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Factors Associated With Short-Term Visual Outcome in Patients With Retinal Vein Occlusion: A Prospective Observational Study at a Tertiary Care Center in Eastern India

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Abstract

Background

Retinal vein occlusion (RVO) is an important retinal vascular disorder and a significant cause of visual impairment worldwide. Although advances in treatment have improved the management of RVO, visual recovery remains variable among patients. Identifying demographic, systemic, and ocular factors associated with visual prognosis may help in clinical assessment, counseling, and follow-up planning. The present study evaluated demographic, systemic, and ocular factors associated with visual outcome at 60 days in patients with established RVO.

Methods

This prospective observational study was conducted at the Regional Institute of Ophthalmology, Rajendra Institute of Medical Sciences, Ranchi, following institutional ethics approval. A total of 60 patients with confirmed RVO aged 41-60 years comprised the enrolled cohort. Participants underwent detailed ophthalmic evaluation, including best-corrected visual acuity (BCVA), fundus examination, optical coherence tomography, fundus fluorescein angiography, and relevant laboratory investigations. Patients were followed for 60 days, with clinical assessments scheduled on days 1, 7, 21, 45, and 60. The primary visual outcome was final BCVA at 60-day follow-up, categorized as good (BCVA better than 6/18) or poor (BCVA of 6/18 or worse). Data were analyzed using SPSS (IBM Corp., Armonk, NY). Appropriate parametric and nonparametric categorical analyses, including independent-samples t-tests, chi-square tests, Fisher's exact test, paired t-test, and multivariable logistic regression, were performed. A two-sided p-value of <0.05 was considered statistically significant.

Results

Of the 60 patients, 35 (58.3%) were men, and 25 (41.7%) were women. Hypertension was present in 21 (35.0%) patients, diabetes mellitus in 26 (43.3%), hyperlipidemia in 28 (46.7%), and previous cerebrovascular events in 12 (20.0%). Increasing age was significantly ($p = 0.0037$) associated with poorer visual outcome among patients with established RVO. Previous cerebrovascular events were also significantly associated with visual outcome ($\chi^2 = 4.444$; degrees of freedom {df} = 1; $p = 0.035$; ϕ=0.272), while most other systemic risk factors were not significantly associated with outcome. Baseline fundus pattern showed a significant association with visual outcome ($\chi^2 = 21.854$; df = 6; $p = 0.001$; Cramer's V = 0.604), whereas lens status was not significantly associated with outcome ($\chi^2 = 2.639$; df = 2; $p = 0.267$; Cramer's V = 0.210). Best-corrected visual acuity improved significantly from baseline to follow-up ($p < 0.001$). In multivariable analysis, age and previous cerebrovascular events were statistically associated with poor visual outcome. At the 60-day follow-up, 36 (60.0%) patients had a good visual outcome, and 24 (40.0%) had a poor visual outcome. Mean BCVA improved from 40.54 ± 13.27 at baseline to 31.05 ± 14.06 at follow-up ($p < 0.001$).

Conclusion

Visual outcome in patients with established RVO was associated with age, baseline retinal characteristics, and previous cerebrovascular disease, whereas lens status was not significantly associated with outcome. Visual acuity improved during follow-up, although the observational design and variation in treatment received do not permit the attribution of this improvement to any specific treatment. Comprehensive ophthalmic assessment and evaluation of systemic vascular history may assist in prognostic assessment and individualized follow-up of patients with established RVO.

Categories: Pathology, Public Health, Ophthalmology

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Keywords: best-corrected visual acuity, fundus findings, optical coherence tomography, retinal vein occlusion, visual prognosis

Introduction

Retinal vein occlusion (RVO) is an important retinal vascular disorder caused by impaired venous drainage within the retinal circulation and may result in visual loss due to retinal hemorrhage, impaired microvascular perfusion, and macular edema. It is considered the second most common retinal vascular disorder after diabetic retinopathy and represents an important cause of visual morbidity, particularly among older adults. RVO is broadly classified into central retinal vein occlusion (CRVO), branch retinal vein occlusion (BRVO), and hemi-retinal vein occlusion (hemi-RVO), each of which may present with distinct clinical features and visual prognoses [1,2]. Globally, the estimated prevalence of any retinal vein occlusion (RVO) was 0.77% (95% confidence interval {CI}: 0.55%-1.08%) among individuals aged 30-89 years in 2015, with prevalence increasing with advancing age. BRVO was more prevalent than CRVO. Increasing age is associated with a higher prevalence of RVO, partly because of cumulative exposure to vascular risk factors such as hypertension, abnormal glucose metabolism, and age-related arterial changes [3]. Geographic variations in the epidemiology of RVO have also been reported, and the condition represents an important ophthalmic problem in the Indian population in the setting of increasing systemic vascular disease and demographic transition [4].

The pathogenesis of RVO involves complex interactions among altered hemodynamics, vascular endothelial dysfunction, and thrombotic mechanisms, ultimately resulting in retinal ischemia and secondary structural changes that may impair visual function. The principles of Virchow's triad, altered blood flow, vascular wall injury, and abnormalities of blood constituents, provide a useful framework for understanding the development of venous occlusion [1]. In BRVO, particularly at arteriovenous crossings, thickened or rigid retinal arteries may compress adjacent veins, contributing to turbulent blood flow and increased venous pressure [2,5]. Systemic vascular risk factors, especially hypertension, diabetes mellitus, and dyslipidemia, are frequently associated with RVO and may contribute to its development and progression through vascular and endothelial abnormalities [6,7].

Despite advances in the management of RVO, particularly the widespread use of intravitreal anti-vascular endothelial growth factor (anti-VEGF) agents and corticosteroids, visual recovery remains variable. Some patients experience substantial improvement following treatment, whereas others have persistent visual impairment or an incomplete response. This variability highlights the importance of identifying clinical, systemic, and ocular factors associated with visual prognosis to facilitate appropriate patient counseling, risk assessment, and follow-up planning [8]. However, published data describing short-term visual outcomes and associated factors among patients with RVO in this setting are relatively limited. Therefore, the present prospective observational study was undertaken at a tertiary care ophthalmology center in Eastern India to evaluate demographic, systemic, and ocular factors associated with short-term visual outcomes at 60 days in patients with established RVO. The primary outcome was final BCVA at 60 days, categorized as good (>6/18) or poor (≤6/18). Secondary analyses described BCVA during the 60-day follow-up and explored factors associated with poor visual outcome.

Materials And Methods

Study design and setting

This prospective observational study was conducted at the Regional Institute of Ophthalmology, Rajendra Institute of Medical Sciences (RIMS), Ranchi, Jharkhand, India. The study was initiated after obtaining approval from the Institutional Ethics Committee (IEC) of Rajendra Institute of Medical Sciences (RIMS), Ranchi (IEC registration number: ECR/769/INST/JH/2015/RR-21; IEC approval number: 222). The study was conducted in accordance with the ethical principles applicable to research involving human participants. Written informed consent was obtained from all eligible participants before enrollment.

Sample size estimation

The sample size was initially estimated using the formula $n = 4PQ/d^2$, where P represents the anticipated proportion, Q represents 100-P, and d represents the acceptable absolute margin of error. In the absence of a single reliable estimate applicable to the heterogeneous retinal vein occlusion population, a conservative anticipated proportion of 50% was assumed, with an absolute margin of error of 10%. Accordingly, the calculated sample size was 100 participants. However, because of the limited availability of eligible patients during the predefined recruitment period and feasibility constraints at the study center, 60 patients were ultimately enrolled and completed follow-up. Thus, the final sample size was feasibility-based and lower than the initially calculated requirement.

Following IEC approval, consecutive patients presenting to the ophthalmology department with confirmed RVO were recruited from June 2025 to July 2025. RVO was diagnosed clinically by the ophthalmologist based on characteristic fundus findings of retinal venous occlusion. During the recruitment period, 78 patients were screened for eligibility. Eighteen patients were excluded, including seven who did not meet the

eligibility criteria, five with incomplete medical records, and six with poor follow-up compliance. Sixty eligible patients were enrolled and followed prospectively for 60 days. No patients were lost to follow-up, and all 60 enrolled patients completed the scheduled outcome assessment and were included in the final analysis. Clinical assessments were performed on days 1, 7, 21, 45, and 60. Records were checked for completeness before analysis. Variable-level missingness among enrolled participants was not separately documented; therefore, analyses were based on the available complete observations.

The numbers of patients screened, excluded, enrolled, lost to follow-up, and included in the final analysis are presented in the patient flow diagram (Figure *1*).

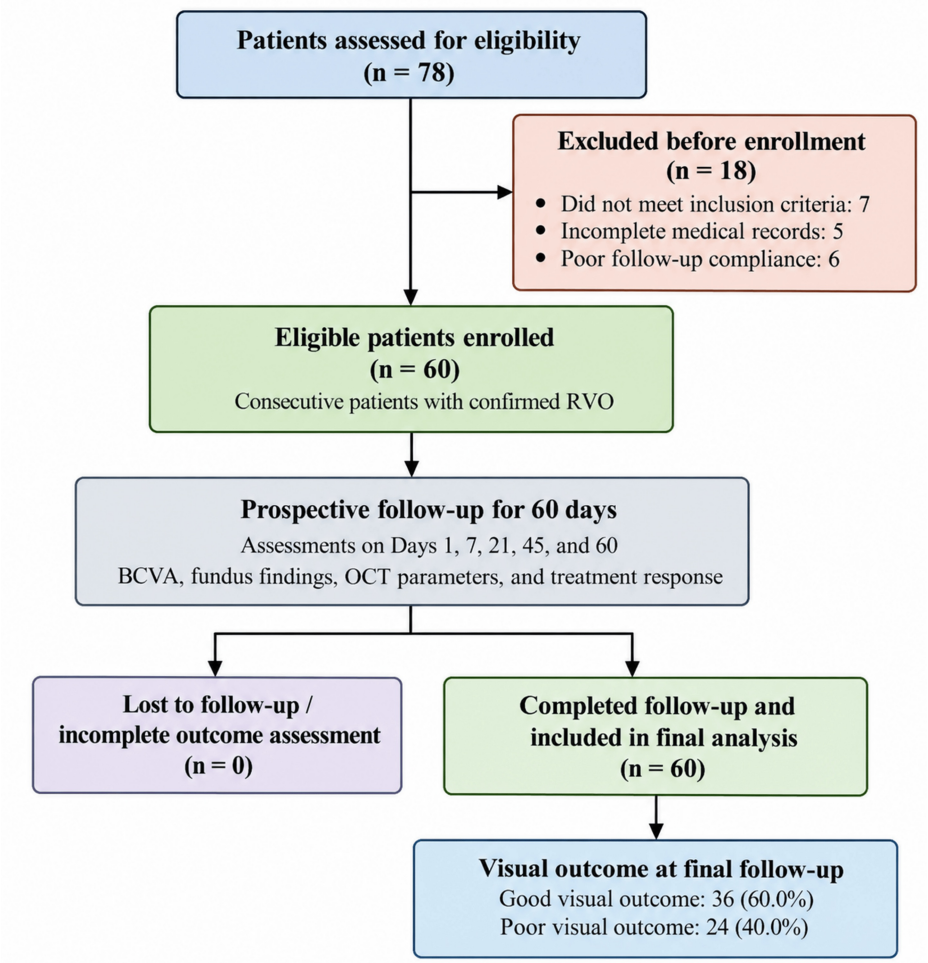


FIGURE 1: Flow diagram of patient recruitment, eligibility assessment, follow-up, and final analysis of patients with retinal vein occlusion

RVO, retinal vein occlusion; BCVA, best-corrected visual acuity; OCT, optical coherence tomography

Selection Criteria

Patients were assessed for eligibility according to predefined inclusion and exclusion criteria. The eligibility criteria are presented in Table *1*. Patients with incomplete clinical or investigative records that precluded outcome assessment and those unable or unwilling to comply with the scheduled follow-up assessments were excluded from the final analysis. An age of >20 years was the prespecified eligibility criterion to capture adult RVO presentations. During the screening process, no patients under 41 years met the full eligibility criteria or presented during the recruitment window, resulting in a final enrolled cohort aged 41-60 years. Patients with systemic diabetes were eligible unless they had another retinal condition that independently affected visual acuity and met the exclusion criteria.

Inclusion criteria	Exclusion criteria
Age of >20 years	Other retinal diseases affecting visual acuity
Confirmed retinal vein occlusion	Previous retinal surgery
Written informed consent	Media opacities preventing adequate fundus evaluation
Willingness to comply with scheduled follow-up	Incomplete medical records
Complete clinical and investigative records	Poor follow-up compliance

TABLE 1: Inclusion and exclusion criteria

Data sources and variables

After obtaining informed consent, demographic, systemic, ocular, and treatment-related information was collected using a structured data collection format. Demographic variables included age and sex. Systemic variables included hypertension, diabetes mellitus, hyperlipidemia, smoking history, previous cerebrovascular accident, coronary artery disease, and oral contraceptive use where applicable. A detailed ophthalmic examination was performed for each participant. Best-corrected visual acuity (BCVA) was assessed using a Snellen chart and converted to the logarithm of the minimum angle of resolution (logMAR) for statistical analysis. For Snellen visual acuity expressed as 6/x, the corresponding logMAR value was calculated as log10(x/6). The conversion was performed using the following formula:

$$\mathrm{logMAR}=\log_{10}\left(\frac{\text{Snellen denominator}}{\text{Snellen numerator}}\right)$$

For numerical reporting, logMAR values were multiplied by 100. Thus, higher numerical values indicated poorer visual acuity, whereas lower values indicated better visual acuity. Intraocular pressure was measured using Goldmann applanation tonometry. Anterior-segment examination and the assessment of lens status were performed using slit-lamp biomicroscopy. Following pupillary dilatation, fundus examination was performed using indirect ophthalmoscopy and slit-lamp biomicroscopy. Optical coherence tomography (OCT) was performed as part of the clinical ophthalmic evaluation to assess macular involvement when clinically indicated. Fundus photography and fundus fluorescein angiography (FFA) were performed when clinically indicated to evaluate retinal perfusion, ischemia, and neovascularization.

Relevant systemic investigations included fasting plasma glucose, postprandial plasma glucose, hemoglobin, lipid profile, and serum homocysteine. Blood pressure and body mass index (BMI) were also recorded.

RVO was classified according to the clinical fundus pattern into central retinal vein occlusion (CRVO), hemi-retinal vein occlusion (hemi-RVO), and branch retinal vein occlusion (BRVO) subtypes. CRVO was further characterized clinically as ischemic or nonischemic where documented. Hemi-retinal vein occlusion (hemi-RVO) was classified according to the predominantly involved retinal hemisphere, whereas branch retinal vein occlusion (BRVO) was classified according to the affected branch territory and the presence or absence of macular involvement. Patients with unilateral RVO were included in the analysis. No patients with bilateral RVO were included; therefore, one affected eye contributed to the analysis for each participant, and the patient was considered the unit of analysis. The principal outcome variable was visual outcome at follow-up, categorized as good outcome (BCVA better than 6/18) or poor outcome (BCVA of 6/18 or worse).

Treatment-related information was recorded according to treatment received during follow-up, including intravitreal anti-vascular endothelial growth factor (anti-VEGF) therapy, intravitreal corticosteroids, and laser photocoagulation. Anti-VEGF agents included ranibizumab and bevacizumab, while laser treatment included grid laser or panretinal photocoagulation when indicated. As this was an observational study, treatments were documented as treatments received and were not assigned by the study protocol. Treatment exposure was therefore not standardized, and treatment-specific effects were not prespecified as study outcomes. Patients were followed prospectively for 60 days. At follow-up visits scheduled on days 1, 7, 21, 45, and 60, BCVA, fundus findings, and treatment response were assessed.

Statistical analysis

Data were entered into a master database and checked for completeness and consistency before statistical analysis. Statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY). Categorical variables were presented as frequencies and percentages, with both n and % reported whenever categorical data were described. Continuous variables were summarized as mean ± standard

deviation (SD). For comparison of continuous variables between patients with good and poor visual outcomes, independent-samples tests were used. Because the variance assumption was not necessarily equal for age between outcome groups, the Welch independent-samples t-test was reported for this comparison. Within-patient change in BCVA between baseline and follow-up was assessed using a paired-samples t-test.

Pearson's chi-square test was used for categorical comparisons when expected cell frequencies were adequate. For contingency tables with sparse expected frequencies, Fisher's exact test or the Fisher-Freeman-Halton exact test was used. Cramer's V was used to describe the magnitude of categorical associations where appropriate.

Poor visual outcome was treated as the dependent variable. Factors potentially associated with poor visual outcome were evaluated using univariable analyses, followed by multivariable logistic regression. Candidate variables included age and previous cerebrovascular events, which were selected a priori based on clinical relevance and available study data. RVO anatomical pattern was assessed descriptively and in univariable analysis but was not entered as a categorical predictor in the adjusted model. No numerical fundus-severity score was derived. Lens status was assessed by slit-lamp examination and categorized as clear lens, immature cataract, or pseudophakia. It was treated as a categorical clinical variable rather than a numerical score and was not included in the final multivariable model. Given the 24 poor-outcome events, a parsimonious multivariable logistic regression model was specified to reduce the risk of overfitting. Age was entered as a continuous variable in years, and previous cerebrovascular event was entered as a binary variable. Odds ratios (ORs) with 95% confidence intervals were reported. Model calibration was assessed using the Hosmer-Lemeshow test, discrimination using the area under the receiver operating characteristic curve (C-statistic), and multicollinearity using variance inflation factors.

Results were expressed as odds ratios (ORs) with corresponding 95% confidence intervals (CIs) and p-values. A two-sided p-value of <0.05 was considered statistically significant. Age was analyzed as a continuous variable for the primary inferential analysis and multivariable logistic regression. Age categories (41-50 and 51-60 years) were used only for the descriptive presentation of the observed age distribution; OCT-derived parameters, including central macular thickness and macular edema, and FFA findings were and were not used as the primary prespecified prognostic variables and were not included in the statistical analysis.

Results

A total of 60 patients with confirmed retinal vein occlusion were included in the analysis. Among them, 35 (58.3%) were men, and 25 (41.7%) were women. Regarding age distribution, 34 (56.7%) patients were aged 41-50 years, and 26 (43.3%) were aged 51-60 years. The mean age of the study population was 50.55 ± 5.84 years, with an age range of 41-60 years (minimum, 41 years; maximum, 60 years). Right-eye involvement was observed in 33 (55.0%) patients, whereas 27 (45.0%) had left-eye involvement. The mean BMI was 25.93 ± 2.49 kg/m^2. The demographic characteristics of the study population are presented in Table *2*.

Variable	n (%)/mean ± SD
Sex	
Male	35 (58.3%)
Female	25 (41.7%)
Age group (years)	
41-50	34 (56.7%)
51-60	26 (43.3%)
Mean age (years)	50.55 ± 5.84
Eye involved	
Right eye	33 (55.0%)
Left eye	27 (45.0%)
Mean BMI (kg/m²)	25.93 ± 2.49

TABLE 2: Demographic characteristics of the study population (n = 60)

Data are presented as n (%) for categorical variables and mean ± SD for continuous variables. Age categories are presented for descriptive purposes; age was analyzed as a continuous variable for primary inferential and multivariable analyses

SD, standard deviation; BMI, body mass index

When age was analyzed as a continuous variable, patients with poor visual outcomes had a higher mean age than those with good visual outcomes (53.04 ± 5.28 versus 48.64 ± 5.81 years), with a statistically significant difference (Welch t = 3.039; p = 0.004). Age was therefore retained as a continuous variable in the primary inferential and multivariable analyses. For descriptive purposes, age was also categorized into 41-50 and 51-60 years. A total of 23 (63.9%) of 36 patients with good outcomes and 11 (45.8%) of 24 patients with poor outcomes were aged 41-50 years, while 13 (36.1%) and 13 (54.2%), respectively, were aged 51-60 years. The categorized analysis did not demonstrate a statistically significant association with visual outcome (χ^2 = 1.912; degrees of freedom {df} = 1; p = 0.167; ϕ = 0.179). Mean BMI did not differ significantly between the good- and poor-outcome groups (26.40 ± 2.48 versus 25.23 ± 2.43 kg/m²; p = 0.076).

Among the 60 patients, 21 (35.0%) had hypertension, 26 (43.3%) had diabetes mellitus, 28 (46.7%) had hyperlipidemia, 13 (21.7%) reported a history of smoking, 12 (20.0%) had a previous cerebrovascular event, 14 (23.3%) had coronary artery disease, and four (6.7%) reported oral contraceptive use. The distribution of systemic risk factors is presented in Table 3.

Risk factor	n (%)
Hypertension	21 (35.0%)
Diabetes mellitus	26 (43.3%)
Hyperlipidemia	28 (46.7%)
Smoking history	13 (21.7%)
Previous cerebrovascular accident	12 (20.0%)
Coronary artery disease	14 (23.3%)
Oral contraceptive use	4 (6.7%)

TABLE 3: Distribution of systemic risk factors in the study population (n = 60)

Data are presented as n (%)

Previous cerebrovascular events were significantly associated with visual outcome ($\chi^2 = 4.444$; df = 1; p = 0.035; $\phi = 0.272$). Diabetes mellitus showed a non-statistically significant association with visual outcome (p = 0.056). No statistically significant association was observed for hypertension ($\chi^2 = 0.049$; df = 1; p = 0.825), hyperlipidemia ($\chi^2 = 0.011$; df = 1; p = 0.916), coronary artery disease ($\chi^2 = 0.062$; df = 1; p = 0.803), or smoking ($\chi^2 = 0.589$; df = 1; p = 0.443).

The mean duration of symptoms at presentation was 5.93 ± 4.61 days, and the mean baseline BCVA measurement was 40.54 ± 13.27. Lens examination showed a clear lens in 30 (50.0%) patients, immature cataract in 15 (25.0%), and pseudophakia in 15 (25.0%). The clinical and ocular characteristics are summarized in Table 4.

Variable	Value
Duration of symptoms (days), mean ± SD	5.93 ± 4.61
Baseline BCVA (logMAR × 100), mean ± SD	40.54 ± 13.27
Lens status	n (%)
Clear lens	30 (50.0%)
Immature cataract	15 (25.0%)
Pseudophakia	15 (25.0%)

TABLE 4: Clinical and ocular characteristics of the study population (n = 60)

Continuous variables are presented as mean ± SD and categorical variables as n (%). Lower values indicate better visual acuity. Lens status was not significantly associated with visual outcome ($\chi^2 = 2.639$; df = 2; p = 0.267; Cramer's V = 0.210)

SD, standard deviation; BCVA, best-corrected visual acuity; logMAR, logarithm of the minimum angle of resolution

The distribution of RVO patterns is shown in Table 5. Ischemic CRVO was observed in 13 (21.7%) patients, superior hemi-RVO in nine (15.0%), superotemporal BRVO in 10 (16.7%), macular BRVO in eight (13.3%), nonischemic CRVO in seven (11.7%), inferior hemi-RVO in six (10.0%), and inferotemporal BRVO in seven (11.7%). The RVO/fundus patterns were categorical clinical diagnoses and were not converted into a numerical severity score. Because of sparse cells across individual RVO categories and the limited number of outcome events, these categories were evaluated in the univariable analysis and were not entered as separate predictors in the final multivariable model.

RVO/fundus pattern	Good outcome	Poor outcome	Total
Ischemic CRVO	0	13	13
Superior hemi-RVO	0	9	9
Superotemporal BRVO	3	7	10
Macular BRVO	8	0	8
Nonischemic CRVO	5	2	7
Inferior hemi-RVO	4	2	6
Inferotemporal BRVO	6	1	7
Total	36	24	60

TABLE 5: Distribution of RVO patterns by visual outcome

Fisher-Freeman-Halton exact test: p < 0.001; Cramer's V = 0.604

CRVO, central retinal vein occlusion; RVO, retinal vein occlusion; BRVO, branch retinal vein occlusion

At follow-up, 36 (60.0%) patients had a good visual outcome, and 24 (40.0%) had a poor visual outcome. Mean BCVA improved from 40.54 ± 13.27 at baseline to 31.05 ± 14.06 at the 60-day follow-up. The mean within-patient improvement was 9.49 logMAR × 100 units (95% CI: 7.76-11.22), corresponding to an improvement of approximately 0.0949 logMAR (95% CI: 0.0776-0.1122). The paired-samples t-test demonstrated a statistically significant change (t = 10.997; df = 59; p < 0.001). These findings are summarized in Table 6.

Variable	Value
Good visual outcome	36 (60.0%)
Poor visual outcome	24 (40.0%)
Baseline BCVA, mean ± SD	40.54 ± 13.27
Follow-up BCVA, mean ± SD	31.05 ± 14.06
Mean within-patient change	9.49
95% CI for mean change	7.76-11.22
Paired-samples t-test	t = 10.997; df = 59; p < 0.001

TABLE 6: Visual outcome and change in best-corrected visual acuity

Categorical data are presented as n (%) and continuous data as mean ± SD. Paired-samples t-test for baseline versus follow-up BCVA: t = 10.997; df = 59; p < 0.001. BCVA values are expressed as logMAR × 100. Mean change represents baseline minus follow-up values, with positive values indicating improvement

SD, standard deviation; BCVA, best-corrected visual acuity; logMAR, logarithm of the minimum angle of resolution; CI, confidence interval

During follow-up, 56 (93.3%) patients received intravitreal anti-VEGF therapy, eight (13.3%) received intravitreal corticosteroids, and 13 (21.7%) underwent laser treatment. The mean number of intravitreal injections was 2.00 ± 0.94. The treatment modalities received are presented in Table 7.

Treatment modality	n (%)/mean ± SD
Intravitreal anti-VEGF therapy	56 (93.3%)
Intravitreal corticosteroids	8 (13.3%)
Laser treatment	13 (21.7%)
Number of intravitreal injections	2.00 ± 0.94

TABLE 7: Treatment modalities received during follow-up (n = 60)

Categorical data are presented as n (%) and the number of intravitreal injections as mean ± SD

Anti-VEGF, anti-vascular endothelial growth factor; SD, standard deviation

The results of multivariable logistic regression are presented in Table 8. A parsimonious multivariable logistic regression model was constructed using age and previous cerebrovascular events as predictors of poor visual outcome. Increasing age was associated with higher odds of poor outcome (OR = 1.105; 95% CI: 1.001-1.220; p = 0.049), corresponding to approximately a 10.5% increase in odds for each additional year of age. Previous cerebrovascular events were also associated with higher odds of poor visual outcome (OR = 4.012; 95% CI: 1.003-16.047; p = 0.049). The relatively wide confidence interval for previous cerebrovascular events indicates uncertainty around the magnitude of the association. The model demonstrated acceptable calibration (Hosmer-Lemeshow p = 0.095) and moderate discrimination (area under the curve = 0.740). No important multicollinearity was identified.

Predictor	OR	95% CI	P-value
Age, per one-year increase	1.105	1.001-1.220	0.049
Previous cerebrovascular event	4.012	1.003-16.047	0.049

TABLE 8: Multivariable logistic regression analysis of factors statistically associated with poor visual outcome

The model included 24 patients with poor visual outcomes and candidate predictors. Data are presented as odds ratios (ORs) with 95% confidence intervals (CIs) and p-values from multivariable logistic regression. A p-value of <0.05 was considered statistically significant

Given the small number of poor outcomes, these multivariable estimates should be interpreted cautiously because of the relatively small number of outcome events. The wide confidence interval observed for previous cerebrovascular events further indicates limited precision of this estimate.

Discussion

The present prospective observational study evaluated demographic, systemic, and ocular factors associated with visual outcomes among patients with RVO at a tertiary care center in Eastern India. Among the 60 patients included, 35 (58.3%) were men, and 25 (41.7%) were women. The findings demonstrate that visual prognosis in RVO is multifactorial, with age, baseline retinal vascular pattern, and previous cerebrovascular disease showing significant associations with poor visual outcome.

Increasing age was associated with poorer visual outcome after RVO in the present study. Patients with poor outcomes had a higher mean age than those with good outcomes (53.04 ± 5.28 versus 48.64 ± 5.81 years; Welch t = 3.039; p = 0.004), and age remained statistically associated with poor visual outcome in the multivariable analysis (OR = 1.270; 95% CI 1.083-1.488; p = 0.003). The significant association was observed when age was analyzed continuously but not when it was categorized into 41-50 and 51-60 years. Categorization reduces the information contained in a continuous variable and may decrease statistical power, particularly in a relatively small sample, so the age categories were used only for descriptive purposes.

Importantly, studies specifically evaluating visual outcomes after RVO have also reported an association between older age and poorer visual prognosis. In a natural-history study of CRVO, increasing age was associated with visual acuity deterioration and the reduced likelihood of visual improvement [9]. Similarly, in patients with BRVO, age of >70 years was associated with poorer final visual acuity after accounting for baseline visual acuity and other clinical factors [10]. A multicenter study of patients with treatment-naïve RVO also found that younger age was associated with greater visual-acuity gain in BRVO, although this relationship was not observed in CRVO [11]. These findings provide more directly relevant support for considering age as a potential prognostic factor after RVO while also indicating that its effect may differ according to RVO subtype and baseline visual status.

More recent evidence also suggests that baseline OCT abnormalities, including ellipsoid zone disruption, may be associated with reduced visual recovery in RVO, although the present study did not specifically evaluate these imaging biomarkers [12]. Future studies incorporating standardized retinal imaging parameters may provide additional insight into structural predictors of visual recovery.

Systemic vascular risk factors were common in this cohort. Hypertension was present in 21 (35.0%) patients, diabetes mellitus in 26 (43.3%), and hyperlipidemia in 28 (46.7%). Previous cerebrovascular events were present in 12 (20.0%) patients and were statistically significantly associated with visual outcome ($\chi^2 = 4.444$; df = 1; p = 0.035; $\phi = 0.272$). This association remained significant after adjustment in the multivariable model (OR = 6.901; 95% CI, 1.113-42.802; p = 0.038). As reflected by the wide 95% confidence interval, although the association reached statistical significance, the magnitude of the estimated effect should not be interpreted as a precise measure of risk. The finding should therefore be considered exploratory and requires confirmation in larger cohorts with a greater number of outcome events. The association should be interpreted as an observational relationship rather than evidence that previous cerebrovascular disease directly causes poorer retinal recovery. The finding is biologically plausible because cerebrovascular and retinal vascular disease share several systemic vascular risk factors. Although studies such as those by Kazantzis et al. have examined systemic vascular disease as a risk factor for RVO occurrence, such findings should be distinguished from determinants of visual outcome among patients with established RVO [13].

Although diabetes mellitus was present in 26 (43.3%) patients, its association with visual outcome was not statistically significant at the predefined threshold ($\chi^2 = 3.665$; df = 1; p = 0.056). Hypertension, hyperlipidemia, coronary artery disease, and smoking were also not significantly associated with visual

outcome. These findings should be interpreted in the context of the relatively small sample size and should not be taken to indicate that these systemic conditions are clinically unimportant in RVO. Epidemiological evidence continues to support the role of vascular risk factors in the development of RVO. Qiu et al. (2025), for example, identified hypertension among the important risk factors associated with RVO in East Asian populations [14], while Yao et al. (2024) reported an increased prevalence of RVO among individuals with diabetes [15]. The present study, however, specifically evaluated visual outcome among patients who already had RVO, which is a different clinical question from identifying factors associated with the development of RVO.

The baseline RVO pattern demonstrated a significant association with visual outcome in univariable analysis ($\chi^2 = 21.854$; df = 6; p = 0.001; Cramer's V = 0.604). Poor outcomes were predominantly observed among patients with ischemic CRVO and superior hemi-RVO, whereas good outcomes were more frequently observed in several BRVO categories. These anatomical patterns were not entered as independent categorical predictors in the multivariable analysis and therefore should be interpreted as descriptive and univariable associations rather than independent predictors of outcome. However, the observations emphasize the importance of the careful characterization of the retinal vascular pattern and the degree of retinal involvement at presentation. Chou et al. (2025) demonstrated the importance of baseline clinical characteristics, including age, diabetes, and initial visual status, in predicting adverse complications among patients with CRVO [16].

Lens status was not significantly associated with visual outcome in the present cohort ($\chi^2 = 2.639$; df = 2; p = 0.267; Cramer's V = 0.210). Although cataract and other media-related factors can influence measured visual acuity, the present data do not support baseline lens status as a significant predictor of good or poor visual outcome in this cohort.

Visual acuity improved significantly during follow-up. Mean BCVA changed from 40.54 ± 13.27 at baseline to 31.05 ± 14.06 at follow-up, with a statistically significant paired comparison (t = 10.997; df = 59; p < 0.001). Overall, 36 (60.0%) patients had a good visual outcome, and 24 (40.0%) had a poor outcome at follow-up. Intravitreal anti-VEGF therapy was received by 56 (93.3%) patients, while eight (13.3%) received intravitreal corticosteroids, and 13 (21.7%) underwent laser treatment. Because treatment was not randomized and patients received treatment according to clinical indications, the observed improvement in BCVA cannot be attributed to any particular treatment. The results therefore demonstrate improvement during follow-up rather than treatment-specific efficacy.

The multivariable analysis further identified age and previous cerebrovascular events as statistically associated with poor visual outcome. The association with age remained significant after adjustment (OR = 1.270; 95% CI, 1.083-1.488; p = 0.003). In particular, the association with previous cerebrovascular events had higher odds of poor visual outcome (OR = 6.901; 95% CI, 1.113-42.802; p = 0.038). This should be interpreted cautiously because of the relatively small number of patients with previous cerebrovascular events and the limited number of poor-outcome events. The wide confidence interval indicates considerable uncertainty around the estimated effect, and the finding should therefore be considered exploratory rather than definitive.

Strengths and limitations

The strengths of this study include its prospective observational design; systematic assessment of demographic, systemic, and ocular variables; standardized categorization of visual outcomes; and use of both univariable categorical analyses and multivariable logistic regression. Effect sizes were also reported alongside chi-square analyses, providing additional information about the magnitude of observed associations.

Several limitations should be considered. First, the sample size was relatively small, with only 60 patients, including 24 patients with poor visual outcomes, limiting the stability and precision of the multivariable regression and creating potential for overfitting, particularly for predictors with wide confidence intervals. The heterogeneity of RVO subtypes in the cohort may have influenced the observed associations, as the small sample size did not permit adequately powered subtype-specific analyses.

Second, the study was conducted at a single tertiary care center, which may limit generalizability to other populations and healthcare settings. Third, the observational design precludes causal conclusions regarding the relationships between identified factors and visual outcomes or the effects of individual treatments. Fourth, treatment modalities varied according to clinical indications, and treatment exposure was therefore not standardized but rather individualized and heterogeneous. Thus, detailed treatment timing and subtype-specific treatment patterns were not incorporated into the prognostic analysis. Fifth, although OCT and FFA were used for clinical assessment, FFA- or OCT-derived biomarkers were not systematically analyzed as prognostic variables. Thus, the present study does not allow conclusions regarding the prognostic contribution of specific OCT or FFA characteristics.

Finally, the study assessed visual outcomes over the specified follow-up period and did not provide the

longer-term assessment of visual prognosis. Owing to probable selection and attrition bias, the findings should be interpreted in light of the possibility that patients excluded because of incomplete records or inadequate follow-up may differ systematically from those retained in the analysis.

Overall, the findings indicate that age and previous cerebrovascular disease were associated with poorer visual outcomes, whereas lens status and most individual systemic risk factors were not statistically significant predictors in this cohort. These findings should be interpreted within the context of the study's sample size, single-center setting, and observational design.

Conclusions

RVO is a multifactorial retinal vascular disorder in which visual prognosis was associated with demographic, systemic, and ocular characteristics. In the present study, increasing age was statistically associated with poorer visual outcome among patients with established RVO, along with baseline retinal vascular characteristics and previous cerebrovascular disease, whereas lens status was not significantly associated with visual prognosis. Visual acuity improved during follow-up; however, the observational design and variation in treatment received preclude the attribution of this improvement to any specific therapeutic modality. These findings emphasize the importance of comprehensive ophthalmic assessment and the consideration of relevant systemic vascular history and baseline retinal characteristics in patients with RVO, with appropriate follow-up and individualized management based on clinical and retinal characteristics. Further prospective studies with larger cohorts, standardized treatment protocols, and longer follow-up are warranted to validate these prognostic associations.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. The Institutional Ethics Committee (IEC) of Rajendra Institute of Medical Sciences (RIMS), Ranchi, issued approval 222. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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