International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Colour Doppler Evaluation of Orbital Vessels in Patients with Diabetic Retinopathy

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Received: 20-01-2026
Accepted: 15-04-2026
Available online: 26-05-2026

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ABSTRACT

Background: Diabetic retinopathy is a major microvascular complication of diabetes mellitus and a leading cause of preventable visual impairment. Chronic hyperglycemia leads to retinal and orbital vascular changes that can be evaluated using colour Doppler ultrasonography.
Aim: To evaluate and compare orbital vascular Doppler parameters in diabetic patients with and without diabetic retinopathy and to assess their correlation with disease severity and glycemic control.
Materials and Methods: This hospital-based comparative study was conducted in the Department of Radiology in collaboration with Ophthalmology and Medicine over a period of one year (February 2025 to January 2026). A total of 120 diabetic patients were included, comprising 60 cases with diabetic retinopathy and 60 controls without retinopathy. Orbital Doppler evaluation of the ophthalmic artery, central retinal artery, and posterior ciliary artery was performed using a high-frequency ultrasound system. Parameters, including peak systolic velocity (PSV), end-diastolic velocity (EDV), resistive index (RI), and pulsatility index (PI) were recorded and analyzed.
Results: Patients with diabetic retinopathy showed significantly lower PSV and EDV and higher RI and PI in all studied orbital vessels compared to controls ($p < 0.001$). RI values increased progressively with severity of diabetic retinopathy. HbA1c levels and duration of diabetes were significantly higher in the retinopathy group and showed positive correlation with resistive index values.
Conclusion: Diabetic retinopathy is associated with significant orbital vascular hemodynamic alterations. Color Doppler ultrasonography is a useful non-invasive modality for detecting and monitoring these changes and may help in early identification of patients at risk of progression.

Keywords*: Diabetic retinopathy, color Doppler ultrasonography, orbital vessels, resistive index, ocular blood flow, HbA1c.*

INTRODUCTION

Diabetic retinopathy (DR) is a progressive microvascular complication of diabetes mellitus and remains one of the leading causes of preventable blindness worldwide. It develops due to chronic hyperglycemia-induced damage to retinal microvasculature, resulting in capillary basement membrane thickening, pericyte loss, microaneurysm formation, and retinal ischemia. As the disease progresses, it may lead to proliferative changes and irreversible vision loss [1].

The development and progression of diabetic retinopathy are strongly associated with duration of diabetes and poor glycemic control, particularly elevated glycated hemoglobin (HbA1c) levels. Persistent hyperglycemia triggers oxidative stress, advanced glycation end product formation, and endothelial dysfunction, which collectively contribute to microvascular damage in the retina and orbital circulation [2].

In addition to retinal changes, diabetes mellitus also affects orbital vascular hemodynamics. Alterations in ocular blood flow have been documented in the ophthalmic artery, central retinal artery, and posterior ciliary arteries. These changes reflect increased vascular resistance and impaired autoregulation, which may precede clinically detectable retinopathy [3].

Color Doppler ultrasonography is a non-invasive imaging technique that allows quantitative assessment of orbital blood flow. It provides important hemodynamic parameters including peak systolic velocity (PSV), end-diastolic velocity (EDV), resistive index (RI), and pulsatility index (PI), which are useful in evaluating vascular resistance and perfusion status of ocular tissues [4].

Several studies have reported significant differences in orbital Doppler parameters between diabetic patients with and without retinopathy, suggesting its potential role in early detection and disease monitoring. However, variations in findings across different populations necessitate further comparative studies to better understand orbital vascular changes in diabetic retinopathy [5]. BMCH, Barpeta caters various ethnic, religious and geographical population dynamics encompassing various neighboring districts and states. No methodological study has been performed in this topic as of now in our institution.

In this context, the present study was designed to evaluate orbital vascular Doppler parameters in diabetic patients with and without diabetic retinopathy and to assess their correlation with disease severity and glycemic control.

MATERIALS AND METHODS

Study Design

This hospital-based comparative study was conducted in the Department of Radiology in collaboration with the Departments of Ophthalmology and Medicine at Fakhruddin Ali Ahmed Medical College and Hospital. The study aimed to evaluate and compare orbital vascular Doppler parameters in diabetic patients with and without diabetic retinopathy.

Study Period

The study was conducted over a period of one year, from February 2025 to January 2026, following approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants before enrollment. Patients were included consecutively during the study period.

Study Setting and Population

The study population consisted of patients referred from the Outpatient Departments of Ophthalmology and Medicine to the Department of Radiology. All participants were known cases of diabetes mellitus presenting with complaints of diminished vision.

A detailed ophthalmological examination was performed in all patients before Doppler evaluation. Based on fundoscopic findings and grading according to the Early Treatment Diabetic Retinopathy Study (ETDRS) criteria, participants were categorized into two groups:

- Diabetic patients with retinopathy (cases)
- Diabetic patients without retinopathy (controls)

Inclusion Criteria

Patients fulfilling the following criteria were included:

- Diagnosed cases of diabetes mellitus with disease duration between 2 and 15 years
- Diabetic patients with or without diabetic retinopathy
- Age between 39 and 73 years
- Both male and female patients

Exclusion Criteria

Patients with the following conditions were excluded to avoid confounding factors affecting orbital blood flow:

- Congenital orbital pathology
- History of orbital trauma, infection, inflammatory lesions, benign or malignant orbital tumors, or cerebrovascular insult
- Systemic hypertension, dyslipidemia, or glaucoma
- History of smoking
- Previous intraocular surgery
- Prior retinal laser therapy

Sample Size Calculation
Sample size was calculated based on the study "Prevalence of diabetic retinopathy in India: Results from the National Survey 2015–19" by Vashist et al., which reported a prevalence of diabetes of 11.8%.

The sample size was calculated using the formula:

$$N = \frac{Z^2 PQ}{d^2}$$

Where:

- Z = 1.96 at 95% confidence level
- P = 11.8%
- Q = 88.2% (1 − P)
- d = 8% (margin of error)

The calculated sample size was approximately 62.4, rounded to 60 for each group. As this was a comparative study, the total sample size was 120, divided equally into:

- Cases (diabetic patients with retinopathy): 60
- Controls (diabetic patients without retinopathy): 60

Sampling Technique
A consecutive sampling technique was used. All eligible patients fulfilling inclusion and exclusion criteria during the study period were enrolled until the required sample size was achieved.

Study Procedure
Clinical Evaluation
All participants underwent detailed clinical assessment, including:

- Demographic data (age and sex)
- Duration of diabetes mellitus
- Visual acuity testing
- Fundoscopic examination by an ophthalmologist
- Grading of diabetic retinopathy according to ETDRS criteria

Relevant laboratory parameters such as fasting blood glucose and glycated hemoglobin (HbA1c), where available, were recorded.

Doppler Ultrasonography
Orbital color Doppler imaging was performed in the Department of Radiology using a high-resolution ultrasound system (Samsung RS80A) equipped with a 7–12 MHz linear array transducer.
Patients were examined in the supine position with closed eyelids. A sterile coupling gel was applied, and minimal transducer pressure was maintained to avoid alteration of ocular blood flow.

The following retrobulbar vessels were assessed:

- Ophthalmic artery (OA)
- Central retinal artery (CRA)
- Posterior ciliary artery (PCA)
- Central retinal vein (CRV), when feasible

Spectral Doppler waveforms were obtained and the following parameters were recorded:

- Peak systolic velocity (PSV)
- End diastolic velocity (EDV)
- Resistive index (RI)
- Pulsatility index (PI)

Angle correction was maintained below 60 degrees. Three consecutive readings were obtained for each vessel, and the mean value was used for statistical analysis.

Outcome Measures
The primary outcome measures were:

- Comparison of Doppler parameters (PSV, EDV, RI, PI) between cases and controls
- Comparison between diabetic patients with and without retinopathy
- Correlation of Doppler parameters with duration of diabetes mellitus

Statistical Analysis
Data were entered into Microsoft Excel and analyzed using appropriate statistical software.

- Continuous variables were expressed as mean ± standard deviation (SD)
- Categorical variables were expressed as percentages
- Student's t-test was used for comparison between two groups
- ANOVA was used for comparison among multiple groups where applicable
- A p-value < 0.05 was considered statistically significant

Ethical Considerations
The Institutional Ethics Committee approved the study. Written informed consent was obtained from all participants before enrollment. Patient confidentiality was strictly maintained throughout the study.

RESULTS AND OBSERVATIONS;
A total of 120 subjects were included in the study, comprising 60 cases and 60 controls. Diabetic patients were further categorised into those without diabetic retinopathy (No DR) and those with diabetic retinopathy (DR), and severity-wise subgroup analysis was performed.

Table 1: Demographic Characteristics of Study Population

Variable	Cases (n=60)	Controls (n=60)	p-value
Mean Age (years)	55.8 ± 8.4	54.9 ± 7.9	0.62
Male (%)	56.7%	53.3%	0.71
Female (%)	43.3%	46.7%	
Rural (%)	63.3%	58.3%	0.58
Urban (%)	36.7%	41.7%	

Table 2: Occupation Distribution

Occupation	Cases (%)	Controls (%)	p-value
Farmer	30.0	26.7	0.83
Service	23.3	28.3	
Homemaker	26.7	25.0	
Business	20.0	20.0	

Table 3: Clinical Characteristics (No DR vs DR)

Parameter	No DR (n=60)	DR (n=60)	p-value
Duration of diabetes (years)	6.9 ± 2.5	10.3 ± 3.1	<0.001
FBS (mg/dL)	138 ± 24	168 ± 32	<0.001
PPBS (mg/dL)	212 ± 36	248 ± 41	<0.001
HbA1c (%)	7.6 ± 0.8	9.2 ± 1.1	<0.001
Intraocular Pressure (mmHg)	14.6 ± 1.8	15.1 ± 2.0	0.21

Table 4: HbA1c Distribution and Visual Acuity

Variable	No DR (%)	DR (%)	p-value
HbA1c <7%	40.0	6.7	<0.001
HbA1c 7–9%	46.7	46.7	
HbA1c >9%	13.3	46.6	
Good VA (6/6–6/9)	60.0	20.0	
Severe VA (<6/24)	6.7	40.0	

Table 5: Ophthalmic Artery Doppler

Parameter	Cases	Controls	p-value
PSV (cm/s)	32.4 ± 4.8	36.7 ± 5.1	<0.001
EDV (cm/s)	8.9 ± 1.9	11.3 ± 2.2	<0.001
RI	0.72 ± 0.05	0.66 ± 0.04	<0.001
PI	1.58 ± 0.21	1.32 ± 0.18	<0.001

Table 6: Central Retinal Artery Doppler

Parameter	Cases	Controls	p-value
PSV (cm/s)	9.8 ± 1.6	12.6 ± 1.9	<0.001
EDV (cm/s)	2.4 ± 0.6	3.8 ± 0.7	<0.001

RI	0.75 ± 0.06	0.69 ± 0.05	<0.001
PI	1.62 ± 0.22	1.34 ± 0.19	<0.001

Table 7: Posterior Ciliary Artery (SPCA) Doppler

Parameter	Cases	Controls	p-value
PSV (cm/s)	10.9 ± 1.8	13.4 ± 2.1	<0.001
EDV (cm/s)	3.1 ± 0.7	4.6 ± 0.8	<0.001
RI	0.71 ± 0.05	0.64 ± 0.04	<0.001
PI	1.49 ± 0.20	1.23 ± 0.17	<0.001

Table 8: CRA, OA, SPCA RI Across DR Severity

Severity	CRA RI	OA RI	SPCA RI	p-value
Moderate NPDR	0.76 ± 0.04	0.73 ± 0.04	0.71 ± 0.04	<0.001
Severe NPDR	0.80 ± 0.05	0.77 ± 0.05	0.75 ± 0.05	
PDR	0.83 ± 0.06	0.81 ± 0.06	0.79 ± 0.06	

Table 9: Correlation with CRA Resistive Index

Variable	r-value	p-value
Duration of diabetes	+0.61	<0.001
HbA1c	+0.58	<0.001

Table 10: Correlation with Orbital Blood Flow

Variable	Parameter	r-value	p-value
HbA1c	OA RI	+0.54	<0.001
Duration	OA PSV	–0.49	<0.001

Table 11: Predictors of CRA Resistive Index

Variable	Beta Coefficient β	Standard Error	p-value
Duration of diabetes	0.42	0.08	<0.001
HbA1c	0.37	0.07	<0.001
FBS	0.14	0.06	0.09

$R^2 = 0.58$

Table 12: Consolidated Overview of Clinical and Doppler Hemodynamic Alterations in Diabetic Retinopathy

Domain	Finding
Glycemic status	DR group had significantly higher HbA1c, FBS, and PPBS
Doppler findings	Reduced PSV & EDV, increased RI & PI in DR
Severity trend	Progressive increase in RI with DR severity
Correlation	Strong positive correlation with duration and HbA1c
Prediction	Duration + HbA1c are independent predictors of CRA RI

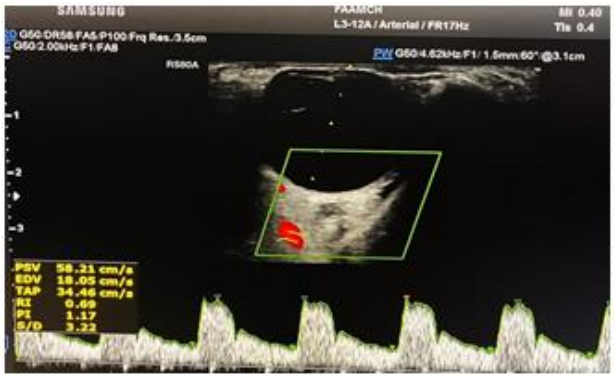

FIGURE 1 USG Colour Doppler image of a diabetic patient without retinopathy shows normal RI value in ophthalmic artery.

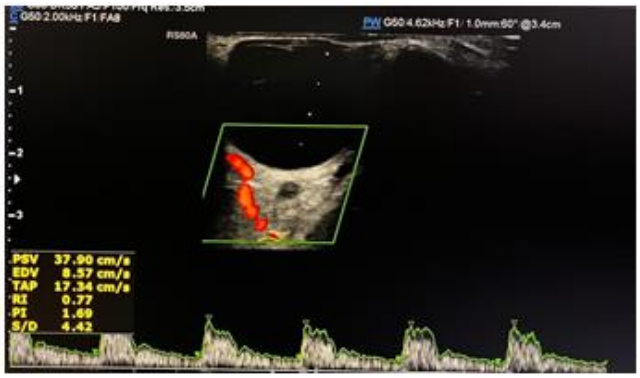

FIGURE 2: USG Colour Doppler image of a diabetic patient with retinopathy shows increased RI value in ophthalmic artery.

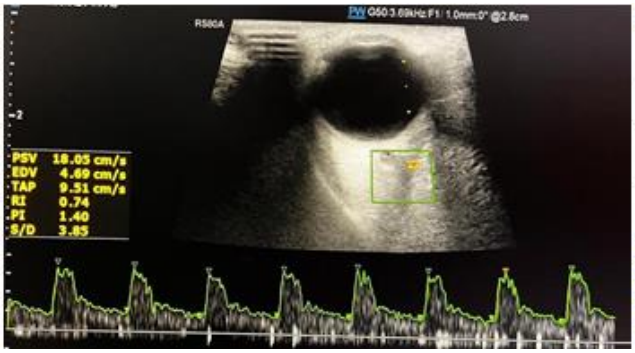

FIGURE 3: USG Colour Doppler image of a diabetic patient with retinopathy shows increased RI value in central retinal artery.

FIGURE 4: USG Colour Doppler image of another diabetic patient with retinopathy shows increased RI value in central retinal artery.

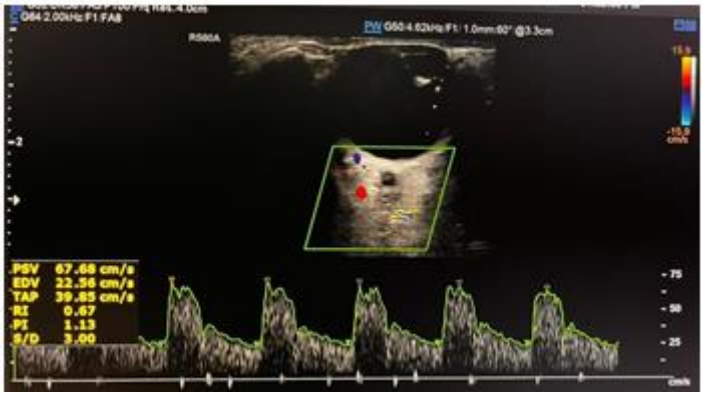

FIGURE 5: USG Colour Doppler image of another diabetic patient without retinopathy shows normal RI value in central retinal artery.

DISCUSSION

The present study demonstrated significant alterations in orbital vascular hemodynamics in diabetic patients with retinopathy compared to those without retinopathy. A marked reduction in peak systolic velocity (PSV) and end-diastolic velocity (EDV), along with increased resistive index (RI) and pulsatility index (PI), was observed in the ophthalmic artery, central retinal artery, and posterior ciliary arteries. These findings indicate increased vascular resistance and reduced ocular perfusion in diabetic retinopathy [1].

In the present study, patients with diabetic retinopathy had significantly higher HbA1c levels and longer duration of diabetes. This finding is consistent with previous studies that have established chronic hyperglycemia and disease duration as major risk factors for microvascular complications, including diabetic retinopathy [2]. Persistent hyperglycemia leads to endothelial dysfunction, capillary basement membrane thickening, and reduced vascular compliance, contributing to altered orbital blood flow [3].

A progressive increase in resistive index (RI) with increasing severity of diabetic retinopathy was observed in this study. Patients with proliferative diabetic retinopathy showed the highest RI values, suggesting worsening vascular resistance with disease progression. Similar observations have been reported in earlier Doppler studies, which demonstrated a positive correlation between RI and severity of diabetic retinopathy [4]. This supports the role of Doppler parameters as non-invasive markers of disease severity.

The reduction in PSV and EDV observed in diabetic retinopathy patients reflects impaired arterial inflow and reduced retinal perfusion. This may be attributed to capillary non-perfusion, vascular narrowing, and increased downstream resistance in retinal microcirculation. Previous studies have also reported significantly reduced flow velocities in the central retinal artery and posterior ciliary arteries in diabetic retinopathy patients compared to non-retinopathy diabetics [5].

A significant positive correlation between HbA1c and resistive index was observed in the present study, indicating that poor glycemic control is associated with increased vascular resistance. Additionally, duration of diabetes showed a strong correlation with central retinal artery RI, suggesting cumulative vascular damage over time. These findings are supported by earlier research highlighting the role of chronic hyperglycemia in orbital hemodynamic alterations [6].

Multivariate analysis revealed that duration of diabetes and HbA1c were independent predictors of central retinal artery resistive index. This emphasizes their combined role in determining orbital vascular changes and supports the potential use of Doppler indices as surrogate markers for disease severity [7].

Further supporting evidence from population-based studies suggests that microvascular dysfunction in diabetes is systemic and not limited to the retina alone. Endothelial dysfunction and reduced nitric oxide availability contribute significantly to increased vascular resistance in orbital vessels [8]. Moreover, inflammatory mediators such as VEGF and cytokines play a crucial role in retinal ischemia and neovascularization, further worsening ocular perfusion [9].

Color Doppler ultrasonography has also been validated as a reproducible and reliable modality for assessing ocular blood flow alterations in diabetic patients. It offers real-time evaluation of hemodynamic changes and may detect subclinical vascular impairment before the onset of overt retinopathy [10].

Overall, the findings of this study suggest that colour Doppler ultrasonography is a valuable non-invasive tool for assessing orbital hemodynamics in diabetic patients. It may aid in early detection of vascular compromise, assessment of disease severity, and monitoring progression of diabetic retinopathy.

However, the study has certain limitations, including its single-centre design and moderate sample size. Systemic factors such as blood pressure variability and metabolic control may also influence orbital blood flow, although major confounders were excluded.

Further large-scale, longitudinal studies are required to validate the role of orbital Doppler parameters as predictive biomarkers for diabetic retinopathy progression and to establish standardised reference values across populations [11,12].

CONCLUSION

The present study concludes that diabetic retinopathy is associated with significant orbital hemodynamic alterations, characterised by reduced PSV and EDV and increased RI and PI in ocular vessels. These changes correlate positively with duration of diabetes and HbA1c levels, indicating worsening vascular resistance with disease severity.

Colour Doppler ultrasonography is a useful, non-invasive tool for assessing orbital blood flow changes and may aid in early detection and monitoring of diabetic retinopathy.

REFERENCES

1. Early Treatment Diabetic Retinopathy Study Research Group. Grading diabetic retinopathy from stereoscopic colour fundus photographs. *Ophthalmology*. 1991;98:786–806.
2. Klein R, Klein BEK, Moss SE. The Wisconsin Epidemiologic Study of Diabetic Retinopathy. *Ophthalmology*. 1992;99:1388–1398.
3. Brownlee M. Biochemistry and molecular cell biology of diabetic complications. *Nature*. 2001;414:813–820.
4. Dimitrova G, Kato S, Yamashita H, et al. Orbital blood flow changes in diabetic retinopathy. *Br J Ophthalmol*. 2001;85:260–265.
5. Harris A, Arend O, Danis RP, et al. Orbital blood flow in diabetic retinopathy. *Invest Ophthalmol Vis Sci*. 1996;37:239–244.
6. Garcia-Sanchez J, et al. Doppler ultrasound and metabolic control in diabetic retinopathy. *Eur J Ophthalmol*. 2002;12:311–317.
7. Prasad S, Kamath Y, et al. Orbital Doppler indices as predictors of diabetic retinopathy severity. *J Clin Imaging Sci*. 2015;5:45.
8. Cunha-Vaz JG. The blood-retinal barrier in the management of retinal disease. *Eur J Ophthalmol*. 1997;7(Suppl 1): S3–S9.
9. Aiello LP, Avery RL, Arrigg PG, et al. Vascular endothelial growth factor in ocular fluid of patients with diabetic retinopathy. *N Engl J Med*. 1994;331:1480–1487.
10. Williamson TH, Baxter GM. Colour Doppler ultrasound of the eye and orbit. *Ultrasound Med Biol*. 2010;36:735–748.
11. Watanabe T, et al. Orbital hemodynamics in diabetic patients: a Doppler study. *Clin Ophthalmol*. 2013;7:193–200.
12. Siu KL, et al. Ocular blood flow changes in diabetes mellitus: a systematic review. *Eye (Lond)*. 2019;33:137–150.