

Evaluation Of Changes In Visual Functions (Color Vision And Amsler Grid) In Patients With Chronic Kidney Disease Stages 3-5

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ABSTRACT

Background:

Chronic Kidney Disease (CKD) is a systemic condition with multi-organ involvement, including subtle yet significant effects on visual function. Visual impairments such as colour vision deficiency and central visual field distortion may occur in CKD.

Methods:

A cross-sectional observational study was conducted on 85 CKD patients (stages III–V) over six months. Visual function was assessed using the Amsler Grid for central field defects and Ishihara plates for colour vision. CKD staging was determined using estimated glomerular filtration rate (eGFR) as per KDIGO guidelines. Statistical analysis included chi-square tests to examine associations between CKD stage and visual findings.

Results:

Of the 85 patients, 30 (35.29%) exhibited abnormal Amsler Grid responses, with a non-significant association across CKD stages ($p = 0.097$). However, color vision deficiency was noted in 32 patients (37.65%), showing a statistically significant association with CKD progression ($p = 0.00034$). Colour vision impairment was most prominent in stage V patients, indicating a possible link between worsening renal function and neuro-ophthalmic dysfunction.

Conclusion:

The study demonstrates a significant correlation between advanced CKD stages and colour vision abnormalities, with a potential trend toward central visual field changes. These findings reinforce the need for incorporating basic visual screening tools in CKD care to detect early neuro-ophthalmic changes. Early ophthalmic referrals may help preserve quality of life in patients with renal impairment.

Keywords: Chronic kidney disease; Visual function; Colour vision deficiency; Amsler Grid; Ishihara plates; CKD stages.

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INTRODUCTION

Chronic Kidney Disease (CKD) is a chronic systemic disease, which involves gradual loss of function of the kidneys, eventually resulting in morbidity and mortality

if left untreated. It is a condition of worldwide public health significance, as it affects millions of people globally, and is accompanied by systemic complications, including those affecting the heart,

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brain, and hormone glands. Besides systemic consequences, chronic kidney disease also results in certain ocular complications. Visual impairments, in terms of reduction of the capacity for central vision and color perception, can occur in patients suffering from CKD as a consequence of various factors including metabolic abnormalities, toxic effects of uremic substances, oxidative stress, and changes in the microvasculature.^[1,2]

Despite the anatomical differences between the kidney and eye, these systems possess common physiological and pathological relationships. Each of the organs is well-vascularized, requiring tightly controlled microvascular flow for proper functioning. The kidneys and the eye, especially the retina, have common structural components, autoregulatory properties, and vulnerability to vascular insults caused by systemic diseases, such as CKD.^[3] Thus, any disorder causing a negative impact on the vasculature and blood supply within the body is expected to have identical effects on the eyes.

The retina and choroid represent some of the most metabolically active structures in the human body, being especially vulnerable to disturbances in systemic circulation and oxygen supply. As a consequence of chronic exposure to uremic toxins and proinflammatory substances, CKD patients might develop endothelial dysfunction, capillary loss, and autoregulatory abnormalities in their retinal vasculature. Such abnormalities do not necessarily manifest as clinical symptoms at first but become evident as slight functional abnormalities detectable with advanced visual testing techniques. Numerous studies indicate that CKD patients may present with initial changes in their vision without obvious clinical findings in regular eye examination procedures.^[4,5]

There are many approaches that can be used to evaluate the status of the visual system. The two most straightforward ways of doing so include using an Amsler Grid and colour vision tests, which are both cheap and simple. The Amsler Grid test is specifically beneficial for diagnosing such defects as distortions, scotomas, etc., occurring in the macular field, thus indicating the involvement of the retina. Likewise, colour vision tests allow detecting the detection of abnormalities of colour perception by photoreceptors and neurons responsible for colour vision. Both methods have one great advantage – they are easy to perform without the need for any advanced

equipment.^[6] This makes them excellent candidates for identifying early-stage visual abnormalities in CKD patients who do not have symptoms.

Earlier works have shown that patients suffering from CKD, especially advanced cases, display multiple visual dysfunctions such as loss of contrast sensitivity, colour perception dysfunction, and visual acuity loss. This is believed to be caused by metabolic changes, blood circulation problems, and neuroretinal impairment caused by chronic renal failure.^[7,8] In addition, visual dysfunction has been observed in dialysis patients and chronic kidney disease patients, which implies an accumulative impact of the duration and severity of CKD on the eye.

Impaired colour vision is often seen in association with underlying disorders, including diabetes mellitus and hypertension. Both diseases are frequently noted in patients suffering from CKD. They are likely to affect retinal health and lead to visual disorders. It makes it difficult to distinguish the effects caused by CKD alone. On the other hand, recent findings prove that CKD may be considered an independent risk factor for ophthalmic diseases irrespective of whether the patient suffers from diabetes mellitus and hypertension. That means there are pathophysiological factors typical for CKD that affect visual ability.^[9]

Apart from colour vision impairments, there have been reports on the presence of Amsler Grid abnormalities among CKD patients. This is indicative of early involvement of either the macula or the optic nerve, which might occur before clinically diagnosed retinal disease. The presence of these abnormalities underscores the necessity of using functional testing methods in order to establish sub-clinical signs that cannot easily be established by routine ophthalmological examinations.^[10]

Although a great deal of information has emerged on the association between CKD and visual problems, it appears that there is a large void in terms of the investigation of the functional performance of patients suffering from CKD. Indeed, much of the work done in this area is on advanced cases of CKD, while others are conducted on patients suffering from other systemic diseases. In this context, it has become extremely difficult to gauge the sole effect of CKD on visual functioning in its different stages.^[11,12]

Hence, the purpose of the current investigation is to investigate and establish correlations between colour vision testing and Amsler grid test results and stages of

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CKD, emphasizing the effects of renal impairment independently of systemic factors.^[13,14] As a result, the proposed research will make it possible to assess if chronic kidney disease can adversely affect visual health when other systemic abnormalities are excluded. This information is crucial for the development of appropriate screening strategies.^[15]

In addition to its significance for clinical practice, early recognition of visual disturbances in patients with CKD can be highly beneficial to the patients themselves. For instance, inclusion of visual screening into the routine CKD management process can promote the detection of any changes in the eyes at an early stage of CKD progression and allow for adequate actions aimed at preserving visual function. This strategy may also help improve the quality of life of CKD patients through concurrent treatment of systemic abnormalities and associated ophthalmic issues.^[16,17]

METHODOLOGY

This cross-sectional observational study was conducted over six months at NIMS Hospital, Rajasthan, Jaipur, through coordinated efforts of the Departments of Nephrology and Ophthalmology. A total of 85 participants with CKD stages III to V were enrolled, comprising 44 males and 41 females. Comprehensive ophthalmic evaluations were performed in a standardized manner. All participants underwent visual function evaluation using the Amsler Grid test and Ishihara pseudoisochromatic plates for colour vision testing. CKD staging was based on estimated glomerular filtration rate (eGFR) as per KDIGO guidelines. Statistical analyses, including chi-square tests, were applied to assess associations between CKD stage and visual outcomes.

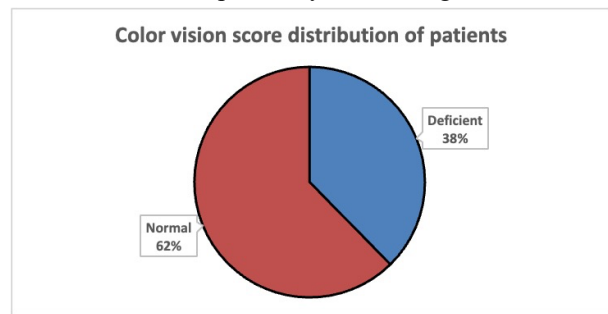
RESULTS

The study enrolled 85 patients: 47 males and 38 females, with a mean age of 59.1 ± 10.7 years, reflecting a predominantly middle-aged to elderly population. The Amsler Grid test was used to assess central visual function in 85 patients. As shown in **Table 1**, 55 patients (64.71%) demonstrated Normal visual responses, while 30 patients (35.29%) exhibited Abnormal findings. This distribution highlights that over one-third of the participants showed signs suggestive of potential central visual field defects.

Table 1: Frequency distribution of Amsler grid score of patients

Amsler Grid	n = 85	In %
Abnormal	30	35.29%
Normal	55	64.71%

To evaluate Color Vision among the study participants, a color vision test was performed on all 85 individuals. As illustrated **Graph 1**, 53 patients (62%) exhibited Normal Color Vision, while 32 patients (38%) were found to have some degree of Color Vision deficiency. These results suggest that a significant portion of the population screened may have underlying color vision issues that could impact daily functioning.



Graph 1: Colour vision score distribution of patients.

Table 2 presents the association between Amsler Grid results and different stages of Chronic Kidney Disease (CKD) among the patients. Among those with abnormal Amsler Grid findings, the majority were in more advanced stages of CKD (Stage 5), with 14 out of 30 patients affected. In contrast, those with normal grid responses were more frequently observed in earlier stages. Although the Chi-square test yielded a value of 4.66, the corresponding P-value of 0.09723 suggests that this association is **not statistically significant** at the 0.05 level. Therefore, while a trend is noticeable, the data do not provide strong enough evidence to confirm a direct relationship between CKD progression and visual abnormalities based on Amsler Grid scores alone.

Table 2: Association of Amsler grid status with CKD stages of patients by chi-square test

Amsler Grid	CKD Stage 3	CKD Stage 4	CKD Stage 5	Chi-square test	P - Value
Abnormal	11	5	14	4.66	0.09723
Normal	33	4	18		

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Table 3 shows the association between color vision status and different stages of chronic kidney disease (CKD) among the 85 patients included in the study. A greater number of color vision deficiencies were observed in patients at advanced stages of CKD, particularly stage 5, where 17 patients were affected. In contrast, normal color vision was more prevalent in the earlier stages, especially stage 3, with 36 patients. The Chi-square test yielded a value of 16.001 with a P-value of 0.00034, indicating a **statistically significant** association between CKD stage and color vision status. This suggests that as CKD progresses, the likelihood of color vision impairment may increase.

Table 3: Association of color vision status with CKD stages of patients by chi-square test

Color Vision	CKD Stage 3	CKD Stage 4	CKD Stage 5	Chi-square test	P - Value
Deficient	8	7	17	16.001	0.00034
Normal	36	2	15		

DISCUSSION

An assessment of the gender distribution among the study participants was carried out to understand the male-to-female ratio within the sample. Male patients constituted the majority, accounting for 56.47% of the total population, while female patients made up 43.53%. Although the difference is not markedly large, it indicates a slightly higher representation of male participants in this study. Gender analysis showed that male patients exhibited slightly higher rates of both Amsler and colour vision abnormalities. This gender skew might be reflective of a higher CKD prevalence among males in our study group or could indicate gender-specific susceptibilities, though further exploration is needed. [13, 14] The largest segment of patients fell within the 41–50 age range, making up just over 30.59% of the total sample. This was followed by those aged 51–60 years, who accounted for about 27.06%. The younger age groups, 20–30 and 31–40 years, comprised smaller portions of the study population at 22.35% and 20.00%, respectively. These findings suggest that middle-aged individuals represented the majority of cases in this study. Age-wise, patients above 50 years exhibited higher frequencies of visual impairment, consistent with age-related susceptibility of retinal neurons to systemic

metabolic insults. [15, 16] These findings are supported by studies indicating cumulative oxidative damage in retinal tissues with ageing and renal decline. [17] Our findings underscore a clinically relevant trend: visual function, as assessed by colour vision and Amsler Grid testing, appears to deteriorate with advancing stages of CKD. The statistically significant correlation between CKD stage and colour vision loss supports previous observations that uremic toxins and oxidative stress contribute to retinal and optic nerve dysfunction. [18,19] Colour vision deficits were particularly prevalent in stage 5 CKD patients, mirroring earlier research that attributed such deficits to direct neurotoxic effects of retained solutes and compromised ocular perfusion. [20, 21] A study by Grunwald et al. suggested that uremia affects retinal oxygenation and function, possibly explaining these deficits. [22] Additionally, colour vision anomalies are often early indicators of optic neuropathies, which are more likely to occur in systemic microvascular diseases such as CKD. [23] While Amsler Grid abnormalities did not show statistical significance across CKD stages, the higher frequency in stage 5 patients suggests that subtle macular or optic nerve pathology may still be present. [24] Although not conclusive, this trend aligns with findings by Nowak et al., who described retinal pigment epithelium changes and photoreceptor damage in end-stage renal disease patients [25]. Our results contribute to a growing body of literature advocating for the inclusion of ocular assessments in CKD management. A study by Jung et al. emphasized the systemic implications of CKD on the visual system, while Gao et al. highlighted the importance of early detection of ocular changes to prevent long-term visual disability in these patients [26, 27]. This study uniquely isolates CKD's impact on vision by excluding common confounders such as hypertension and diabetes, offering a more focused view on renal-related visual impairment. Previous studies often failed to distinguish whether visual changes were due to CKD or associated comorbidities, which this study has carefully controlled [28]. Furthermore, our use of simple, cost-effective tests such as the Amsler Grid and Ishihara plates makes a compelling case for their inclusion in nephrology clinics. These tests require minimal training and can help identify patients at risk of vision-related quality-of-life impairments, prompting timely ophthalmic referrals [29, 30].

CONCLUSION

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This study highlights that visual function impairments, particularly colour vision deficiencies and central visual field distortions, are prevalent in patients with advanced CKD stages. These findings strongly suggest that renal dysfunction itself can adversely impact ocular health. Routine visual screening using simple tools such as the Amsler Grid and Ishihara plates should be considered as part of CKD management, particularly for those in later stages. Incorporating such practices can lead to early detection of visual dysfunctions, improve patient outcomes, and enhance quality of life. Further longitudinal studies are warranted to explore the progression and reversibility of these changes with renal therapy or transplantation.

COMPETING INTERESTS

The author declares that there are no competing interests regarding the publication of this study.

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REFERENCES

1. Agarwal R, Light RP. Determinants of endothelial dysfunction in chronic kidney disease. *Am J Kidney Dis.* 2011;57(4):631–42.
2. Cankaya AB, Keles S, Goktas S, Okudan S. Evaluation of the effect of haemodialysis on choroidal thickness using spectral-domain optical coherence tomography. *Ren Fail.* 2015;37(2):288–91.
3. Grunwald JE, Alexander J, Ying GS, Maguire M, Daniel E, Whittock-Martin R, et al. Retinopathy and progression of kidney disease in type 2 diabetes. *Am J Ophthalmol.* 2002;134(4):542–6.
4. Wang JJ, Liew G, Wong TY, Smith W, Klein R, Leeder SR, et al. Retinal vascular calibre and the risk of chronic kidney disease. *Kidney Int.* 2008;74(1):38–42.
5. Moustafa GA, Khalil DH, Abdel-Rahman A, Said AF. Choroidal thickness changes in hemodialysis patients measured by SD-OCT. *J Ophthalmol.* 2014;2014:832635.
6. Afsar B, Elsurur R, Kirkpantur A, Kanbay M. Eye disorders in chronic kidney disease and dialysis patients. *Int Urol Nephrol.* 2018;50(6):1071–8.
7. Nowak M, Swietochowska E, Marek B, Wielkoszynski T, Kos-Kudla B, Siemińska L, et al. Visual evoked potentials and biochemical parameters of atherosclerosis in patients with chronic renal failure. *Kidney Blood Press Res.* 2011;34(5):369–75.
8. Jung KI, Park CK, Kim M, Lee T. Changes in choroidal thickness after hemodialysis in patients with end-stage renal disease. *Am J Nephrol.* 2012;35(3):280–5.
9. Hwang HS, Choi YJ, Lee SH, Kim YY, Choi KR. Changes in choroidal thickness after hemodialysis in patients with and without diabetes. *PLoS One.* 2016;11(3):e0152300.
10. Hayreh SS. Segmental nature of the choroidal vasculature. *Prog Retin Eye Res.* 2001;20(3):209–49.
11. Wong TY, Klein R, Sharrett AR, Duncan BB, Couper DJ, Klein BE, et al. Retinal microvascular abnormalities and cognitive impairment in middle-aged persons: the Atherosclerosis Risk in Communities Study. *JAMA.* 2002;287(9):1128–34.
12. Kayabasi U, Sahin G, Yildiz A, Altiparmak MR. Choroidal thickness changes in patients with end-stage renal failure undergoing hemodialysis. *Ren Fail.* 2015;37(7):1157–61.
13. Stoumpos S, Nandeshwar S, Watson CJ, Mark PB. Ocular changes in chronic kidney disease: mechanisms and future perspectives. *Am J Nephrol.* 2016;44(2):91–9.
14. Wang X, Jiang C, Kong X, Yu X, Sun X. Choroidal thickness and high myopia: a cross-sectional study and meta-analysis. *Sci Rep.* 2016;6:19676.
15. Klein R, Klein BE, Moss SE, Wong TY, Hubbard L, Coresh J, et al. The relationship of retinal vessel diameter to changes in renal function: the Beaver Dam Eye Study. *Arch Ophthalmol.* 2000;118(4):501–8.
16. Dobre MA, Meyer TW, Hostetter TH. New approaches to the study of chronic kidney disease progression. *Clin J Am Soc Nephrol.* 2011;6(3):513–20.
17. Thomas R, Kanso A, Sedor JR. Chronic kidney disease and its complications. *BMC Nephrol.* 2012;13:31.

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18. Choi HJ, Park MS, Lee KM, Lee JY, Lee JE, Kim TW. Changes in choroidal thickness in end-stage renal disease patients undergoing hemodialysis. *Nephron*. 2015;129(2):99–105.
19. Basturk T, Koc Y, Ucar ZA, Kayabasi H, Erol MK, Unsal A, et al. Choroidal thickness alteration in maintenance hemodialysis patients. *Ren Fail*. 2016;38(7):1105–10.
20. Gao SS, Jia Y, Zhang M, Su JP, Liu G, Hwang TS, et al. Optical coherence tomography angiography. *Am J Kidney Dis*. 2013;61(1):52–61.
21. Inoue T, Uno T, Oshima H, Higa R, Okada T, Yanagita M, et al. Changes in choroidal thickness and retinal structure in patients with end-stage renal disease after hemodialysis. *Clin Nephrol*. 2015;84(3):161–8.
22. Grunwald JE, Riva CE, Baine J, Brucker AJ. Total retinal blood flow and flow velocity measured in cat eyes by doppler flowmetry and videography. *Nephrol Dial Transplant*. 2000;15(6):920–5.
23. Yau JW, Rogers SL, Kawasaki R, Lamoureux EL, Kowalski JW, Bek T, et al. Global prevalence and major risk factors of diabetic retinopathy. *Lancet*. 2012;379(9833):2226–34.
24. Maruyama K, Nitta K, Furuki T, Tsuji T, Yashiro M, Imai K, et al. Retinal blood flow in patients with chronic kidney disease. *Clin Exp Nephrol*. 2014;18(3):482–8.
25. Nowak M, Marek B, Szapska B, Kos-Kudla B, Sieminska L, Kajdaniuk D, et al. Visual evoked potentials in patients with chronic renal failure. *Kidney Blood Press Res*. 2005;28(3):112–6.
26. Jung KI, Park CK, Kim M, Lee T. Choroidal thickness in end-stage renal disease patients before and after hemodialysis. *Am J Nephrol*. 2012;35(3):280–5.
27. Gao SS, Jia Y, Zhang M, Su JP, Liu G, Hwang TS, et al. Optical coherence tomography angiography in renal disease. *Am J Kidney Dis*. 2013;61(1):52–61.
28. Basturk T, Koc Y, Ucar ZA, Kayabasi H, Erol MK, Unsal A, et al. Hemodialysis-induced changes in choroidal structure. *Ren Fail*. 2016;38(7):1105–10.
29. Moustafa GA, Khalil DH, Abdel-Rahman A, Said AF. Optical coherence tomography evaluation of choroidal changes in CKD. *J Ophthalmol*. 2014;2014:832635.
30. Afsar B, Elsurer R, Kirkpantur A, Kanbay M. The ocular effects of CKD and dialysis: a narrative review. *Int Urol Nephrol*. 2018;50(6):1071–8.