revealed that retinal photos contain clinically valuable information which can be utilized in the diagnosis of CKD. This implies that the eye examination is a non-invasive procedure that can be used to assess the health status of the kidneys and other microvascular structures in the human body [10-12]. This information highlights the anatomical and physiological link between the kidney and the eye and provides valuable information on the role of the eye as an ancillary tool in the management of renal diseases. In Bangladesh, the evidence is limited, although abnormal eye fundus has been reported among predialytic chronic kidney disease (CKD) patients [13].

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However, there is a scarcity of hospital-based evidence of the overall spectrum, frequency, and pattern of ocular involvement among patients with CKD. Timely recognition of eye abnormalities helps in timely ophthalmic referral, appropriate management, and the prevention of avoidable visual morbidity. Therefore, this study was performed to determine the pattern and frequency of ocular findings among patients suffering from chronic kidney disease in a hospital-based setting that would add to the existing evidence on the manifestations and their importance in CKD.

METHODS & MATERIALS

Study Design and Setting

A hospital-based observational study was conducted among patients with chronic kidney disease (CKD) attending the nephrology and ophthalmology departments of a tertiary care hospital. The study aimed to determine the spectrum of ocular manifestations among patients with CKD and to assess their distribution according to CKD stage and selected clinical characteristics.

Study Population and Eligibility

A total of 180 patients with CKD were included in the study. Patients aged 18 years or older with an established diagnosis of CKD and classified as stage 3a, 3b, 4, or 5 were eligible for inclusion. Patients who declined participation, had incomplete clinical or laboratory information, or had ocular conditions that prevented adequate ophthalmological assessment were excluded.

Data Collection and Clinical Assessment

Sociodemographic and clinical data were collected using a structured data collection form. Variables included age, sex, duration of CKD, CKD stage, diabetes mellitus, hypertension, and anemia. Duration of CKD was recorded in years and categorized as <5 years or ≥5 years for analysis. Anemia was defined as a hemoglobin concentration of <11 g/dL. Relevant laboratory parameters, including serum creatinine, estimated glomerular filtration rate (eGFR), hemoglobin, and serum albumin, were obtained from medical records or routine clinical investigations. CKD stage was determined according to the documented stage and corresponding eGFR.

Ophthalmological Assessment

All participants underwent a comprehensive ophthalmological examination. Best-corrected visual acuity (BCVA) was assessed and recorded in logMAR units. Anterior and posterior segment examinations were performed to identify ocular abnormalities, including cataract, dry eye disease, glaucoma, hypertensive retinopathy, diabetic retinopathy, diabetic macular edema, and optic nerve/optic disc abnormalities. The presence of at least one of these abnormalities was considered an ocular manifestation. Since individual participants could have more than one ocular condition, each manifestation was recorded independently and the corresponding percentages were not considered mutually exclusive.

Among participants with diabetes mellitus, diabetic retinopathy was assessed and categorized as mild non-proliferative diabetic retinopathy (NPDR), moderate NPDR, severe NPDR, or proliferative diabetic retinopathy (PDR) according to clinical ophthalmological assessment.

Outcome Measures

The primary outcome was the presence of any ocular manifestation among patients with CKD. Secondary outcomes included the distribution of individual ocular manifestations, BCVA, and the severity of diabetic retinopathy. The occurrence of ocular manifestations was evaluated in relation to CKD stage, age, diabetes mellitus, hypertension, and duration of CKD.

Statistical Analysis

Data were entered, cleaned, and analyzed using IBM SPSS Statistics version 27. Continuous variables were summarized as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Differences in continuous variables across CKD stages were assessed using one-way analysis of variance (ANOVA), while categorical variables were compared using the chi-square test. The association between selected clinical factors and the presence of any ocular manifestation was evaluated using the chi-square test. The distribution of diabetic retinopathy severity across CKD stages was assessed using the Pearson chi-square test. A two-sided p-value <0.05 was considered statistically significant. Participants with missing information were excluded from the relevant analysis, and no imputation was performed.

Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board/Ethics Committee of the study institution before commencement of data collection. Written informed consent was obtained from all participants before enrollment. Confidentiality of participant information was maintained throughout data collection, analysis, and reporting, and the data were used solely for research purposes.

RESULTS

Sociodemographic and Clinical Characteristics

Table I shows total of 180 patients with chronic kidney disease (CKD) were included in the study. The mean age of the participants was 54.7 ± 11.7 years, with 99 (55.0%) aged 40–59 years and 63 (35.0%) aged ≥60 years. There was a male predominance, with 104 (57.8%) male and 76 (42.2%) female participants. The mean duration of CKD was 4.8 ± 3.2 years, and 69 (38.3%) patients had CKD for ≥5 years. Diabetes mellitus was present in 82 (45.6%) participants, while hypertension was the most frequent comorbidity, affecting 119 (66.1%) patients. Anemia, defined as hemoglobin <11 g/dL, was present in 87 (48.3%) patients. Regarding CKD stage, 35 (19.4%) had stage 3a, 40 (22.2%) had stage 3b, 45 (25.0%) had stage 4, and 60 (33.3%) had stage 5 disease.

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Table I: Sociodemographic and clinical characteristics of the study participants (*n*=180)

Variable	Frequency (%) / Mean ± SD
Age (years)	54.7 ± 11.7
Age group	
<40 years	18 (10.0)
40–59 years	99 (55.0)
≥60 years	63 (35.0)
Sex	
Male	104 (57.8)
Female	76 (42.2)
Duration of CKD (years)	4.8 ± 3.2
≥5 years	69 (38.3)
<5 years	111 (61.7)
Diabetes mellitus	82 (45.6)
Hypertension	119 (66.1)
Anemia (Hb <11 g/dL)	87 (48.3)
CKD stage	
Stage 3a	35 (19.4)
Stage 3b	40 (22.2)
Stage 4	45 (25.0)
Stage 5	60 (33.3)

Clinical and Laboratory Characteristics According to CKD Stage

Table II shows there were significant differences in age and laboratory parameters across the CKD stage. Mean age increased progressively from 48.2 ± 11.3 years in stage 3a to 58.7 ± 10.2 years in stage 5 (p<0.001). Serum creatinine increased significantly with advancing CKD stage, from 1.7 ± 0.4 mg/dL in stage 3a to 5.1 ± 1.3 mg/dL in stage 5 (p<0.001). Conversely, mean eGFR declined progressively from 48.5 ± 6.8 to 11.4 ± 4.3 mL/min/1.73 m^2 across the corresponding stages (p<0.001). Mean hemoglobin also decreased significantly from 11.8 ± 1.3 g/dL in stage 3a to 9.9 ± 1.5 g/dL in stage 5, while serum albumin decreased from 3.9 ± 0.4 to 3.4 ± 0.5 g/dL, respectively (both p<0.001). The proportion of patients with diabetes mellitus increased significantly across CKD stages, from 28.6% in stage 3a to 56.7% in stage 5 (p=0.043). Although hypertension was more frequent in advanced CKD, the difference across stages was not statistically significant (51.4%, 62.5%, 71.1%, and 73.3%; p=0.091).

Table II: Clinical and laboratory characteristics according to CKD stage

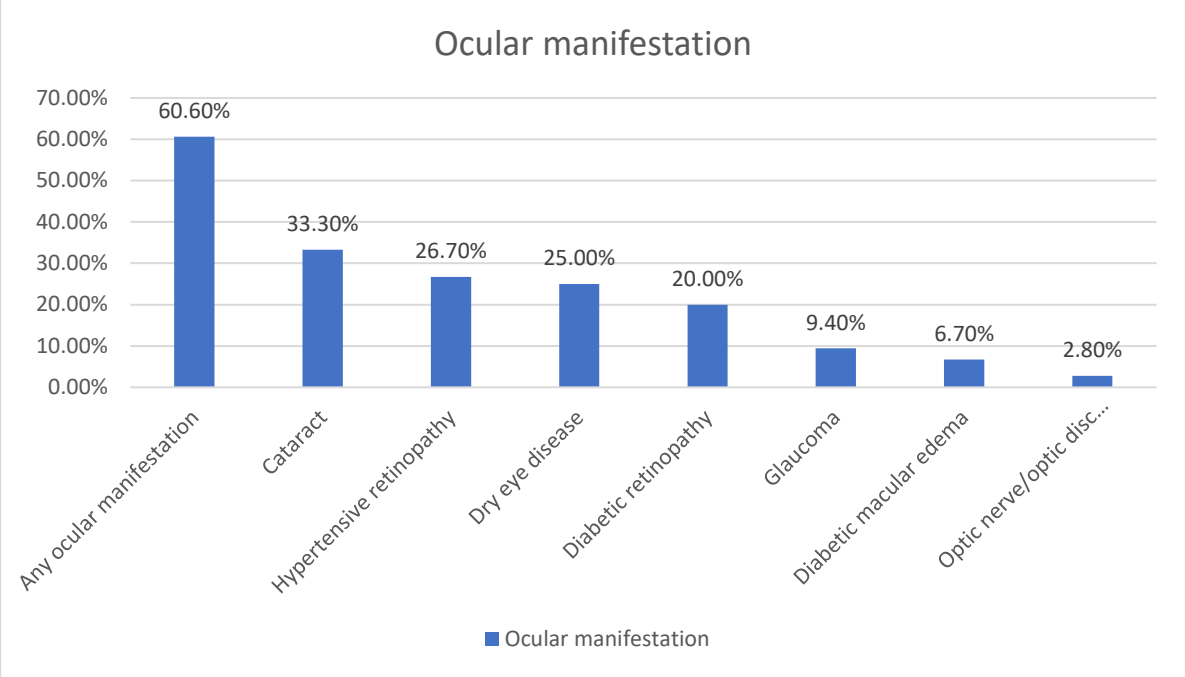
Variable	Stage 3a (n=35)	Stage 3b (n=40)	Stage 4 (n=45)	Stage 5 (n=60)	p-value*
Age (years)	48.2 ± 11.3	51.6 ± 10.8	55.1 ± 12.1	58.7 ± 10.2	<0.001
Serum creatinine (mg/dL)	1.7 ± 0.4	2.3 ± 0.5	3.4 ± 0.8	5.1 ± 1.3	<0.001
eGFR (mL/min/1.73 m^2)	48.5 ± 6.8	37.2 ± 5.7	24.1 ± 6.1	11.4 ± 4.3	<0.001
Hemoglobin (g/dL)	11.8 ± 1.3	11.4 ± 1.2	10.8 ± 1.4	9.9 ± 1.5	<0.001
Serum albumin (g/dL)	3.9 ± 0.4	3.8 ± 0.4	3.6 ± 0.5	3.4 ± 0.5	<0.001
Diabetes mellitus, n (%)	10 (28.6)	16 (40.0)	22 (48.9)	34 (56.7)	0.043
Hypertension, n (%)	18 (51.4)	25 (62.5)	32 (71.1)	44 (73.3)	0.091

**One-way ANOVA for continuous variables and chi-square test for categorical variables.*

Spectrum of Ocular Manifestations

Figure 1 illustrate the spectrum of ocular manifestations among the 180 study participants. Overall, 109 (60.6%) patients had at least one ocular manifestation. Cataract was the most frequently observed condition (60, 33.3%), followed by hypertensive retinopathy (48, 26.7%), dry eye disease (45, 25.0%), and diabetic retinopathy (36, 20.0%). Glaucoma was present in 17 (9.4%) patients, while diabetic macular edema and optic nerve/optic disc abnormalities were observed in 12 (6.7%) and 5 (2.8%) patients, respectively. Percentages were not mutually exclusive because individual patients could have more than one ocular manifestation.

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Multiple ocular manifestations could be present in the same patient; therefore, percentages do not sum to 100%.

Figure 1: Spectrum of ocular manifestations among patients with CKD (*n*=180).

Ocular Manifestations and Visual Acuity According to CKD Stage

Table III shows the frequency of any ocular manifestation increased significantly with advancing CKD stage. Ocular manifestations were present in 13 (37.1%) patients with stage 3a, 19 (47.5%) with stage 3b, 29 (64.4%) with stage 4, and 48 (80.0%) with stage 5 CKD (χ^2=20.67, p<0.001). The frequency of cataract increased descriptively from 22.9% in stage 3a to 40.0% in stage 5, although the difference was not statistically significant (p=0.268). Similarly, hypertensive retinopathy increased from 14.3% to 36.7% (p=0.077), while dry eye disease increased from 17.1% to 30.0% (p=0.541). Diabetic retinopathy was observed in 11.4%, 17.5%, 22.2%, and 25.0% of patients across stages 3a, 3b, 4, and 5, respectively, without a statistically significant difference (p=0.417). Glaucoma was identified in 5.7%, 7.5%, 11.1%, and 11.7%, respectively (p=0.744). Mean best-corrected visual acuity (BCVA), expressed in logMAR, deteriorated progressively with increasing CKD stage. Mean BCVA was 0.12 ± 0.14 logMAR in stage 3a, 0.18 ± 0.18 in stage 3b, 0.29 ± 0.23 in stage 4, and 0.42 ± 0.31 in stage 5, with a statistically significant difference across stages (p<0.001) (*Table III*).

Table III: Ocular manifestations and visual acuity according to CKD stage

Ocular finding	Stage 3a (n=35),n(%)	Stage 3b (n=40),n(%)	Stage 4 (n=45),n(%)	Stage 5 (n=60),n(%)	p-value
Any ocular manifestation	13 (37.1)	19 (47.5)	29 (64.4)	48 (80.0)	<0.001
Cataract	8 (22.9)	11 (27.5)	17 (37.8)	24 (40.0)	0.268
Hypertensive retinopathy	5 (14.3)	8 (20.0)	13 (28.9)	22 (36.7)	0.077
Dry eye disease	6 (17.1)	9 (22.5)	12 (26.7)	18 (30.0)	0.541
Diabetic retinopathy	4 (11.4)	7 (17.5)	10 (22.2)	15 (25.0)	0.417
Glaucoma	2 (5.7)	3 (7.5)	5 (11.1)	7 (11.7)	0.744
Mean BCVA, logMAR	0.12 ± 0.14	0.18 ± 0.18	0.29 ± 0.23	0.42 ± 0.31	<0.001

Factors Associated with Ocular Manifestations

Table IV shows several clinical factors were significantly associated with the presence of at least one ocular manifestation. Patients aged ≥60 years had a significantly higher frequency of ocular manifestations than those aged <60 years (76.2% vs. 52.1%, p=0.003). Similarly, ocular manifestations were more frequent among patients with diabetes mellitus than among those without diabetes (73.2% vs. 50.0%, p=0.003). A significant association was also observed with hypertension. Ocular manifestations were present in 69.7% of hypertensive patients, compared with 42.6% of those without hypertension (p<0.001). Patients with CKD duration ≥5 years had a higher frequency of ocular manifestations than those with CKD duration <5 years (78.3% vs. 49.5%, p<0.001). Likewise, ocular manifestations were significantly more common among patients with stage 5 CKD than among those with stages 3–4 disease (80.0% vs. 50.8%, p<0.001).

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Table IV: Association between selected clinical factors and presence of any ocular manifestation

Factor	Ocular manifestation present, n (%)	Ocular manifestation absent, n (%)	p-value
Age ≥60 years	48/63 (76.2)	15/63 (23.8)	0.003
Age <60 years	61/117 (52.1)	56/117 (47.9)	
Diabetes mellitus	60/82 (73.2)	22/82 (26.8)	0.003
No diabetes	49/98 (50.0)	49/98 (50.0)	
Hypertension	83/119 (69.7)	36/119 (30.3)	<0.001
No hypertension	26/61 (42.6)	35/61 (57.4)	
CKD duration ≥5 years	54/69 (78.3)	15/69 (21.7)	<0.001
CKD duration <5 years	55/111 (49.5)	56/111 (50.5)	
CKD stage 5	48/60 (80.0)	12/60 (20.0)	<0.001
CKD stage 3–4	61/120 (50.8)	59/120 (49.2)	

Chi-square test; p<0.05 considered statistically significant.

Distribution of Diabetic Retinopathy Severity

Table V shows among the 82 patients with diabetes mellitus, 36 (43.9%) had diabetic retinopathy. Mild non-proliferative diabetic retinopathy (NPDR) was the most common category, accounting for 16 (44.4%) cases, followed by moderate NPDR in 10 (27.8%), severe NPDR in 6 (16.7%), and proliferative diabetic retinopathy (PDR) in 4 (11.1%) cases. The distribution of diabetic retinopathy severity varied across CKD stages. In stage 3a, all four patients with diabetic retinopathy had mild NPDR. Among stage 3b patients, 4 (57.1%) had mild NPDR, 2 (28.6%) had moderate NPDR, and 1 (14.3%) had severe NPDR. In stage 4, 5 (50.0%) had mild NPDR, 3 (30.0%) had moderate NPDR, and 2 (20.0%) had severe NPDR. Among stage 5 patients, 3 (20.0%) had mild NPDR, 5 (33.3%) had moderate NPDR, 3 (20.0%) had severe NPDR, and 4 (26.7%) had PDR.

Table V: Distribution of diabetic retinopathy severity among patients with diabetic retinopathy according to CKD stage

Severity of diabetic retinopathy	Stage 3a (n=4),n(%)	Stage 3b (n=7),n(%)	Stage 4 (n=10),n(%)	Stage 5 (n=15),n(%)	Total (n=36),n(%)	χ^2, p-value
Mild NPDR	4 (100.0)	4 (57.1)	5 (50.0)	3 (20.0)	16 (44.4)	
Moderate NPDR	0 (0.0)	2 (28.6)	3 (30.0)	5 (33.3)	10 (27.8)	
Severe NPDR	0 (0.0)	1 (14.3)	2 (20.0)	3 (20.0)	6 (16.7)	
Proliferative DR	0 (0.0)	0 (0.0)	0 (0.0)	4 (26.7)	4 (11.1)	
Total	4 (100.0)	7 (100.0)	10 (100.0)	15 (100.0)	36 (100.0)	
Overall						12.872, 0.168

Pearson chi-square test; χ^2=12.872, df=9, p=0.168.

Thus, the proportion of advanced diabetic retinopathy categories was descriptively higher among patients with advanced CKD, and all four cases of PDR were observed in patients with stage 5 CKD. However, the overall association between CKD stage and diabetic retinopathy severity was not statistically significant (χ^2=12.87, p=0.168) (*Table V*).

DISCUSSION

In this hospital-based cohort, 60.6% of patients had at least one ocular manifestation. Cataract (33.3%) was most common, followed by hypertensive retinopathy (26.7%), dry eye (25.0%) and diabetic retinopathy (20.0%). This substantial burden is consistent with the Singapore Epidemiology of Eye Disease analysis, in which ocular disease was more prevalent among people with CKD than among those without it (84.7% vs 54.3%); differences in population, setting and outcome definitions limit direct comparison [14].

The proportion with any ocular manifestation increased from 37.1% in stage 3a to 80.0% in stage 5, alongside progressively poorer visual acuity. The supplied studies do not provide directly comparable stage-specific estimates for overall ocular disease or visual acuity. Older age may contribute to the observed burden: the cohort's mean age was 54.7 years, and ocular findings were more frequent in participants aged ≥60 years. Minutolo et al. discuss the high prevalence of CKD in older populations, while Hill et al.'s global meta-analysis describes CKD as common, particularly at stage 3; neither study reports ocular outcomes [15,16].

Diabetic retinopathy affected 43.9% of participants with diabetes. A Korean national survey found an adjusted association between CKD and diabetic retinopathy [17]. In a Taiwanese cohort of 4,050 diabetic patients with CKD, retinopathy—particularly proliferative disease—was associated with CKD progression [18]. However, the present study's increase in retinopathy prevalence across CKD stages and its trend toward more severe disease were not statistically significant. This is comparable to the 100-patient study by Mian et al., which also found a nonsignificant trend toward more advanced retinopathy with higher CKD stage [19]. Small numbers within severity categories may limit inference.

The high prevalence of hypertension and diabetes in this cohort is relevant context. Wang et al. describe both conditions as leading CKD causes in North and East Asia, although that review does not assess eye findings [20]. Overall, the results support attention to ocular assessment in CKD, while the cross-sectional design and nonsignificant stage-specific comparisons preclude conclusions that CKD progression causes individual ocular disorders. The supplied sources do not identify the study's country, so a country-specific national comparison cannot be established.

CONCLUSION

CKD was associated with a substantial burden of ocular abnormalities, with 60.6% of participants having at least one ocular manifestation. Cataract, hypertensive retinopathy, dry eye disease, and diabetic retinopathy were the most frequently observed findings. The prevalence of any ocular manifestation increased significantly with advancing CKD stage and was also associated with older age, diabetes, hypertension, and longer CKD duration. Visual acuity progressively worsened across CKD stages. Although more advanced diabetic retinopathy was observed among patients with advanced CKD, the association

between CKD stage and retinopathy severity was not statistically significant. These findings support the importance of systematic ophthalmological assessment as part of the comprehensive management of patients with CKD, particularly those with advanced disease and multiple vascular risk factors.

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