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Original Research Article

IMPACT OF DIABETES DURATION AND GLYCEMIC STATUS ON THE SEVERITY OF DIABETIC RETINOPATHY: A PROSPECTIVE STUDY ON CAMP PATIENTS

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ABSTRACT

Background: Diabetic retinopathy is an important microvascular complication of diabetes and a preventable cause of visual impairment. Longer exposure to diabetes, poor glycaemic status and coexisting hypertension may increase the likelihood of advanced retinal disease. This study evaluated these associations among diabetic patients attending rural outreach eye camps.

Materials and Methods: This prospective cross-sectional observational study was conducted over three months among 200 adults with known type 1 or type 2 diabetes mellitus attending diabetic-retinopathy screening camps organized by Sankara Eye Hospital, Ludhiana. Age, sex, diabetes duration, random blood sugar, hypertension, previous eye examination and screening awareness were recorded. Participants underwent best-corrected visual-acuity assessment, slit-lamp examination and dilated fundus examination. Diabetic retinopathy was graded as no DR, mild, moderate or severe non-proliferative diabetic retinopathy, or proliferative diabetic retinopathy. The participant was the unit of analysis, with severity assigned according to the more severely affected eye.

Results: Of 216 patients assessed, 16 were excluded and 200 were analysed. The mean age was 55.6 ± 9.8 years, and 56.0% were men. DR was present in 92 participants (46.0%): mild NPDR in 15.5%, moderate NPDR in 13.5%, severe NPDR in 9.0% and PDR in 8.0%. The proportion with severe NPDR or PDR increased from 1.7% among participants with diabetes for <5 years to 52.4% among those with diabetes for ≥15 years ($p<0.001$). Mean RBS increased from 200.0 ± 42.6 mg/dL in participants without DR to 322.4 ± 71.9 mg/dL in PDR ($p<0.001$). Hypertension was associated with greater severity ($p<0.001$). DME was identified in 13.0%, and BCVA worsened significantly with increasing DR grade. In ordinal regression, diabetes duration, RBS and hypertension remained independently associated with increasing DR severity.

Conclusion: Longer diabetes duration, poorer current glycaemic status and coexisting hypertension were independently associated with more severe diabetic retinopathy in this camp-based cohort. The high burden of previously unscreened participants supports regular retinal examination, targeted risk-based referral and stronger integration of outreach eye screening with routine diabetes care.

Keywords: diabetic retinopathy; diabetes duration; glycaemic status; random blood sugar; diabetic macular edema; rural eye camp; retinal screening; visual acuity.

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterised by persistent hyperglycaemia and progressive vascular injury. Its long-term complications affect the retina, kidneys, peripheral nerves and cardiovascular system. Diabetic retinopathy (DR) is the principal retinal microvascular complication of diabetes and may progress from early non-proliferative changes to retinal ischaemia, neovascularisation, vitreous haemorrhage and tractional retinal detachment. Diabetic macular edema (DME) may occur at different stages and can substantially reduce central vision.

India has a large and heterogeneous burden of diabetes and diabetic eye disease. The SMART India population-based screening study estimated a national DR prevalence of 12.5% and vision-threatening DR prevalence of 4.0% among people with diabetes. The National Survey 2015-19 reported DR in 16.9% and sight-threatening disease in 3.6% of persons with diabetes.[1,2] Earlier studies from urban and rural India also demonstrated clinically important DR prevalence, although estimates varied according to age criteria, diabetes ascertainment, examination method and sampling setting.[3-5]

Duration of diabetes is one of the most consistently reported determinants of DR. Longer duration reflects greater cumulative exposure of the retinal microvasculature to hyperglycaemia and related metabolic disturbances. Indian studies have demonstrated progressively higher odds of retinopathy with increasing years since diagnosis, and duration has remained an independent risk marker after adjustment for other clinical variables.[4-6] The recorded duration represents time since diagnosis rather than the true biological onset of type 2 diabetes, but it remains practical for risk stratification.

Glycaemic status is another major determinant of retinal microvascular injury. Hyperglycaemia promotes endothelial dysfunction, pericyte loss, capillary leakage and retinal ischaemia. Observational studies have linked elevated glucose or glycated haemoglobin with DR presence and severity.[6-9] Random blood sugar is less informative than glycated haemoglobin for long-term control, but it is practical in outreach camps because fasting is not required and testing can be performed rapidly.

The association between glycaemic exposure and retinal outcomes is supported by major clinical trials. Intensive glycaemic therapy reduced retinopathy development and progression in type 1 diabetes in the Diabetes Control and Complications Trial. The United Kingdom Prospective Diabetes Study demonstrated a reduction in microvascular complications with intensive glucose control in type 2 diabetes, and the ACCORD Eye Study reported reduced retinopathy progression in selected adults receiving intensive glycaemic management.[10-12] These trials support the clinical importance of metabolic control, although a single cross-sectional RBS measurement cannot substitute for longitudinal glycaemic assessment.

Hypertension may aggravate retinal microvascular injury through increased hydrostatic stress, endothelial dysfunction and impaired autoregulation. Diabetes type may also influence the observed disease profile because type 1 and type 2 diabetes differ in age at onset, duration, treatment and associated systemic factors. In an adult camp population, however, the type 1 subgroup is likely to be small and comparative results require cautious interpretation.

DR is frequently asymptomatic during its early stages. Patients may not seek ophthalmic care until macular involvement or proliferative disease causes visual disturbance. Risk-stratification research from India has highlighted the potential value of prioritising patients with longer diabetes duration and poor glycaemic status when screening resources are limited.[13] Outreach models have also shown that local screening, health education and integration with diabetes services can improve access in rural populations.[14-16]

Patients attending rural camps may have irregular diabetes follow-up, delayed retinal evaluation, limited awareness and restricted access to specialist care. A camp-based study can therefore provide clinically useful information about the relationship of diabetes duration and current glycaemic status with retinopathy severity in an underserved population. The present study evaluated these associations among diabetic patients attending screening camps organised by Sankara Eye Hospital, Ludhiana.

Aim and Objectives

Aim: To evaluate impact of duration of diabetes and glycaemic status on severity of DR among patients screened in outreach eye camps.

Primary objective: To determine association between duration of diabetes and severity of DR among camp patients.

Secondary Objectives

1. To assess the relationship between glycaemic control and severity of DR.
2. To evaluate effect of DR on Type 1 and Type 2 DM patients.
3. To evaluate the effect of coexisting systemic conditions such as hypertension on DR severity.

MATERIALS AND METHODS

Study Design

This was a prospective cross-sectional observational study. Data were collected prospectively during outreach screening encounters, while each participant underwent a single study assessment. The design therefore evaluated associations between

existing exposures and current retinopathy severity rather than longitudinal progression or causation.

Study Setting

The study was conducted among patients attending diabetic-retinopathy screening camps organised in rural and semi-rural areas by Sankara Eye Hospital, Ludhiana, Punjab, India.

Study Period

The study was carried out over three months from June 2026 to August 2026.

Study Population

The study population comprised adults with previously diagnosed type 1 or type 2 diabetes mellitus who presented to the selected outreach camps and met the eligibility criteria.

Sample Size and Sampling

The protocol-specified sample size was 200 participants. Consecutive eligible patients were enrolled until the required sample was achieved. During the study period, 216 patients were assessed; after 16 exclusions, the final analysed sample was 200.

Inclusion Criteria

- Age more than 20 years.
- Known case of type 1 or type 2 diabetes mellitus.
- Willingness to participate.
- Provision of written informed consent.

Exclusion Criteria

- Hazy ocular media preventing adequate fundus examination and reliable DR grading.
- Retinal disease other than diabetic retinopathy that interfered with grading or attribution of visual impairment.
- Critical illness or systemic instability preventing completion of the examination.

Study Unit and Eye-Selection Rule

The participant was the statistical unit. Both eyes were examined and graded separately. Participant-level DR severity was assigned according to the more severely affected eye. DME was considered present when detected in either eye. Study-eye BCVA corresponded to the more severely affected eye; where both eyes had the same grade, the eye with poorer BCVA was selected.

Data Collection

After written informed consent, demographic and clinical information was recorded using a structured proforma. The collected variables included age, sex, diabetes type, duration since diagnosis, RBS, history of hypertension, systolic and diastolic blood pressure, previous ophthalmic examination and awareness of diabetic eye disease.

Assessment of Diabetes Duration and Glycaemic Status

Diabetes duration was calculated from the recorded date or year of diagnosis to the camp assessment and analysed both continuously and in the categories <5 years, 5-9 years, 10-14 years and ≥15 years. Current glycaemic status was assessed using RBS measured in mg/dL. RBS was analysed as a continuous variable; it was interpreted as current glucose status rather than a measure of long-term glycaemic control.

Blood-Pressure and Hypertension Assessment

Systolic and diastolic blood pressures were measured after seated rest. Hypertension was defined by a previous physician diagnosis or current antihypertensive treatment. A single elevated camp reading without a previous diagnosis was not used alone to establish chronic hypertension.

Ophthalmic Examination

All participants underwent best-corrected visual-acuity assessment, slit-lamp examination of the anterior segment and dilated retinal examination. BCVA was recorded separately for each eye using the available Snellen method and converted to logMAR units for analysis.

Anterior-segment examination documented corneal opacity, cataract, pseudophakia, rubeosis iridis and other findings affecting vision or retinal visibility. Fundus examination was performed using indirect ophthalmoscopy and/or slit-lamp biomicroscopy with a 90 D lens.

Diabetic-Retinopathy and Macular-Edema Grading

DR was graded using clinically applicable ETDRS-based categories: no DR, mild NPDR, moderate NPDR, severe NPDR and PDR. DME was documented separately as absent or present on clinical biomicroscopic examination.

Awareness and Previous Screening

Participants were asked whether they knew that diabetes could damage the retina, whether early DR could remain asymptomatic, whether periodic retinal examination was required, whether they had previously been advised to undergo screening, and whether they had previously received a dilated retinal examination. The timing of the most recent examination was recorded.

Outcome Measures

The primary outcome was the association between diabetes duration and ordered DR severity. Secondary outcomes were the association of RBS, diabetes type and hypertension with severity; prevalence of DME; BCVA across DR grades; awareness and prior screening; and independent predictors of increasing DR severity.

Statistical Analysis

Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics version 26.0.

Continuous variables were summarised as mean ± SD, while categorical variables were presented as frequency and percentage. The association between duration categories and DR severity was assessed using the chi-square test; Spearman rank correlation evaluated continuous duration against ordered DR grade. RBS and logMAR BCVA were compared across DR categories using one-way analysis of variance, with Spearman correlation additionally used for RBS and ordered severity. Fisher's exact test was used for diabetes type where cell counts

were small, and the chi-square test assessed hypertension and DME distributions.

Multivariable ordinal logistic regression was performed with ordered DR severity as the dependent variable. Candidate predictors were diabetes duration, RBS, hypertension, diabetes type, age and sex. Adjusted odds ratios with 95% confidence intervals were reported. A two-sided p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was undertaken after approval from the appropriate Institutional Ethics Committee. Written informed consent was obtained from each participant. Personal identifiers were excluded from the analytical dataset. Participants with sight-threatening disease were counselled and referred for definitive evaluation and treatment.

RESULTS

Participant Flow and Baseline Profile

During the three-month study period, 216 patients with known diabetes mellitus were assessed. Sixteen were excluded: 10 because media opacity prevented reliable fundus grading, four because of retinal disease other than diabetic retinopathy, and two because critical illness prevented completion of the examination. The final analysis therefore included 200 participants.

The mean age was 55.6 ± 9.8 years (range 22-82 years); 112 participants were men and 88 were women. The mean duration of diabetes was 9.4 ± 6.3 years and the mean RBS was 228.0 ± 63.7 mg/dL. Mean systolic and diastolic blood pressures were 134.4 ± 15.6 mmHg and 81.4 ± 8.8 mmHg, respectively.

All analysed participants had media sufficiently clear for retinal grading. Anterior-segment findings were normal or clinically insignificant in 118 participants, while 60 had mild-to-moderate cataract not preventing fundus examination, 18 were pseudophakic and four had non-obscuring corneal opacity. Rubeosis iridis was identified in three participants. The overall mean study-eye BCVA was 0.32 ± 0.30 logMAR.

Diabetic-Retinopathy Distribution

Participant-level retinopathy severity, classified according to the more severely affected eye, is shown in Figure 1. DR was present in 92 participants (46.0%).

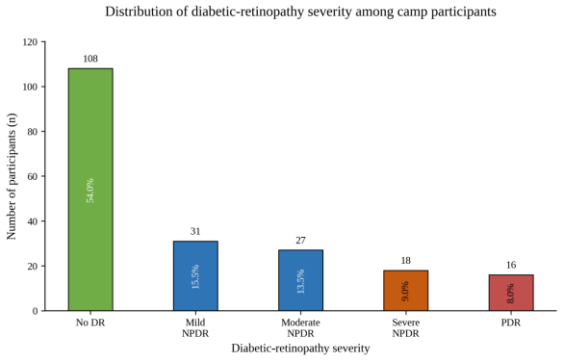

Figure 1: Distribution of diabetic-retinopathy severity among 200 camp participants. Counts are displayed above the bars and percentages within the bars.

Diabetes Duration and Retinopathy Severity

The severity distribution shifted progressively towards advanced disease with increasing diabetes duration. The prevalence of any DR rose from 18.3% among participants with diabetes for less than five years to 85.7% among those with diabetes for at least 15 years.

Table: Association between duration of diabetes and diabetic-retinopathy severity (N=200)

Diabetes duration	No DR n (%)	Mild NPDR n (%)	Moderate NPDR n (%)	Severe NPDR n (%)	PDR n (%)	Total	p-value
<5 years	49 (81.7)	7 (11.7)	3 (5.0)	1 (1.7)	0 (0.0)	60	<0.001
5-9 years	36 (65.5)	10 (18.2)	6 (10.9)	2 (3.6)	1 (1.8)	55	—
10-14 years	17 (39.5)	9 (20.9)	9 (20.9)	5 (11.6)	3 (7.0)	43	—
≥15 years	6 (14.3)	5 (11.9)	9 (21.4)	10 (23.8)	12 (28.6)	42	—
Total	108 (54.0)	31 (15.5)	27 (13.5)	18 (9.0)	16 (8.0)	200	—

Statistical tests: chi-square test for association, $\chi^2=78.57$, df=12, p<0.001; Spearman rank correlation between continuous diabetes duration and ordered DR severity, ρ=0.552, p<0.001.

Glycaemic Status and Retinopathy Severity

Mean RBS rose progressively with increasing DR severity, indicating a significant relationship between poorer current glycaemic status and advanced retinal disease.

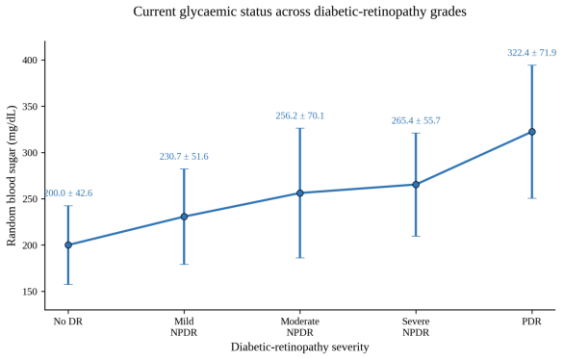

Figure 2: Mean ± SD random blood sugar across diabetic-retinopathy grades. One-way ANOVA: F=25.12, p<0.001; Spearman rank correlation: ρ=0.513, p<0.001.

Diabetes Type and Hypertension

Eight of the 12 participants with type 1 diabetes and 84 of the 188 participants with type 2 diabetes had DR. The difference in the presence of DR was not statistically significant. Hypertension was associated with a greater proportion of advanced disease.

Table 2: Diabetic-retinopathy severity according to diabetes type and hypertension status

Risk factor	No DR n (%)	Mild NPDR n (%)	Moderate NPDR n (%)	Severe NPDR n (%)	PDR n (%)	Total	p-value
Type 1 diabetes	4 (33.3)	2 (16.7)	2 (16.7)	2 (16.7)	2 (16.7)	12	0.231
Type 2 diabetes	104 (55.3)	29 (15.4)	25 (13.3)	16 (8.5)	14 (7.4)	188	—
Hypertension present	29 (35.4)	16 (19.5)	15 (18.3)	11 (13.4)	11 (13.4)	82	<0.001
Hypertension absent	79 (66.9)	15 (12.7)	12 (10.2)	7 (5.9)	5 (4.2)	118	—

Statistical tests: Fisher's exact test for the presence of any DR by diabetes type, p=0.231; chi-square test for hypertension and the complete DR-severity distribution, χ^2=20.85, df=4, p<0.001.

Visual Acuity and Diabetic Macular Edema

Visual acuity worsened significantly across increasing DR grades. Clinically detected DME was present in 26 participants (13.0%) and became progressively more frequent with advanced retinopathy.

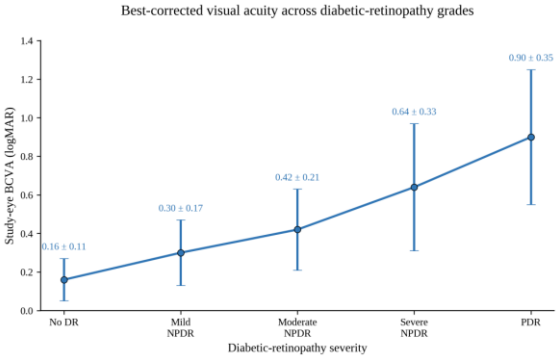

Figure 3: Study-eye best-corrected visual acuity across diabetic-retinopathy grades. Values are mean ± SD. One-way ANOVA: F=73.02, p<0.001.

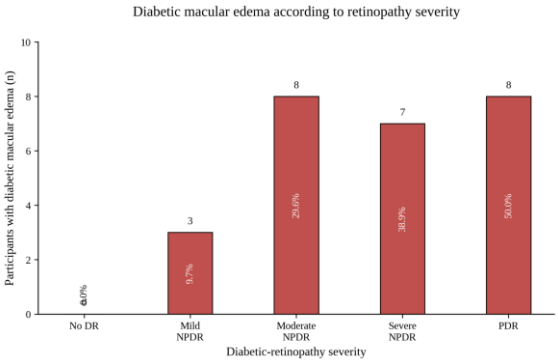

Figure 4: Clinically detected diabetic macular edema according to diabetic-retinopathy severity. Chi-square test: χ^2=53.08, df=4, p<0.001.

Awareness and Previous Retinal Screening

Awareness of asymptomatic retinal disease and utilisation of periodic dilated examination were limited. Positive awareness responses and previous examination history are presented in Figures 5 and 6.

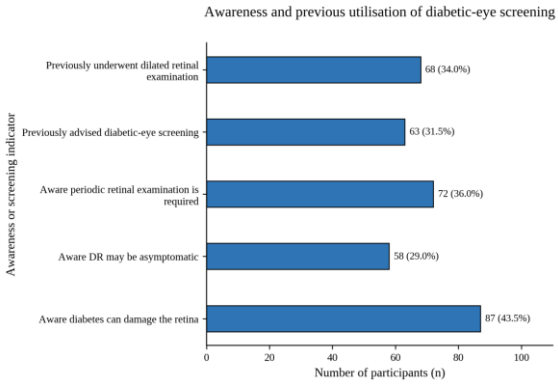

Figure 5: Positive awareness and screening-utilisation indicators among 200 participants. Labels show n (%)

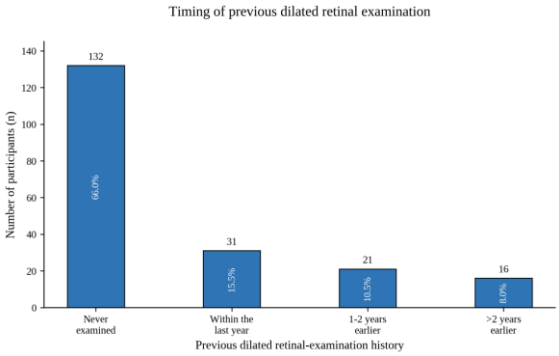

Figure 6: Timing of previous dilated retinal examination among 200 participants. Counts are displayed above bars and percentages within bars.

Independent Predictors of Increasing Retinopathy Severity

In the adjusted ordinal model, diabetes duration, RBS and hypertension remained independently associated with increasing DR severity. Diabetes type, age and sex were not statistically significant.

Table 3: Multivariable ordinal logistic-regression analysis of factors associated with increasing diabetic-retinopathy severity (N=200)

Predictor	Adjusted odds ratio	95% confidence interval	p-value
Diabetes duration, per 5-year increase	2.59	1.96-3.42	<0.001
RBS, per 50 mg/dL increase	2.56	1.93-3.39	<0.001
Hypertension present	2.70	1.46-5.02	0.002
Type 1 versus type 2 diabetes	2.92	0.65-13.17	0.163

Age, per 10-year increase	1.37	0.93-2.02	0.113
Male versus female	1.71	0.93-3.17	0.086

Statistical test: multivariable ordinal logistic regression.
Model statistics: likelihood-ratio χ^2=144.79, df=6, p<0.001; McFadden pseudo-R^2=0.276.

DISCUSSION

Principal Findings

This camp-based study demonstrated a substantial burden of diabetic eye disease. DR was present in 46.0% of the analysed participants, including severe NPDR in 9.0% and PDR in 8.0%. The most important finding was a strong graded association between longer diabetes duration and greater DR severity. Mean RBS also increased across the severity spectrum, and hypertension was associated with advanced retinal disease. DME was present in 13.0%, visual acuity worsened with increasing grade, and previous retinal-screening utilisation was low. In the adjusted model, duration, RBS and hypertension remained independently associated with increasing severity.

Prevalence and Severity of Diabetic Retinopathy

The observed DR prevalence of 46.0% was considerably higher than nationally weighted estimates from India. SMART India reported a prevalence of 12.5%, while the National Survey 2015-19 reported 16.9%.[1,2] The difference is likely to reflect the present study's camp-based sample of patients with known diabetes rather than an unselected population sample. Participants attending a dedicated retinal-screening camp may include people with longer disease duration, poor metabolic control, visual symptoms, previous referral or limited access to routine eye care.

Indian prevalence estimates vary markedly by setting. Urban and rural population studies have generally reported lower prevalence than hospital- or camp-based samples [3-5]. The present results should therefore not be interpreted as a population prevalence for Punjab. They describe the burden among diabetic patients who attended the selected outreach camps and had gradable fundi.

Diabetes Duration and Retinopathy Severity

Diabetes duration showed the strongest unadjusted gradient. Only 1.7% of participants with diabetes for less than five years had severe NPDR and none had PDR. Among those with diabetes for at least 15 years, 23.8% had severe NPDR and 28.6% had PDR. The prevalence of any DR increased from 18.3% to 85.7% across these groups.

This finding is consistent with Indian studies that identified duration as a major predictor of DR.[4-6] Chatziralli and colleagues also reported years since diagnosis as an independent risk factor for severe disease in type 2 diabetes.[7] The adjusted odds ratio of 2.59 per five-year increase in the present model reinforces the clinical value of duration as a simple risk-stratification variable.

Duration since diagnosis may underestimate the actual metabolic exposure in type 2 diabetes because hyperglycaemia can remain unrecognised for several years. Nevertheless, the variable is readily obtainable in camp settings and can help prioritise patients for urgent retinal evaluation.

Glycaemic Status and Retinopathy Severity

Mean RBS increased from 200.0 ± 42.6 mg/dL in participants without DR to 322.4 ± 71.9 mg/dL among those with PDR. The overall difference and rank correlation were significant, and each 50 mg/dL increase was associated with 2.56 times higher adjusted odds of belonging to a more severe DR category.

The observed pattern is consistent with studies relating poor glycaemic control to DR severity.[6-9] Landmark trials demonstrated that intensive glucose management reduces the development or progression of diabetic microvascular complications.[10-12] The present cross-sectional association supports the importance of metabolic management but cannot establish that the RBS measured at the camp caused the observed retinal grade.

RBS is influenced by recent meals, medication timing, stress and intercurrent illness. It is practical for outreach work but does not represent chronic glycaemic exposure as accurately as HbA1c. Future camp studies should include HbA1c where feasible, particularly when the objective is to evaluate long-term control.

Diabetes Type

DR was present in eight of 12 participants with type 1 diabetes and in 84 of 188 with type 2 diabetes. Although the type 1 subgroup had a numerically greater burden of advanced disease, the comparison was not statistically significant. The wide confidence interval around the adjusted estimate reflects the small type 1 sample. These findings should not be interpreted as evidence that diabetes type is unrelated to DR; the study was not powered for a definitive comparison between types.

Hypertension

Hypertension was present in 82 participants and was associated with a clear shift towards more severe DR. Severe NPDR or PDR affected 26.8% of hypertensive participants compared with 10.1% of those without hypertension. After adjustment, hypertension remained associated with 2.70 times higher odds of increasing severity.

This relationship is clinically plausible because elevated vascular pressure and endothelial dysfunction may aggravate retinal capillary leakage and ischaemia. Indian studies have also identified blood-pressure-related variables as important correlates of diabetic microvascular disease.[4,5] The finding supports integrated control of both glucose and blood pressure in patients undergoing retinal screening.

Visual Acuity and Diabetic Macular Edema

Mean study-eye BCVA worsened from 0.16 ± 0.11 logMAR in participants without DR to 0.90 ± 0.35 logMAR among those with PDR. DME was detected in 26 participants and became more frequent with advancing severity, reaching 50.0% among participants with PDR.

The association between advanced retinal disease and reduced visual acuity is expected, but visual impairment in a camp population can also be influenced by cataract, refractive error, corneal disease and macular ischaemia. DME was diagnosed clinically. In the absence of OCT confirmation, subtle retinal thickening may have been missed, and the reported prevalence should be interpreted as clinically detected DME.

Awareness and Screening Utilisation

Only 43.5% of participants knew that diabetes could damage the retina, 29.0% knew that early DR could remain asymptomatic, and 36.0% knew that periodic retinal examination was required. Only 34.0% had ever undergone a previous dilated retinal examination, while 66.0% had never been examined.

The gap between diabetes care and retinal screening is important because early disease may not affect vision. Rural screening studies have shown that community education, accessible screening locations and integrated diabetic-eye services can improve uptake.[14-16] The present findings support counselling at every diabetes encounter and linkage of outreach screening with a reliable referral and follow-up pathway.

Independent Predictors and Clinical Implications

Duration, RBS and hypertension remained independently associated with increasing severity after adjustment for age, sex and diabetes type. These readily available variables may help identify participants who require expedited dilated examination or referral when camp capacity is limited. Risk-based prioritisation should supplement, not replace, regular retinal screening for all patients with diabetes.

Sen and colleagues highlighted the potential value of targeted screening using routinely available clinical information in resource-limited settings.[13] In the present cohort, patients with long-standing diabetes, markedly elevated RBS or hypertension constituted a particularly high-risk group. Those with reduced vision, DME or severe NPDR/PDR require prompt referral to a retinal service.

CONCLUSION

Among diabetic patients attending outreach eye camps, longer duration of diabetes, higher current random blood sugar and coexisting hypertension were independently associated with more advanced diabetic retinopathy. DR was identified in nearly half of the participants, and advanced grades were accompanied by poorer visual acuity and a greater frequency of diabetic macular edema. The substantial proportion of participants who had never undergone dilated retinal examination demonstrates an important screening gap.

Patients with long-standing diabetes, markedly elevated glucose, hypertension, reduced vision or suspected macular edema should be prioritised for prompt retinal assessment and referral. Regular dilated retinal examination, better metabolic and blood-pressure management, patient education and dependable camp-to-hospital referral pathways are essential to reduce avoidable visual impairment in rural and semi-rural diabetic populations.

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