Section: Miscellaneous

Original Research Article

# RENAL FUNCTION AS A PREDICTOR OF DIABETIC RETINOPATHY SEVERITY IN DIABETES MELLITUS – A CROSS-SECTIONAL STUDY

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ABSTRACT

**Background:** Diabetes damages small vessels in retina and kidney together. Many patients come late for eye check. Simple renal tests like eGFR and ACR may help to pick higher-risk cases early. Objectives was to study whether eGFR and ACR reflect DR severity and presence of DME in adults with diabetes.

**Materials and Methods:** Hospital based cross-sectional study in a tertiary care hospital, South India (6 months). 630 diabetics (18–80 years, Type 1/Type 2) were enrolled by convenient sampling. Fundus exam with photos was done and DR graded by modified ETDRS (No DR, mild/moderate/severe NPDR, PDR). DME was marked present/absent clinically, OCT when possible. Renal markers were serum creatinine based eGFR and spot urine ACR categories. Associations were analysed using standard tests.

**Results:** DR distribution: No DR 223 (35.4%), Mild NPDR 217 (34.4%), Moderate NPDR 154 (24.4%), Severe NPDR 16 (2.5%), PDR 20 (3.2%). Mean eGFR fell with DR severity from 104 ± 14 (No DR) to 54.8 ± 12.0 mL/min/1.73 m² (PDR). Mean ACR rose from 12.5 ± 5.5 to 76.4 ± 29.7 mg/g. DME increased with DR grade: 2.2%, 9.2%, 27.3%, 81.3%, 90% (No DR → PDR). DME also increased with worse eGFR stage, maximum in Stage 5 (72%). In DR cases (n=407), ACR stages did not differ significantly by diabetes type.

**Conclusion:** Falling eGFR and rising ACR track worse DR and higher DME. These routine tests can be used as simple triggers for early retinal and macular screening in OPD.

**Keywords:** diabetic retinopathy; eGFR; albumin–creatinine ratio; albuminuria; diabetic macular edema; diabetes mellitus.

## INTRODUCTION

Diabetes mellitus (DM) is a major public health problem and India has heavy burden. IDF 2021 says around 77 million Indian adults have diabetes and it may reach 134 million by 2045.[1] Diabetic retinopathy (DR) is one common microvascular complication and a major cause of visual loss in working age people. If not treated early it can progress from NPDR to sight-threatening PDR and DME.[2]

In our OPD setup many patients come for first eye check only when vision starts disturbing. By that time retinal capillaries already got damaged. Similar silent damage happens in kidney too. Small rise in albumin excretion or mild fall in filtration can be early warning of glomerular stress.[3-5] Eye and kidney look separate in routine practice but both share same microvascular injury from chronic hyperglycaemia. Endothelial dysfunction and basement membrane thickening slowly pushes both organs towards failure. Many studies from Asia and West show albuminuria and early fall in eGFR are linked with DR presence and more severe grades including PDR.[3-7] Some nephrology observations suggest ACR rise can come even before obvious retinal changes so it may reflect systemic vascular injury rather than only eye disease.[4]

In India follow-up is irregular, work issues, travel issues, low awareness. So renal markers can act like simple screening flags. Albuminuria is useful because it rises earlier than creatinine and even modest elevation is linked with worse DR and DME.[6,8] Based on this we planned this study to see

whether ACR and eGFR mirror DR severity and macular involvement in a large diabetic cohort.

## MATERIALS AND METHODS

This was a hospital-based cross-sectional study done in the Departments of Ophthalmology and General Medicine at a tertiary care hospital in South India over 6 months. Ethical approval was taken from the Institutional Human Ethics Committee (IHEC/395/Ophthalmology/02/2025) and the study followed the Declaration of Helsinki.

A total of 630 adults with diagnosed diabetes (Type 1 or Type 2), age 18–80 years, attending OPD were included by convenient sampling. Written informed consent was obtained and all agreed for ocular and renal evaluation. Adults 18–80 years with diabetes (Type 1/Type 2) willing for fundus exam and renal function tests. End-stage renal disease/on dialysis, non-diabetic kidney disease, retinal pathology due to other causes (hypertensive retinopathy, retinal vein occlusion), pregnancy/lactation, severe cognitive impairment, or unwilling for procedures.

After consent, history and complete eye exam were done (visual acuity, slit-lamp biomicroscopy, fundus exam with +90D). Fundus photographs were taken. DR was graded using modified ETDRS as No DR, Mild NPDR, Moderate NPDR, Severe NPDR, PDR. DME was recorded as present/absent clinically, supported by OCT when available. Blood and spot urine samples were taken on the visit. eGFR was calculated from serum creatinine and classified into standard eGFR stages. ACR was classified into A1, A2, A3 categories.

Data were entered in Excel and analysed in SPSS v26. Continuous variables were expressed as mean ± SD. Mean eGFR/ACR across DR grades were compared using one-way ANOVA. Categorical variables were compared using Chi-square test. $p < 0.05$ was considered significant. ROC curves were generated using Python 3.10 (scikit-learn and matplotlib) to assess ability of eGFR and ACR to predict PDR and any DR.

## RESULTS

In [Table 1], the cohort is mostly early disease. No DR was seen in 223 (35.4%) patients. Mild NPDR was almost similar at 217 (34.4%) and Moderate NPDR in 154 (24.4%). Advanced grades were fewer Severe NPDR 16 (2.5%) and PDR 20 (3.2%). So in routine OPD terms, most patients were not yet in the "end-stage fundus" group, but still a sizeable portion already had definite retinopathy.

**Table 1: Distribution of diabetic retinopathy stages**

| DR stage | n | % |
|---|---|---|
| No DR | 223 | 35.4 |
| Mild NPDR | 217 | 34.4 |
| Moderate NPDR | 154 | 24.4 |
| Severe NPDR | 16 | 2.5 |
| PDR | 20 | 3.2 |
| Total | 630 | 100 |

**Table 2: Mean eGFR and ACR across DR stages**

| DR stage | Mean eGFR (mL/min/1.73 m²) | Mean ACR (mg/g) |
|---|---|---|
| No DR | 104 ± 14 | 12.5 ± 5.5 |
| Mild NPDR | 98.4 ± 16.3 | 19.7 ± 7.9 |
| Moderate NPDR | 89.1 ± 15.4 | 29.6 ± 11.3 |
| Severe NPDR | 76.2 ± 13.8 | 47.4 ± 18.1 |
| PDR | 54.8 ± 12.0 | 76.4 ± 29.7 |

[Table 2] is the cleanest signal in this paper. eGFR keeps falling as DR severity increases: from 104 ± 14 in No DR, down to 98.4 ± 16.3 in Mild NPDR, 89.1 ± 15.4 in Moderate NPDR, then 76.2 ± 13.8 in Severe NPDR and finally 54.8 ± 12.0 in PDR. ACR behaves opposite way rising stepwise from 12.5 ± 5.5 mg/g (No DR) to 19.7 ± 7.9, 29.6 ± 11.3, 47.4 ± 18.1 and highest at 76.4 ± 29.7 mg/g in PDR. As retina worsens kidney markers worsen too and the separation becomes very obvious by severe NPDR and PDR.

**Table 3: DR severity vs presence of DME**

| DR stage | DME present n (%) | DME absent n (%) | Total |
|---|---|---|---|
| No DR | 5 (2.2) | 218 (97.8) | 223 |
| Mild NPDR | 20 (9.2) | 197 (90.8) | 217 |
| Moderate NPDR | 42 (27.3) | 112 (72.7) | 154 |
| Severe NPDR | 13 (81.3) | 3 (18.7) | 16 |
| PDR | 18 (90.0) | 2 (10.0) | 20 |
| Total | 98 (15.6) | 532 (84.4) | 630 |

[Table 3] shows DME is not randomly distributed, it climbs with DR grade. In No DR, DME was only 5/223 (2.2%). In Mild NPDR, it was still low at 20/217 (9.2%). But once cases reach Moderate NPDR, DME becomes fairly common (42/154, 27.3%). After that it becomes almost expected Severe

NPDR 13/16 (81.3%) and PDR 18/20 (90%) had DME. Clinically this matches what we see the moment retinopathy turns severe, macula involvement also comes along in majority.

**Table 4. eGFR staging vs presence of DME**

| eGFR stage | DME present n (%) | DME absent n (%) | Total |
|---|---|---|---|
| Stage 1 (≥90) | 10 (3.8) | 250 (96.2) | 260 |
| Stage 2 (60–89) | 17 (10.0) | 153 (90.0) | 170 |
| Stage 3A (45–59) | 19 (23.8) | 61 (76.2) | 80 |
| Stage 3B (30–44) | 21 (35.0) | 39 (65.0) | 60 |
| Stage 4 (15–29) | 13 (37.1) | 22 (62.9) | 35 |
| Stage 5 (<15) | 18 (72.0) | 7 (28.0) | 25 |
| Total | 98 (15.6) | 532 (84.4) | 630 |

[Table 4] gives a very practical message: poorer kidney filtration is linked with more macular edema. DME prevalence was 3.8% (10/260) in eGFR Stage 1 and 10% (17/170) in Stage 2. It then rises noticeably in mid CKD: Stage 3A 23.8% (19/80) and Stage 3B 35% (21/60). Late stages had the heaviest burden Stage 4 37.1% (13/35) and Stage 5 72% (18/25). So when a diabetic patient is already in Stage 3B and beyond DME screening should not be delayed, because the chance becomes high.

**Table 5: ACR stage vs type of diabetes among DR cases**

| ACR stage | Type 1 (n=18) | Type 2 (n=389) | Total (n=407) |
|---|---|---|---|
| A1 | 13 (72.2%) | 210 (54.0%) | 223 (54.8%) |
| A2 | 4 (22.2%) | 135 (34.7%) | 139 (34.2%) |
| A3 | 1 (5.6%) | 44 (11.3%) | 45 (11.0%) |

[Table 5] is a DR-only subgroup (n=407). Within these DR patients, A1 was still the largest group (223/407, 54.8%), A2 accounted for 139/407 (34.2%) and A3 was 45/407 (11.0%). When split by diabetes type, Type 1 patients were few (n=18) and mostly stayed in A1 (72.2%) while Type 2 (n=389) had more spread across A1–A3 (A1 54.0%, A2 34.7%, A3 11.3%).

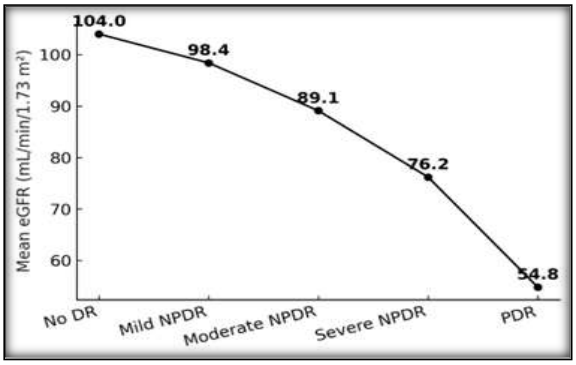


**Figure 1: Mean eGFR across diabetic retinopathy stages.**

Grey-scale line plot showing declining eGFR with increasing DR severity

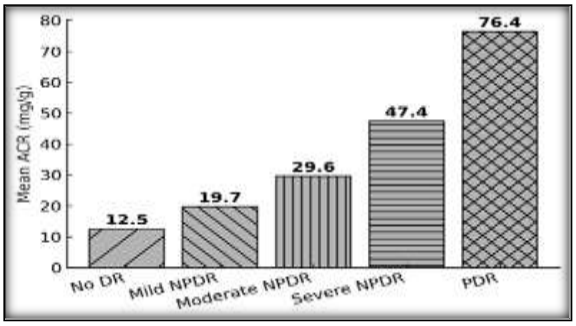


**Figure 2: Mean albumin–creatinine ratio across diabetic retinopathy stages.**

Hatched grey-tone bar chart displaying rising ACR from No DR to PDR.

## DISCUSSION

Diabetes is increasing fast and in India many patients still come late for screening, mostly when vision starts fluctuating or some symptoms begin.[1] DR remains a major cause of preventable visual loss in working age adults.[2] Retina and kidneys both get hit by chronic hyperglycaemia through similar microvascular pathways, so in real practice these two complications often travel together. In this study we tried to keep it simple and practical, using routinely available renal markers eGFR and ACR and comparing them with DR severity and DME presence.

First the distribution of retinopathy in our cohort is quite typical of tertiary OPD mix. [Table 1] shows 35.4% had no DR, but the remaining had some grade of DR. Most cases were mild to moderate (Mild NPDR 34.4%, Moderate NPDR 24.4%). Severe NPDR and PDR were fewer in number (2.5% and 3.2%), but clinically they matter most because that is where macula and proliferative complications sit. So even though advanced DR numbers were less, it still represents a real high-risk group.

The key finding is the clear renal gradient across DR severity. [Table 2] shows mean eGFR falls steadily from 104 ± 14 in No DR to 54.8 ± 12.0 in PDR. At the same time mean ACR rises stepwise from 12.5 ± 5.5 mg/g in No DR to 76.4 ± 29.7 mg/g in PDR. This looks like classic shared microvascular injury. Albuminuria rises early and becomes marked as retinopathy advances. Chen et al. also reported that microalbuminuria can show stronger association with retinopathy than mild reductions in GFR, especially in Asian type 2 diabetic populations where metabolic

injury builds silently over years.[9] Similar relationship between albuminuria and DR severity has been reported in population data from Spain and Asian cohorts.[10,11] From a clinician point of view, this is familiar ACR starts creeping up even when creatinine looks "not too high" and those same patients often have background or worse retinopathy. DME relationship in our results is very striking and clinically useful. [Table 3] shows DME prevalence increases sharply with DR grade. In No DR it was 2.2%, in Mild NPDR 9.2%, then it rises to 27.3% in Moderate NPDR. After that it becomes very common in the advanced grades 81.3% in Severe NPDR and 90% in PDR. So the message is simple: once DR crosses moderate stage, macula involvement becomes much more likely and in severe/PDR it is almost expected. This aligns with the concept that retinal vascular leakage and capillary non-perfusion increase with DR severity, so fluid accumulation in macula also rises.[12-15]

Kidney staging also showed a strong link with macular edema. [Table 4] demonstrates that DME prevalence increases as eGFR stage worsens. It is low in Stage 1 (3.8%) and Stage 2 (10.0%), then becomes substantial in Stage 3A (23.8%) and Stage 3B (35.0%). Late CKD stages carry high DME burden Stage 4 37.1% and Stage 5 72.0%. This is clinically important in OPD practice. A diabetic with CKD stage 3B or worse should be treated as high risk for DME, even if they are not complaining much. The biology also fits CKD is associated with endothelial dysfunction, inflammation, oxidative stress and fluid imbalance, all of which can worsen retinal vascular permeability and edema.[16,17] So declining filtration is not only a renal marker here, it is a systemic "leaky microvasculature" marker.

We also examined albuminuria stage distribution by diabetes type among DR patients. [Table 5] includes DR cases only (n=407). In this subgroup, A1 still formed majority (54.8%), A2 was 34.2% and A3 was 11.0%. The type-wise split did not show significant difference, but the Type 1 sample is very small (n=18), so this comparison is underpowered. Practically, it suggests that in our dataset albuminuria burden among DR patients is not strongly driven by diabetes type alone and other factors like duration, blood pressure and glycaemic control may play larger role, though those were not analysed in table form here.

Overall, this study gives a practical Indian OPD message. Renal markers that are already part of routine diabetes follow-up eGFR and ACR mirror DR severity in a graded way (Table 2) and also align strongly with DME burden (Tables 3 and 4). In settings where screening is delayed due to travel, time or low awareness a rise in ACR or a drop in eGFR should trigger early referral for fundus and macula evaluation. It is not a replacement for eye exam, but it can act as a simple risk flag.

The cross-sectional design cannot prove causality or direction. Single-centre cohort may not represent community prevalence. DME diagnosis was clinical and OCT was not possible in all, so mild edema could be missed. Also we did not adjust for important confounders like diabetes duration, HbA1c, blood pressure and medications, which can influence both renal parameters and retinopathy severity.

Still, within these limits the pattern in our data is consistent and clinically meaningful. Albuminuria rises and eGFR declines as DR becomes severe [Table 2] and both advanced DR and reduced eGFR stages show very high DME prevalence [Table 3 and 4]. In Indian settings, this can help clinicians identify high-risk diabetics early and reduce late presentation of sight-threatening disease.

## CONCLUSION

Renal dysfunction showed a close parallel with retinal disease severity in our cohort. Mean eGFR declined stepwise and mean ACR increased progressively as DR advanced from No DR to PDR. DME frequency also rose sharply with worsening DR grade, becoming very common in Severe NPDR and PDR. Lower eGFR stages carried a much higher DME burden, especially from Stage 3B onward and maximal in Stage 5. Since eGFR and ACR are routine low-cost tests in diabetes follow-up using abnormal values as a referral trigger can help earlier retinal and macular screening in Indian OPD settings and may reduce delayed detection of sight-threatening DR.

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