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Original Research Article

DIALYSIS-LINKED OCULAR INJURY MAPPING IN CHRONIC KIDNEY DISEASE: A CROSS-SECTIONAL STUDY FROM SOUTH INDIAN TERTIARY CENTRE

Vamshi Chakra Sriram[1], Swathi Taduri[2]

[1]Assistant Professor, Department of Ophthalmology, Government Medical College, Jagtial, Telangana, India
[2]Assistant Professor, Department of Pathology, Singareni Institute of Medical Sciences, Ramagundam, Telangana, India

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Corresponding Author:
Dr. Vamshi Chakra Sriram,
Email: vamshichakra87@gmail.com

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ABSTRACT

Background: Chronic kidney disease (CKD) and the eye share microvascular, inflammatory and metabolic pathways. Patients receiving maintenance haemodialysis may develop ocular surface disease, retinopathy, lens opacity, optic neuropathy and calcific corneal or conjunctival changes. Objective: To assess the prevalence, pattern, and predictors of ocular manifestations among CKD patients on maintenance hemodialysis. **Materials and Methods:** This cross-sectional study was conducted in the Department of Ophthalmology, Government Medical College, Jagtial, from November 2025 to April 2026. Adults with CKD receiving maintenance haemodialysis for at least 6 months were enrolled consecutively. Participants underwent best-corrected visual acuity assessment, slit-lamp biomicroscopy, intraocular pressure measurement and dilated fundus examination. Demographic details, dialysis duration, diabetes, hypertension, haemoglobin, serum calcium and phosphate were recorded. Chi-square tests and multivariable logistic regression were used for analysis. **Result:** Among 160 participants, mean age was 46.2 +/- 16.0 years and 81 (50.6%) were male. At least one ocular manifestation was detected in 79 (49.4%) patients. The mean pre-dialysis intraocular pressure (IOP) was 15.1 ± 2.8 mmHg. The most common findings were dry eye in 42 (26.3%), hypertensive retinopathy in 35 (21.9%), diabetic retinopathy in 28 (17.5%), cataract in 23 (14.4%), optic neuropathy in 15 (9.4%), macular oedema in 13 (8.1%) and conjunctival/corneal calcification in 12 (7.5%). Ocular manifestations were significantly associated with diabetes (68.2% vs. 36.2%, p<0.001) and dialysis duration >3 years (60.7% vs. 42.4%, p=0.038). On logistic regression, diabetes (OR 3.91, 95% CI 1.95-7.88, p<0.001) and dialysis duration >3 years (OR 2.25, 95% CI 1.11-4.57, p=0.025) remained independent predictors. **Conclusion:** Ocular morbidity was frequent among haemodialysis patients, with dry eye and retinopathy predominating. Routine ophthalmic screening integrated with dialysis care may improve early diagnosis and reduce preventable visual impairment.

INTRODUCTION

Chronic kidney disease (CKD) is a long-term systemic disorder with rising global burden, high cardiovascular risk and progressive need for renal replacement therapy.[1,2] Its impact is not restricted to renal function. The kidney and eye have shared microvascular architecture, endothelial dependence and inflammatory pathways; therefore, renal dysfunction may coexist with retinal, choroidal and ocular surface disease.[3] Several ocular manifestations have been described across renal disorders, including hypertensive retinopathy, diabetic retinopathy, cataract, retinal haemorrhage, macular oedema, corneal deposits and optic neuropathy.[4]

Haemodialysis introduces additional ocular stressors. Rapid changes in plasma osmolarity, oncotic pressure and urea gradients can influence aqueous humour dynamics and intraocular pressure, although net pressure changes vary between studies.[5,6] Dialysis-related fluid shifts may also alter ocular perfusion and choroidal thickness, potentially affecting the optic nerve and retina in susceptible patients.[5] Ocular surface disturbance is common, as reductions in tear break-up time, Schirmer test values and tear meniscus parameters have been described among haemodialysis recipients.[5,7]

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Mineral-bone disorder in CKD may affect the cornea and conjunctiva. Hyperphosphatemia and an increased calcium-phosphate product can promote calcific deposition, producing conjunctival calcification or band keratopathy, particularly in patients exposed to prolonged dialysis.[8] At the same time, diabetes and hypertension remain dominant shared drivers of both kidney failure and retinal disease.[3,4] These overlapping mechanisms make it difficult to distinguish lesions caused by CKD itself from lesions caused by comorbidity or dialysis exposure.

The convergence of renal and ocular disease in CKD is also evident at the histopathological level. In diabetic nephropathy, glomerular and tubular basement membrane thickening, mesangial matrix expansion and pericapillary pericyte loss are paralleled in the retina by capillary basement membrane thickening and pericyte dropout, reflecting a common microvascular lesion driven by hyperglycaemia-induced matrix accumulation.[9] Similarly, hypertensive nephrosclerosis is characterised by arteriolar hyalinosis, fibroelastic intimal hyperplasia and ischemic glomerulosclerosis, changes that mirror the arteriolar wall thickening, hyaline sclerosis and arteriovenous nicking seen on fundoscopy in hypertensive retinopathy.[10] Metastatic calcification, driven by an elevated calcium-phosphate product in CKD-mineral bone disorder, deposits calcium salts in both the vascular media and ocular tissue such as the conjunctiva, cornea and sclera, producing band keratopathy or conjunctival/corneal calcification that is histologically analogous to vascular calcification elsewhere in the body.[8] These parallel tissue-level processes provide a pathological basis for using ocular findings as an indirect marker of systemic microvascular and mineral disease burden in CKD, beyond their value as isolated ophthalmic diagnoses.

Despite this biologic plausibility, routine ophthalmic screening is not uniformly embedded in haemodialysis care. Recent work on eye-care needs in CKD has shown a high burden of undetected disease, low awareness and increased referral requirements, particularly among patients with advanced CKD or dialysis dependence.[11,12] Population-level evidence further indicates that CKD is associated with incident visual impairment and age-related eye disease, highlighting the need for preventive surveillance.[13,14] Data from Indian government medical colleges remain limited, especially in semi-urban dialysis populations. This study was therefore conducted to estimate the prevalence and spectrum of ocular manifestations among CKD patients on maintenance haemodialysis at Government Medical College, Jagtial, and to evaluate associations with diabetes, hypertension and dialysis duration.

MATERIALS AND METHODS

Study design, setting and duration: This hospital-based cross-sectional observational study was carried out in the Department of Ophthalmology, Government Medical College, Jagtial, in collaboration with the haemodialysis unit. The study period extended from November 2025 to April 2026. Institutional ethics committee approval was obtained before enrolment, and written informed consent was taken from all participants.

Sample size calculation: The sample size was estimated using the single-proportion formula: n = Z^2 x p(1-p) / d^2. Because prevalence estimates of ocular manifestations among haemodialysis patients vary widely, a conservative prevalence (p) of 50% was used, with 95% confidence (Z=1.96) and absolute precision (d) of 8%. The minimum required sample was 150. Allowing for incomplete records and non-response, 160 patients were enrolled.

Inclusion criteria

Patients were included if they were aged 18 years or older, had a documented diagnosis of CKD, were receiving maintenance haemodialysis for at least 6 months, were clinically stable enough to undergo ophthalmic examination, and provided written informed consent.

Exclusion criteria

Patients were excluded if they had ocular trauma or ocular surgery within the preceding 12 months, active ocular infection, known congenital ocular anomaly, inherited retinal dystrophy, severe media opacity precluding fundus assessment, prior renal transplantation, peritoneal dialysis, pregnancy, active malignancy, inability to cooperate with examination, or refusal to participate.

Data collection and ophthalmic evaluation: Demographic variables, duration of haemodialysis, diabetes mellitus, hypertension, haemoglobin, serum calcium and serum phosphate were collected from case records and patient interviews. Dialysis duration was categorised as <=3 years or >3 years. Best-corrected visual acuity was assessed using a Snellen chart and categorised as normal, mild impairment, moderate impairment or severe impairment. Slit-lamp biomicroscopy was performed to evaluate conjunctival/corneal calcification, tear film status and cataract. Intraocular pressure was measured using Goldmann applanation tonometry before dialysis. Dilated fundus examination was performed using indirect ophthalmoscopy and slit-lamp biomicroscopy with a 90-dioptre lens. Ocular manifestations recorded included dry eye, hypertensive retinopathy, diabetic retinopathy, cataract, optic neuropathy, macular oedema and conjunctival/corneal calcification. Hypertensive retinopathy was graded using the Keith-Wagener-Barker classification. Diabetic retinopathy was graded according to the ETDRS/International Clinical Diabetic Retinopathy severity scale. Cataract was graded using LOCS III. A patient was classified

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as having ocular manifestation if at least one of these findings was present.

Statistical analysis: Data were entered in Microsoft Excel and analysed using SPSS version 26. Continuous variables were expressed as mean +/- standard deviation. Categorical variables were expressed as frequencies and percentages. Associations between ocular manifestations and diabetes, hypertension, and dialysis duration were assessed with chi-square tests. Chi-square test with Yates' continuity correction was applied for 2×2 comparisons. Multivariable logistic regression was used to identify independent predictors of ocular manifestations. Results are reported as odds ratios (OR) with 95% confidence intervals (CI). A two-tailed p value less than 0.05 was considered statistically significant.

RESULTS

A total of 160 haemodialysis patients were evaluated. The mean age was 46.2 +/- 16.0 years. The age distribution was <40 years in 61 (38.1%), 40-60 years in 61 (38.1%) and >60 years in 38 (23.8%). There were 81 males (50.6%) and 79 females (49.4%). Haemodialysis duration was <=3 years in 99 (61.9%) and >3 years in 61 (38.1%). Diabetes mellitus was present in 66 (41.3%) and hypertension in 101 (63.1%). Mean haemoglobin was 10.7 +/- 1.4 g/dL, serum calcium was 8.8 +/- 0.8 mg/dL and serum phosphate was 5.6 +/- 1.0 mg/dL [Table 1].

At least one ocular manifestation was observed in 79 (49.4%) participants. Dry eye was the most frequent finding, occurring in 42 (26.3%) patients. Hypertensive retinopathy was present in 35 (21.9%), diabetic retinopathy in 28 (17.5%), cataract in 23 (14.4%), optic neuropathy in 15 (9.4%), macular oedema in 13 (8.1%) and conjunctival/corneal calcification in 12 (7.5%) [Table 2]. Multiple ocular findings occurred in 28 (17.5%) participants. Visual acuity was normal in 61 (38.1%), mildly impaired in 47 (29.4%), moderately impaired in 36 (22.5%) and severely impaired in 16 (10.0%) (Table 4). The mean pre-dialysis intraocular pressure (IOP) was 15.1 ± 2.8 mmHg.

Ocular manifestations were more frequent among patients with diabetes mellitus than among non-diabetic patients (45/66, 68.2% vs. 34/94, 36.2%; chi-square=14.641, p<0.001). Among patients with hypertension, 54/101 (53.5%) had ocular manifestations compared with 25/59 (42.4%) without hypertension; this association was not statistically significant (p=0.234). Ocular manifestations were also more frequent among patients receiving haemodialysis for >3 years than among those receiving haemodialysis for <=3 years (37/61, 60.7% vs. 42/99, 42.4%; chi-square=4.316, p=0.038) [Table 3].

Multivariable logistic regression identified diabetes mellitus as an independent predictor of ocular manifestations (OR 3.91, 95% CI 1.95-7.88, p<0.001). Dialysis duration >3 years was also independently associated with ocular manifestations (OR 2.25, 95% CI 1.11-4.57, p=0.025). Hypertension (OR 1.47, 95% CI 0.72-3.01, p=0.287), age >60 years (OR 1.17, 95% CI 0.53-2.62, p=0.697), haemoglobin (OR 0.88, 95% CI 0.68-1.14, p=0.325), serum calcium (OR 0.68, 95% CI 0.44-1.05, p=0.079) and serum phosphate (OR 1.13, 95% CI 0.81-1.57, p=0.469) were not statistically significant predictors [Table 5].

Table 1: Demographic and clinical characteristics of study participants (n=160).

Variable	Category	n (%) / mean ± SD
Age group (years)	<40	61 (38.1)
	40-60	61 (38.1)
	>60	38 (23.8)
Sex	Male	81 (50.6)
	Female	79 (49.4)
Duration of haemodialysis	<=3 years	99 (61.9)
	>3 years	61 (38.1)
Diabetes mellitus	Present	66 (41.3)
	Absent	94 (58.7)
Hypertension	Present	101 (63.1)
	Absent	59 (36.9)
Haemoglobin (g/dL) Mean ± SD		10.7 ± 1.4
Serum calcium (mg/dL) Mean ± SD		8.8 ± 0.8
Serum phosphate (mg/dL) Mean ± SD		5.6 ± 1.0

Table 2: Spectrum of ocular manifestations among CKD patients on haemodialysis (n=160).

Ocular manifestation	n	%
Dry eye	42	26.3
Hypertensive retinopathy	35	21.9
Diabetic retinopathy	28	17.5
Cataract	23	14.4
Optic neuropathy	15	9.4
Macular oedema	13	8.1
Conjunctival/corneal calcification	12	7.5

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Table 3: Comparative analysis of systemic factors and ocular manifestations.

Variable	Category	Ocular manifestations present	Ocular manifestations absent	p value
Diabetes mellitus	Present (n=66)	45 (68.2)	21 (31.8)	<0.001
	Absent (n=94)	34 (36.2)	60 (63.8)	
Hypertension	Present (n=101)	54 (53.5)	47 (46.5)	0.234
	Absent (n=59)	25 (42.4)	34 (57.6)	
Duration of haemodialysis	>3 years (n=61)	37 (60.7)	24 (39.3)	0.038
	<3 years (n=99)	42 (42.4)	57 (57.6)	

Table 4: Visual acuity distribution among study participants (n=160).

Visual acuity category	n	%
Normal	61	38.1
Mild impairment	47	29.4
Moderate impairment	36	22.5
Severe impairment	16	10.0

Table 5: Multivariable logistic regression for predictors of ocular manifestations.

Predictor	Odds ratio (OR)	95% CI	p value
Diabetes mellitus	3.91	1.95-7.88	<0.001
Hypertension	1.47	0.72-3.01	0.287
Duration >3 years	2.25	1.11-4.57	0.025
Age >60 years	1.17	0.53-2.62	0.697
Haemoglobin (per g/dL)	0.88	0.68-1.14	0.325
Serum calcium (per mg/dL)	0.68	0.44-1.05	0.079
Serum phosphate (per mg/dL)	1.13	0.81-1.57	0.469

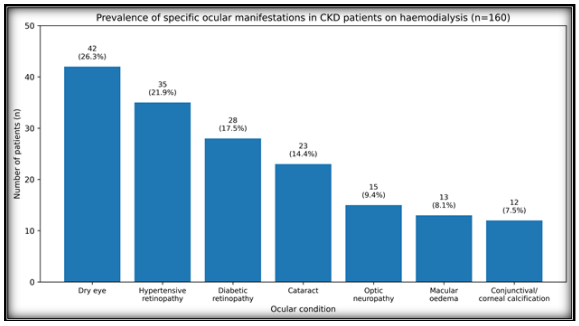

Figure 1: Prevalence of specific ocular manifestations in CKD patients on haemodialysis.

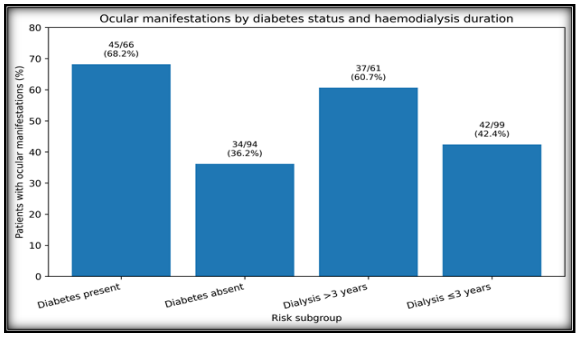

Figure 2: Ocular manifestations by diabetes status and haemodialysis duration.

DISCUSSION

This study demonstrates that ocular morbidity is common among CKD patients on maintenance haemodialysis. Nearly half of the participants had at least one ocular manifestation, and dry eye, hypertensive retinopathy, diabetic retinopathy and cataract were the dominant findings. The study was conducted because ocular assessment is not routinely integrated into dialysis care despite biologically plausible renal-ocular interactions and accumulating evidence of visual morbidity in CKD.[3,4,11]

The prevalence of any ocular manifestation in our study was 49.4%. Kafle et al. reported ocular abnormalities in 83.33% of 150 eyes among patients undergoing maintenance haemodialysis, with cataract and conjunctival calcification among common findings.[15] Shatnawi et al. reported hypertensive retinopathy in 24.4%, retinal haemorrhages in 17.1%, cataracts in 14.6% and macular oedema in 7.3% among CKD patients.[16] Our rate of hypertensive retinopathy (21.9%) was similar to Shatnawi et al., while cataract prevalence (14.4%) was nearly identical. The lower rate of conjunctival/corneal calcification in our cohort (7.5%) compared with several dialysis cohorts may reflect differences in dialysis vintage, mineral metabolism or ascertainment methods.[8,15]

Dry eye was the most frequent finding in our cohort (26.3%). This aligns with the haemodialysis literature describing reduced tear break-up time, reduced tear secretion and ocular surface instability.[5,7] Protsyk and Lacorzana noted that haemodialysis sessions may affect tear parameters, intraocular pressure in susceptible eyes, choroidal thickness and ocular perfusion, supporting the need to standardise timing of ophthalmic examinations in dialysis patients.[5] Ahuja et al. similarly emphasised ocular surface changes in dialysis populations and showed that clinically silent abnormalities may be present.[7]

Diabetes was the strongest independent predictor of ocular manifestations in our study (OR 3.91, 95% CI 1.95-7.88). This finding is clinically expected because diabetes simultaneously drives CKD progression and retinal microvascular injury. Liem et al. reported high ocular disease burden and referral needs among CKD patients, reinforcing the importance of targeted eye-care pathways.[12]

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Population-based evidence also shows that CKD is associated with incident visual impairment and age-related eye disease, suggesting that the ocular burden is not limited to hospital-based dialysis cohorts.[13,14] Dialysis duration >3 years was independently associated with ocular manifestations (OR 2.25, 95% CI 1.11-4.57). This finding is consistent with the concept that cumulative exposure to osmotic shifts, perfusion changes and mineral imbalance increases ocular risk. Hong et al. reported an association between haemodialysis duration and retinal nerve fibre layer thinning, suggesting possible cumulative neuro-retinal effects.[17] Widjaja et al. also described major ocular abnormalities among haemodialysis patients, supporting the need for systematic ophthalmic evaluation in dialysis settings.[18]

These associations also have a histopathological correlate. The dominance of diabetes as an independent predictor is consistent with the shared basement membrane pathology underlying diabetic nephropathy and retinopathy,[9] while the association with longer dialysis duration parallels the cumulative arteriolar hyalinosis and vascular calcification described in hypertensive nephrosclerosis and CKD-mineral bone disorder.[8,10] This shared tissue-level pathology reinforces the rationale for combined ophthalmology-nephrology-pathology evaluation in long-standing CKD.

The clinical implications are direct. Haemodialysis units should consider routine ocular screening at baseline and at regular intervals, especially for patients with diabetes and those on dialysis for more than three years. Early identification of dry eye can improve comfort and adherence to care, while timely detection of retinopathy, macular oedema, cataract and optic neuropathy may prevent irreversible visual loss. Ophthalmology-nephrology collaboration is particularly important because ocular signs may reflect systemic vascular burden and dialysis-related complications.

This study has limitations. It was conducted at a single centre and used a cross-sectional design, so causal relationships cannot be established. Dry eye was clinically assessed and not supplemented by tear osmolarity or inflammatory biomarkers. Optical coherence tomography and optical coherence tomography angiography were not routinely performed, which may have underestimated subtle macular and optic nerve changes. The sample size was adequate for primary prevalence estimates but may not have been sufficient to detect weaker associations with mineral markers. Future multicentre longitudinal studies should incorporate OCT, ocular surface biomarkers, dialysis prescription variables and serial follow-up to clarify mechanisms and guide screening intervals.

CONCLUSION

Ocular manifestations were common among CKD patients receiving maintenance haemodialysis at Government Medical College, Jagtial. Dry eye, hypertensive retinopathy, diabetic retinopathy and cataract were the leading manifestations. Diabetes mellitus and haemodialysis duration greater than three years independently predicted ocular disease. These findings support incorporation of routine ophthalmic screening into dialysis care, with priority for diabetic patients and patients with longer dialysis exposure. Early recognition and treatment of ocular morbidity may reduce avoidable visual impairment and improve quality of life in this high-risk group.

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