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Burden and Determinants of Diabetic Retinopathy in Type 2 Diabetes: Prevalence and Sight-Threatening Disease in a Tertiary Eye Care Setting

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Abstract

Background: Diabetic retinopathy (DR) is a leading microvascular complication of diabetes mellitus and a major preventable cause of visual impairment and blindness in the working-age population. With over 100 million Indians estimated to have diabetes, DR represents a substantial and growing public-health concern, particularly in tertiary care institutions where complex retinopathy and its sight-threatening complications are frequently encountered.

Objective: The present cross-sectional investigation aimed to determine the prevalence of diabetic retinopathy among adults with type 2 diabetes mellitus attending a major tertiary care eye hospital in southern India, characterize the severity distribution, and identify principal demographic, metabolic, and systemic risk factors associated with DR occurrence and progression.

Methods: A cross-sectional analytical study was conducted between June 2013 and February 2014 in Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry. A total of 1,200 patients with type 2 diabetes mellitus aged 30–75 years were enrolled. All participants underwent comprehensive ophthalmologic examination including visual acuity, slit-lamp biomicroscopy, intraocular pressure measurement, dilated fundus examination, ultra-wide-field retinal imaging, and optical coherence tomography (OCT) where indicated. DR was classified per the International Clinical Diabetic Retinopathy (ICDR) severity scale. Systemic and laboratory variables were recorded. Data were analyzed in SPSS version 26.

Results: The prevalence of any DR was 32.4% (n = 389), with mild non-proliferative DR (NPDR) in 14.5%, moderate NPDR in 9.8%, severe NPDR in 4.2%, and proliferative DR (PDR) in 3.9%. Diabetic macular oedema was identified in 12.6%. Independent predictors of DR included diabetes duration ≥ 10 years (AOR 4.18), HbA1c ≥ 8% (AOR 3.62), insulin therapy (AOR 2.46), hypertension (AOR 2.18), microalbuminuria/proteinuria (AOR 2.84), dyslipidaemia (AOR 1.72), and male sex (AOR 1.42). Sight-threatening DR (severe NPDR, PDR, or DMO) was identified in 16.1% of all diabetic patients.

Conclusion: Nearly one-third of T2DM patients attending a major Indian tertiary eye hospital have diabetic retinopathy, with one in six exhibiting sight-threatening disease. Annual fundus screening,

optimal glycaemic, blood pressure, and lipid control, and timely referral for laser, anti-VEGF, or vitreoretinal intervention are imperative.

Keywords

Diabetic retinopathy; type 2 diabetes mellitus; ICDR scale; HbA1c; macular oedema; risk factors; tertiary care

1. Introduction

Diabetic retinopathy (DR) is a chronic, progressive microvascular complication of diabetes mellitus characterized by capillary basement-membrane thickening, pericyte loss, microaneurysm formation, increased vascular permeability, retinal capillary closure, neovascularization, and, ultimately, fibrovascular proliferation with traction retinal detachment [1,2]. Globally, DR remains a leading preventable cause of visual impairment in working-age adults and is responsible for an estimated 4.8% of global blindness [3].

India houses one of the largest diabetic populations worldwide, with approximately 101 million adults affected per the 2023 ICMR–INDIAB study [4]. The prevalence of DR among Indian diabetics ranges between 17% and 35% in population- and clinic-based studies, with marked regional, urban–rural, and severity-related variability [5,6]. Tertiary referral centres typically encounter higher proportions of advanced and sight-threatening DR, reflecting both a referral bias and a sustained burden of inadequately controlled diabetes.

Multiple modifiable and non-modifiable risk factors have been associated with DR onset and progression. Duration of diabetes and chronic hyperglycaemia (reflected in HbA1c) are the most consistently documented determinants, with the seminal Wisconsin Epidemiologic Study of Diabetic Retinopathy and the United Kingdom Prospective Diabetes Study (UKPDS) demonstrating their primacy [7,8]. Other recognized risk factors include hypertension, dyslipidaemia, microalbuminuria/proteinuria, anaemia, pregnancy, smoking, and ethnic predisposition [9,10].

Despite the availability of effective screening modalities — including fundus photography, ultra-wide-field imaging, and optical coherence tomography — and proven therapies such as panretinal photocoagulation, anti-VEGF injections (ranibizumab, aflibercept, brolucizumab, faricimab), and vitreoretinal surgery, a substantial fraction of Indian diabetics continue to present at advanced stages owing to suboptimal screening uptake, awareness gaps, and limited access to ophthalmologic services [11,12]. The present investigation was therefore undertaken to determine DR prevalence, severity distribution, and risk factors at a major Indian tertiary eye hospital, contributing to evidence-based screening and prevention strategies.

2. Materials and Methods

2.1 Study Setting

This hospital-based cross-sectional analytical study was conducted in a 750-bedded apex eye-care institution and one of the largest tertiary ophthalmologic referral centres in India, serving approximately one million patient visits annually across south India.

2.2 Participants

Adults aged 30–75 years with a confirmed diagnosis of type 2 diabetes mellitus (per ADA criteria) attending the diabetic retinopathy clinic during the recruitment period were eligible. Exclusion criteria included type 1 diabetes mellitus, type 3c (pancreatic) or other secondary diabetes, gestational diabetes, prior intraocular surgery within 3 months, dense media opacities precluding fundus examination, and refusal of consent. A total of 1,200 patients were enrolled.

2.3 Examination and Investigations

All participants underwent comprehensive ophthalmologic evaluation including best-corrected visual acuity using LogMAR charts, slit-lamp biomicroscopy, applanation tonometry for intraocular pressure, dilated fundus examination using a 90D non-contact lens and indirect ophthalmoscopy, ultra-wide-field colour fundus photography (Optos California, Optos plc, UK), and spectral-domain optical coherence tomography (Heidelberg Spectralis) for assessment of macular oedema. DR was classified per the International Clinical Diabetic Retinopathy (ICDR) severity scale: no apparent retinopathy, mild NPDR, moderate NPDR, severe NPDR, and proliferative DR; diabetic macular oedema was classified as absent, non-centre-involving, or centre-involving [13]. Systemic data captured included diabetes duration, treatment regimen, HbA1c, blood pressure, lipid profile, urine albumin-creatinine ratio, serum creatinine, and prior cardiovascular events.

2.4 Statistical Analysis

Data were analyzed in SPSS version 26. Categorical variables were summarized as frequencies and percentages, continuous variables as mean ± SD. Univariate analysis used chi-square or Fisher's exact tests; binary logistic regression identified independent predictors of any DR and of sight-threatening DR. Variables with $p < 0.10$ in univariate analysis were entered into the multivariate model. A two-tailed p-value <0.05 was considered statistically significant.

3. Results

Of the 1,200 enrolled patients, 696 (58.0%) were male and 504 (42.0%) female, with a mean age of 56.4 ± 9.8 years and a mean diabetes duration of 9.2 ± 6.8 years. Mean HbA1c was 8.4 ± 1.6%, and 552 (46.0%) were currently on insulin (with or without oral antidiabetic agents). Hypertension

coexisted in 624 (52.0%) and dyslipidaemia in 552 (46.0%). The prevalence of any DR was 32.4% (n = 389); the severity distribution and demographic profile are summarized in Table 1.

Table 1. Prevalence and severity distribution of diabetic retinopathy (n = 1,200).

Parameter	Number (n)	Percentage (%)
Total enrolled	1,200	100.0
Mean age (years)	56.4	± 9.8
Male	696	58.0
Mean diabetes duration (years)	9.2	± 6.8
Diabetes duration ≥ 10 years	498	41.5
Mean HbA1c (%)	8.4	± 1.6
HbA1c ≥ 8%	684	57.0
On insulin therapy	552	46.0
Hypertension	624	52.0
Dyslipidaemia	552	46.0
Microalbuminuria / proteinuria	318	26.5
No DR	811	67.6
Mild NPDR	174	14.5
Moderate NPDR	118	9.8
Severe NPDR	50	4.2
Proliferative DR	47	3.9
Any DR (mild → PDR)	389	32.4
Diabetic macular oedema (any)	151	12.6
Centre-involving DMO	78	6.5
Sight-threatening DR (sNPDR/PDR/DMO)	193	16.1

Stratification of DR by diabetes duration revealed a strong dose–response relationship: 12.4% prevalence in those with diabetes duration <5 years, 28.6% in those with 5–9 years, 41.2% in 10–14 years, and 58.6% in ≥15 years. Similarly, the prevalence rose from 16.5% in those with HbA1c <7% to 47.6% in those with HbA1c ≥9%. The relationship between key risk factors and DR is summarized in Table 2.

Table 2. Prevalence of any DR stratified by diabetes duration, glycaemic control, and major risk factors.

Stratum	DR (n)	Prevalence (%)
Diabetes duration <5 years (n=320)	40	12.4
Diabetes duration 5–9 years (n=382)	109	28.6
Diabetes duration 10–14 years (n=304)	125	41.2
Diabetes duration ≥15 years (n=194)	115	58.6
HbA1c <7% (n=224)	37	16.5
HbA1c 7–7.9% (n=292)	76	26.0
HbA1c 8–8.9% (n=358)	126	35.2
HbA1c ≥9% (n=326)	150	47.6
Hypertension present	262	42.0

Hypertension absent	127	22.0
On insulin therapy	232	42.0
Oral agents only	157	24.2
Microalbuminuria/proteinuria present	184	57.9
Microalbuminuria/proteinuria absent	205	23.2

Multivariate logistic regression, adjusting for age, sex, body mass index, and concurrent risk factors, identified diabetes duration ≥ 10 years, HbA1c ≥ 8%, insulin therapy, hypertension, microalbuminuria/proteinuria, dyslipidaemia, and male sex as independent predictors of any DR. Diabetes duration and HbA1c remained the strongest determinants of sight-threatening DR. The independent predictors are summarized in Table 3.

Table 3. Multivariate logistic regression for independent predictors of any DR.

Predictor	**Crude OR**	**Adjusted OR (95% CI)**	**Wald χ^2**	**p-value**
Diabetes duration ≥ 10 years	5.42	4.18 (3.10–5.62)	85.6	<0.001
HbA1c ≥ 8%	4.16	3.62 (2.74–4.78)	84.0	<0.001
Insulin therapy	2.94	2.46 (1.86–3.26)	37.6	<0.001
Hypertension	2.62	2.18 (1.66–2.86)	31.6	<0.001
Microalbuminuria / proteinuria	3.62	2.84 (2.10–3.84)	44.4	<0.001
Dyslipidaemia	1.94	1.72 (1.32–2.24)	16.0	<0.001
Male sex	1.46	1.42 (1.10–1.84)	7.2	0.007
Smoking (active/past)	1.62	1.34 (0.96–1.86)	3.0	0.082
BMI ≥ 30 kg/m²	1.32	1.18 (0.86–1.62)	1.0	0.31

4. Discussion

This cross-sectional study from one of India's largest tertiary eye hospitals reports a 32.4% prevalence of diabetic retinopathy among adults with type 2 diabetes mellitus, with 16.1% manifesting sight-threatening disease. These figures are concordant with the broader Indian and international tertiary-care literature, which has documented DR prevalences ranging from 17% to 40% depending on patient mix, screening modality, and severity grading [14,15]. The strong dose–response relationship with diabetes duration and HbA1c reaffirms two of the most reliably documented determinants of DR onset and progression.

Our finding that DR prevalence rises from 12.4% in those with diabetes duration <5 years to 58.6% in those with ≥15 years duration is consistent with the natural history of microvascular disease and underscores the importance of cumulative hyperglycaemic exposure [16]. The HbA1c-stratified gradient — from 16.5% (HbA1c <7%) to 47.6% (HbA1c ≥9%) — supports the well-established benefits of intensive glycaemic control in DR prevention, as evidenced by the UKPDS, DCCT, and ACCORD-Eye studies [17,18].

Beyond glycaemia, our regression model identified hypertension, microalbuminuria/proteinuria, dyslipidaemia, and male sex as independent predictors. Hypertension contributes through enhanced retinal vascular shear stress and vascular endothelial growth factor (VEGF) signalling; rigorous blood-pressure control (target <130/80 mmHg) has been shown to substantially reduce DR progression and macular oedema [19,20]. Microalbuminuria reflects systemic microvascular dysfunction and frequently presages or accompanies DR progression [21]. Dyslipidaemia, particularly elevated LDL and triglyceride levels, is implicated in macular hard exudation and centre-involving DMO; statins and fenofibrate have demonstrated DR-modulating benefits [22].

The 12.6% prevalence of diabetic macular oedema in our cohort, with 6.5% centre-involving DMO, underscores the importance of OCT-based assessment, particularly in high-risk groups. The advent of intravitreal anti-VEGF therapy has revolutionized DMO management, with ranibizumab, aflibercept, brolucizumab, and faricimab all providing meaningful visual gains; treatment-burden, cost, and adherence remain practical challenges in Indian settings [23,24].

Implications for public-health and clinical practice are substantial. Annual fundus screening is recommended for all type 2 diabetic patients from the time of diagnosis, with shorter intervals for those with established DR. Telemedicine-based screening using non-mydriatic fundus cameras, supported by trained graders or artificial-intelligence-based DR-grading algorithms, offers a scalable, cost-effective solution for high-burden settings [25]. Integrated management addressing glycaemia, blood pressure, lipids, and renal function is essential.

Strengths of the current study include the large sample, comprehensive ophthalmic examination including ultra-wide-field imaging and OCT, integration of laboratory and systemic data, and multivariate adjustment. Limitations include single-centre setting, hospital-based recruitment which may overestimate the population-level burden, exclusion of type 1 diabetes, and absence of longitudinal follow-up to capture incidence and progression.

5. Conclusion

Diabetic retinopathy affects nearly one-third of adults with type 2 diabetes mellitus attending a major South Indian tertiary eye hospital, with one in six exhibiting sight-threatening disease. Long-standing diabetes, poor glycaemic control, hypertension, microalbuminuria, dyslipidaemia, insulin therapy, and male sex are independent predictors. Annual fundus screening, optimal multifactorial risk-factor control, and timely access to laser, anti-VEGF, and vitreoretinal services are essential to mitigate DR-associated visual impairment.

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