Clinical Ophthalmology

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Regression Patterns of Neovascularization in Proliferative Diabetic Retinopathy Following Panretinal Photocoagulation - A Prospective, Observational Study

Barkha Singh[1], Vijaya Sahu[1], Aseem Kumar[1], Shivani Shrivastava[1], Bharat Gurnani[2], Kirandeep Kaur[3]

[1]Department of Ophthalmology, All India Institute of Medical Sciences, Raipur, Chhattisgarh, 492099, India; [2]Department of Cataract, Cornea and Refractive Surgery, Gomabai Netralaya and Research Centre, Neemuch, Madhya Pradesh, 458441, India; [3]Department of Cataract, Pediatric Ophthalmology and Strabismus, Gomabai Netralaya and Research Centre, Neemuch, Madhya Pradesh, 458441, India

Correspondence: Vijaya Sahu, Department of Ophthalmology, All India Institute of Medical Sciences, Raipur, Chhattisgarh, 492099, India, Tel +91 9752679556, Email drvijayasahu77@gmail.com

Purpose: To determine the short-term patterns of regression of neovascularization after panretinal photocoagulation (PRP) in eyes with proliferative diabetic retinopathy (PDR) without clinically significant macular edema.

Methods: The study was a prospective, observational pilot study conducted at a tertiary care hospital in India from January 2023 to April 2024. The single eye (worst eye) of 30 patients with PDR without diabetic macular edema was selected using convenient sampling. This approach was chosen to avoid inter-eye correlation bias. The patients meeting the inclusion criteria underwent PRP laser using Green LASER (532nm), and visual acuity (VA), central macular thickness (CMT), and fundus photographs were analyzed at baseline, 1 month, and 3 months post-PRP.

Results: The VA at baseline remained similar at 1-month and 3-month post-PRP. The CMT increased significantly at 1-month and 3 months but was within 300 microns, remaining below the threshold for clinically significant macular edema. No regression was seen at one month in most eyes. However, at 3 months, complete regression was seen in 10% of cases, incomplete regression in 47%. There was no difference in the regression rates based on the amount of neovascularization at baseline. NVD showed a higher odds ratio for non-regression; however, this did not reach statistical significance, and a 25-micron increment in spot size demonstrated a non-significant trend toward reduced likelihood of non-regression. Every 1gm% HbA1c increment was associated with a 2.7 times higher likelihood of CME.

Conclusion: In this pilot study, short-term regression of neovascularization following PRP was variable. Exploratory trends suggested possible differential regression between NVD and NVE.

Keywords: neovascularization, panretinal photocoagulation, proliferative diabetic retinopathy, green laser, iabetes mellitus

Introduction

Diabetes mellitus (DM) has reached pandemic proportions, affecting more than 537 million adults worldwide in 2021 and projected to rise to 783 million by 2045.[1] In 2020, an estimated 103 million individuals had some form of diabetic retinopathy (DR), with 18 million suffering sight-threatening proliferative diabetic retinopathy (PDR).[2] Chronic hyperglycemia in DM inflicts both macrovascular and microvascular damage, the latter manifesting most devastatingly in the retina.[3–5] In India, population-based studies report that 16.9% of persons with diabetes have DR, and 3.6% develop sight-threatening disease.[6] According to the Wisconsin Epidemiology Study for Diabetic Retinopathy (WESDR), the prevalence of PDR in patients with an earlier onset of diabetes is 23%, in those with a later onset of diabetes is 10%, and 3% in those who do not take insulin therapy.[6] The onset of neovascularization—new, fragile vessels growing on the optic

https://doi.org/10.2147/OPTH.S575268
Received: 18 October 2025
Accepted: 12 March 2026
Published: 19 March 2026

disc (NVD) or elsewhere in the retina (NVE)—marks progression from nonproliferative to proliferative DR. Driven by ischemia-induced overexpression of vascular endothelial growth factor (VEGF), these vessels leak blood or fibrous tissue, causing preretinal and vitreous hemorrhages, fibrovascular proliferation, and tractional retinal detachment if left untreated.[7] Since the landmark Diabetic Retinopathy Study (DRS), panretinal photocoagulation (PRP) has been established as the gold standard for PDR, demonstrating a more than 60% reduction in severe visual loss at five years.[8] Nevertheless, PRP is not universally effective: approximately 20–30% of eyes experience incomplete neovascular regression or even disease worsening despite adequate initial treatment.[9–11] Early trials, including DRS and the Early Treatment Diabetic Retinopathy Study (ETDRS), hinted that lesion location and scatter-spot number influenced treatment response, but these studies predated modern laser technology and did not systematically analyze individualized laser parameters.[7,8] In a more recent prospective series, Chappelow et al examined 75 treatment-naïve PDR eyes treated with either large-spot (500 µm) or standard-spot (200 µm) PRP and reported faster NVE regression with larger spots; however, their analysis did not control for baseline lesion severity or total spot count, limiting generalizability.[9] Similarly, Chen et al retrospectively reviewed 60 eyes and found that peripheral NVE locations correlated with poorer response, yet their study lacked quantitative data on delivered laser energy and spot distribution.[10] Few prospective studies have incorporated detailed laser-treatment variables into multivariate models of neovascular involution, and many investigations group NVD and NVE outcomes together, limiting clarity regarding lesion-specific regression patterns. Much of the existing data derive from retrospective series with heterogeneous follow-up intervals and imaging modalities, hampering causal inference about temporal regression patterns. To fill these knowledge gaps, we undertook a prospective, observational study of treatment-naïve eyes with PDR undergoing standardized PRP using a modern pattern-scan laser system. Our primary objective was to characterize the regression patterns of NVD and NVE over three months, correlating changes with specific laser parameters—including total spot count, spot size (200 µm vs. 500 µm), cumulative energy delivered, and quadrant-wise distribution of burns. Given that early regression assessment influences retreatment decisions in clinical practice, evaluation of short-term outcomes is clinically relevant. We further aimed to determine whether these laser characteristics independently predict neovascular regression after adjusting for baseline lesion size and location, and to delineate the temporal kinetics of disc versus peripheral neovascular response. By integrating precise lesion mapping and comprehensive laser-treatment metrics, this study seeks to identify modifiable factors in PRP delivery that could refine treatment protocols, maximize neovascular involution, and ultimately improve visual outcomes for patients with PDR.

Methods

This was a hospital-based, prospective, observational, non-comparative, pilot study conducted at a tertiary care hospital in central India between January 2023 and April 2024. The study was conducted in accordance with the principles of the Declaration of Helsinki. This study was approved by the Institute ethics committee of All India Institute of Medical Sciences, Raipur (2630/IECAIIMSRPR/2022). Written informed consent was obtained from all patients willing to participate in the study. A total of 30 patients with proliferative diabetic retinopathy without diabetic macular edema (DME) were selected by convenient sampling, and the worst eye (defined as the eye with poorer vision and advanced stage of DR) was selected for analysis in the study. This strategy was adopted to avoid inter-eye correlation bias. The present study included all treatment-naïve (meaning the eye never had any PRP/treatment in the past) type I or type II diabetes mellitus patients with proliferative diabetic retinopathy without vitreous hemorrhage (VH) and DME with adequate pupil dilatation and clear media to perform digital photography, laser photocoagulation, and OCT scans.

We excluded subjects with a history of laser photocoagulation, central macular thickness >300 microns, previous vitreoretinal surgery, PDR with retinal detachment (RD), non-resolving vitreous hemorrhage, fibrovascular proliferation, history of intravitreal anti-VEGF in the past 3 months, cataract obscuring the retinal view, or patients unable to sit for PRP laser therapy.

All participants underwent a preliminary detailed history taking, a comprehensive ophthalmic examination, which included best corrected visual acuity (BCVA) assessment, slit lamp biomicroscopy using +90D lens, fundus examination using indirect ophthalmoscopy, fundus imaging (Topcon retinal camera-50DX, type 1A, Tokyo, Japan), and central macular thickness (CIRRUS HD-OCT 5000, Zeiss, Dublin, CA) examination. The fundus images were obtained in

primary gaze, and superior, inferior, nasal, and temporal gazes to look for NVD and NVEs. OCT was used to detect the central macular thickness (CMT) at different time points.

PRP was performed by a retina specialist (initials) using a slit lamp delivery system with a double frequency Nd-YAG green laser (Appasamy green laser JERICHO 532nm) system. PRP was done in 3 sessions with an interval of 1 week between each session. The PRP was performed in order of the nasal, inferior, superior, and temporal sides with 1000–1500 scatter laser burn spots per session, with a total number of 3000–4500 spots. The laser parameters were individually adjusted to obtain a moderate burn with a 150 or 300-micron spot size separated by a 150 or 300-micron spot size. Laser power was recorded; however, duration and fluence were titrated clinically and were not protocol-standardized, thereby limiting energy-based comparisons. Repeat OCT and fundus photography were done at the end of 1 month and at the end of 3 months. The data was analyzed at 3 time points: at baseline before they underwent the PRP session during the same visit, at 1 month post-PRP, and at 3 months post-PRP. Images of low quality were discarded, and the best image for the detection of new vessels was selected for the analysis. Both NVD and NVEs were included in the study. If multiple NVEs were present, all of them were included in the study. All the images were captured and analyzed by two observers to avoid interobserver bias.

The number, location, and size of neovascularization of the retina, including NVD and NVEs, were studied. The various locations of neovascularization were evaluated in 5 zones: at or within 1DD from the disc, NVE at supero-temporal arcade, NVE at inferotemporal arcade, and NVE temporal to the disc. The categorization into 5 zones was based on anatomical location using the optic disc as the central reference. Although no validated Early Treatment Diabetic Retinopathy Study (ETDRS) grid was used, a custom grid centered on the optic disc was applied for consistent localization across observers. The disc-centered grid was selected intentionally because, the lesions of interest (NVD and arcade NVEs) are disc-referenced rather than macula-centered. The size of neovascularization considered were <0.5 DD, 0.5–1 DD, 1–2 DD, and >2 DD. The NV size was graded subjectively using the disc diameter (DD) as a reference scale, and the overall dimension of the neovascular frond was included in the measurement. Pruning of vessels was not included in the measurement unless it led to a substantial reduction in the size of the frond. The treatment response was categorized into the following 4 groups: (1) Complete regression – defined strictly as complete absence of neovascularization on follow-up fundus photographs. (2) Partial regression – defined as ≥50% reduction in total neovascular area. (3) Persistence – defined as <50% reduction in size of NV. (4) Progression – defined as increase in area, appearance of new fronds, additional anatomical zones, or vitreous hemorrhage.

Statistical Analysis

Snellen's visual acuity was converted to a logarithm of the minimum angle of resolution (logMAR) for statistical analysis. CME was considered at 1 and 3 months post-PRP if the CMT was >310 microns or at least a 20% increment from pre-PRP levels. The site of neovascularization was coded as 1=NVD, 2=Supero-temporal (ST) arcade, 3=Infero-temporal (IT) arcade, 4=Nasal to disc, 5=Temporal to disc (outside the arcades). All continuous variables were presented as mean with standard deviation or median with interquartile range (IQR). The normality of the distribution of continuous variables was checked, and the difference in continuous variables between the before and after treatment was assessed using the Student's *t*-test when the distribution was normal, and the Mann–Whitney *U*-test was used when the distribution was non-parametric. Comparison between continuous variables across three groups was assessed using the analysis of variance (ANOVA) or the Kruskal–Wallis test for non-parametric distributions. Similarly, group differences between categorical variables were assessed using the chi-square or Fischer's exact test. Factors influencing non-regression or progression of neovascularization at 3 months were assessed using univariate logistic regression analysis for exploratory purposes. Given the limited number of outcome events and insufficient events-per-variable ratio, multivariable modeling was not performed. Associations are therefore interpreted as exploratory and hypothesis-generating. All p-values <0.05 were considered statistically significant. Results are presented as descriptive statistics, where each variable is described by itself, and analytic statistics, where the relationship between variables has been explored.

Results

A total of 30 eyes of 30 patients who satisfied the inclusion criteria, completed 3 sittings of PRP, and followed up for 3 months were analyzed. All patients were non-insulin dependent diabetes mellitus (NIDDM). The mean age ± SD of participants was 50.2 ± 7.05 years, with a median age of 49.5 years (IQR: 48–54, range: 30–66 years). [Figure 1] The participants were predominantly males (n=24, 80%) and 6 (20%) were females. The M:F ratio was 4:1. There was no statistically significant difference in the age of males (49.3 ± 6.6 years) and females (53.6 ± 8.3 years). In the present study, we found that the younger age group had more neovascularization.

All 30 patients underwent PRP in both eyes, but only one eye (the worst eye with clear media) was included in the study. In 12 participants (40%), the right eye was analyzed, and in 18 (60%), the left eye was included. The mean duration of diabetes was 9.8 ± 5.6 years, with a median of 10 years (IQR: 5–15 years, range: 1–20 years). The mean HbA1c of the participants was 8.6 ± 1.9 mg%, with a median of 8.55 (IQR: 7.6–9.7, range: 6–14). [Figure 2] The pre-PRP visual acuity at baseline was 0.41 ± 0.27 LogMAR (median: 0.39, IQR: 0.18–0.48 LogMAR) and remained similar at 1-month post-PRP with mean = 0.44 ± 0.28 LogMAR (median: 0.20, IQR: 0.18–0.48 LogMAR) (p=0.24). The visual acuity at 3 months was also similar to that at baseline, with a mean of 0.38 ± 0.29 (median: 0.3, IQR: 0.18–0.60 LogMAR) (p=0.65). [Table 1] [Figure 3] The CMT increased significantly at the 1-month and remained higher than baseline at 3 months. Although there was an increase in mean CMT, it was within 300 microns, signifying no macular edema. [Table 1] [Figure 4] The mean number of PRP spots used was 2874 ± 806 (median: 2681, IQR: 2230–3488),

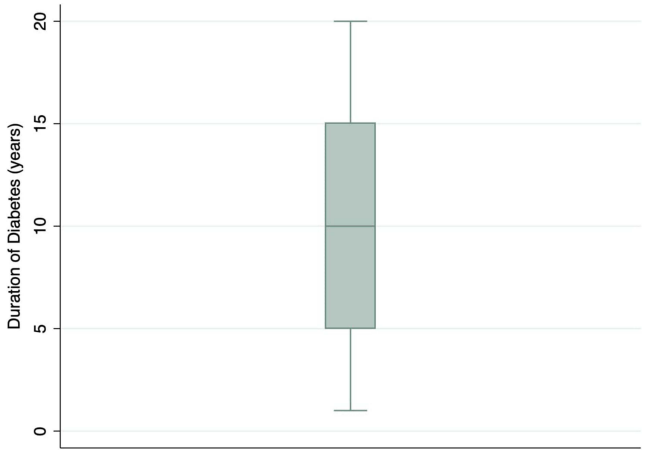

Figure 1 Distribution of participants in terms of diabetes duration (in years).

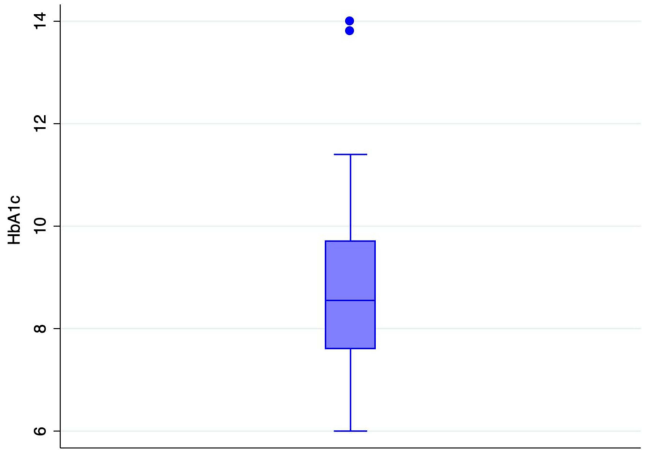

Figure 2 Distribution of HbA1c among the participants.

https://doi.org/10.2147/OPTH.S575268

Table 1 Depicts the Visual Acuity (logMAR) and Central Macular Thickness (μm) Over Time

S. No	Parameter	Baseline (Mean ± SD)	1 Month (Mean ± SD)	3 Months (Mean ± SD)	p-value vs Baseline
1	Visual Acuity (logMAR)	0.41 ± 0.27	0.44 ± 0.28	0.38 ± 0.29	0.24 (1m), 0.65 (3m)
2	Central Macular Thickness (μm)	267 ± 26	287 ± 43	287 ± 45	0.001 (1m), 0.02 (3m)

range = 1510–4713. The mean power used for PRP was 311 ± 106 (median: 300, IQR: 280–340), range = 100–675. The majority had PRP with a spot size of 200μm (n=18, 60%), while another 11 (37%) had a 150μm spot size, and only 1 had PRP with a spot size of 300μm. Fifteen eyes had single-site neovascularization (50%), while 12 (40%) had neovascularization at two sites, and three eyes (10%) had neovascularization at three sites in the same eye. When neovascularization occurred alone, the ST arcade was the most common site. NVD rarely occurred alone, as did NVE in the inferotemporal arcade. When neovascularization occurred at two sites in the same eye, the commonest combination was the NVD+ST arcade, followed by the NVD+IT arcade, ST arcade and Nasal NVE, and ST arcade and Temporal NVE. Only three eyes had neovascularization at three sites, and all these had a combination of NVD+NV in the ST and IT arcades. The majority of neovascularization was between 0.5 and 1DD in size. [Table 2]

No regression was seen in most of the eyes at 1 month (70% at 1 site and 73% at 2 sites). However, at 3 months, 10% showed complete regression, 47% showed incomplete regression, and 43% showed no regression or progression. There

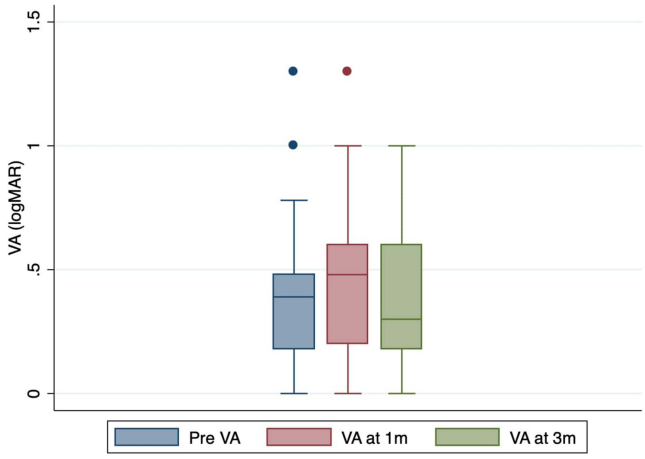

Figure 3 Distribution of visual acuity among the participants at baseline, at 1 month post PRP, and at 3 months post PRP laser.

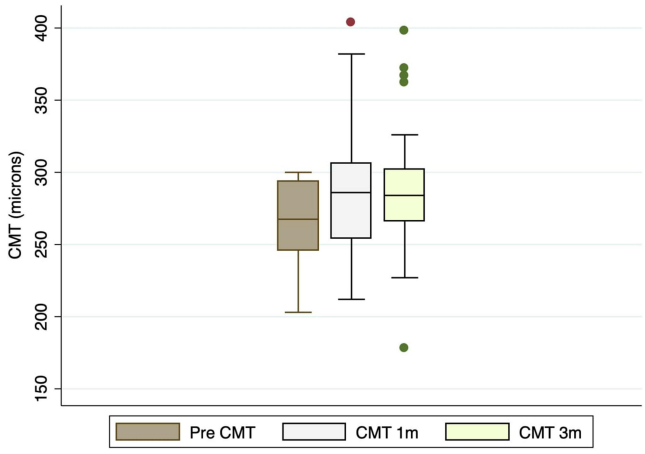

Figure 4 Distribution of Central macular thickness (CMT) among the participants at baseline, 1 month, and 3 months.

https://doi.org/10.2147/OPTH.S575268

Table 2 Depicts the Distribution of Various Sites of Neovascularization

S. No	One Site Neovascularization		Two Site Neovascularization		Three Site Neovascularization	
	Location	Number of Patients	Location	Number of Patients	Location	Number of Patients
1	NVD	4	NVD + STA	5	NVD + STA + ITA	3
2	STA	8	NVD + ITA	3		
3	ITA	3	STA + Nasal	3		
4			STA + Temporal	1		
5	Total	15		12		3

Abbreviations: STA, Superotemporal arcade; ITA, Inferotemporal arcade; NVD, Neovascularization of disc.

was no difference in the resolution rates based on the number of sites of neovascularization at baseline. Eyes with NVD received significantly higher PRP spots and had more eyes with CME, leading to lower visual acuity at 3 months. [Figures 5–10] There appeared to be more eyes with progression in the NVD group. Patients with 3 sites of neovascularization were significantly younger and received more PRP laser spots. [Table 3] The logistic regression analysis was done to find out the predictors of no regression or progression. A total of 13 eyes (43%) experienced no regression or progression at three months in the primary neovascularization. None of the factors analyzed with univariate analysis could predict the risk of non-regression or progression, likely due to the small sample size. Hence, multivariable regression was not performed. However, trends showed that the presence of NVD was associated with a 2.3 times higher likelihood of non-regression, and every 25-micron increment in spot size reduced the likelihood of non-regression by 36%. Trends showed that the presence of NVD was associated with a higher odds ratio for non-regression; however, this did not reach statistical significance. Similarly, a 25-micron increment in spot size demonstrated a non-significant trend toward reduced likelihood of non-regression. Given the asymmetric distribution of spot sizes and limited statistical power, these findings should not be interpreted as definitive predictors. [Table 4] A total of 8 eyes (27%) experienced CME at 1 or 3 months post-PRP. The logistic regression analysis results showing factors predicting CME was HbA1c, the only factor that significantly predicted the occurrence of CME with every 1gm% increment associated with a 2.7 times higher likelihood of CME. [Table 5]

Discussion

The current study examined the regression patterns of neovascularization following pan-retinal photocoagulation (PRP) in eyes with proliferative diabetic retinopathy (PDR) without diabetic macular edema (DME) and assessed associated

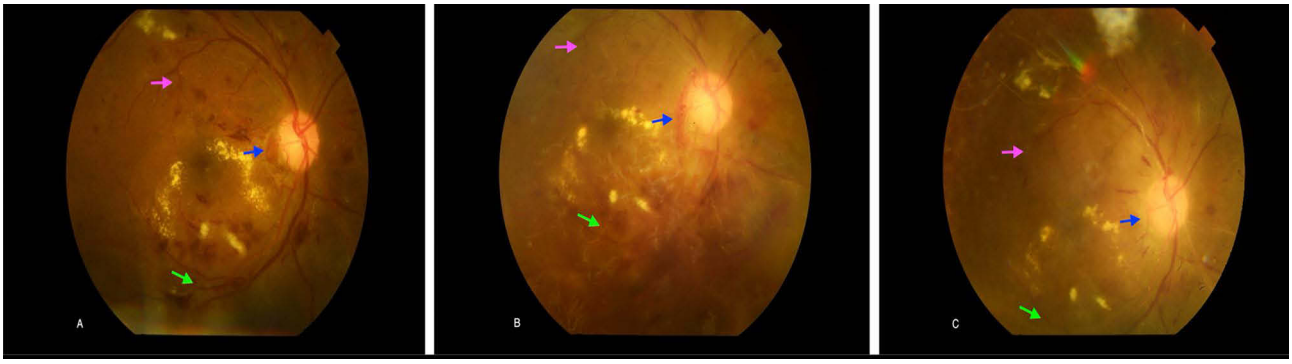

Figure 5 The fundus photograph (**A**) At baseline and shows neovascularization at 3 sites: Neovascularization at disc (NVD) (Site 1), Neovascularization elsewhere at Superotemporal arcade (site2) and Inferotemporal arcade (site 3). (**B**) At 1 month's post PRP session shows persistence of Neovascularization at all 3 sites, (**C**) At 3-month post-PRP session shows incomplete regression of NVD (course of neovascularization: 2), incomplete regression of NVE at superotemporal arcade (course of neovascularization: 2), progression of neovascularization at inferotemporal arcade.

https://doi.org/10.2147/OPTH.S575268

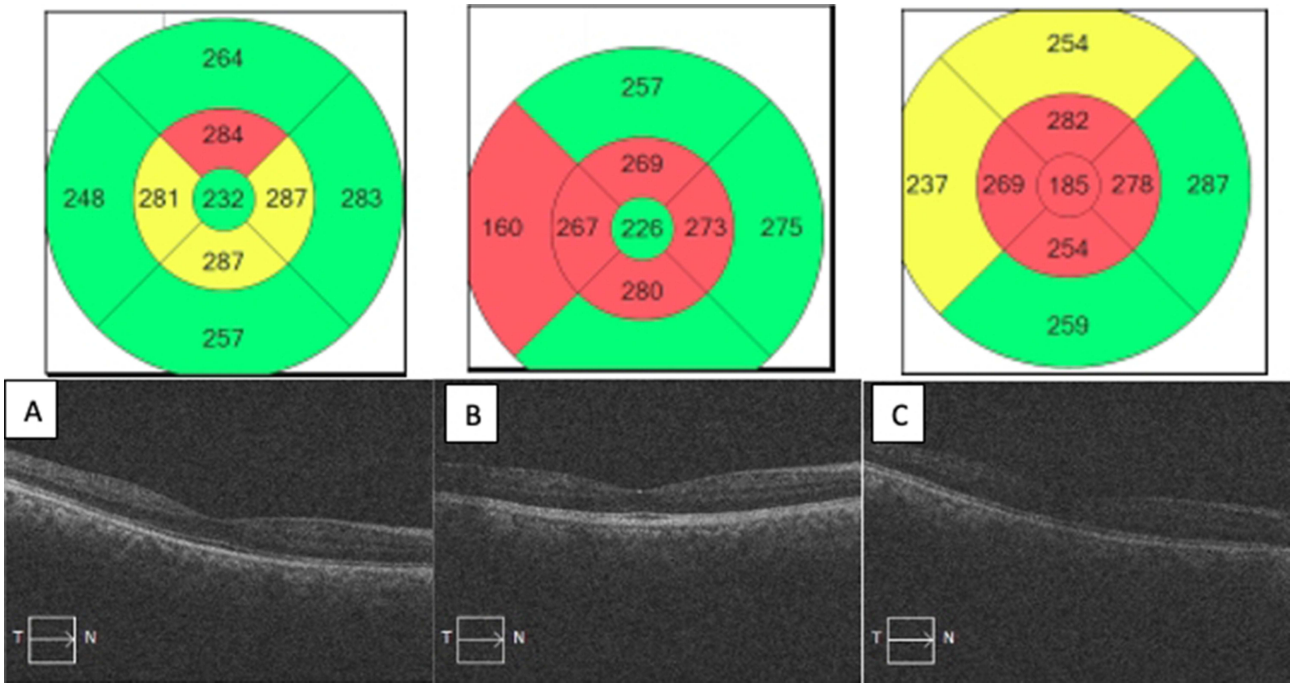

Figure 6 Macular thickness maps with ETDRS grid and corresponding SD-OCT scans demonstrating central macular thickness changes in cystoid macular edema (CME). (**A**) Baseline showing near-normal macular thickness and preserved foveal contour. (**B**) At 1-month follow-up showing mild increase in retinal thickness with subtle alteration of foveal architecture. (**C**) At 3-month follow-up demonstrating more pronounced retinal thickening with irregular foveal contour.

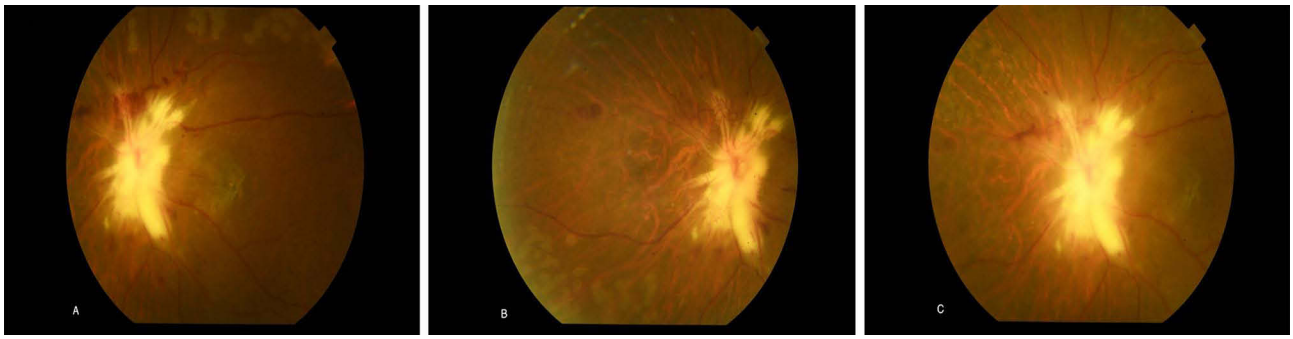

Figure 7 Fundus photographs demonstrating neovascularization at the disc (NVD) during follow-up. (**A**) At baseline showing prominent NVD with surrounding vascular proliferation. (**B**) At 1-month post-PRP session showing persistence of NVD with partial reduction in vascular activity. (**C**) At 3-months post-PRP showing complete regression of NVD with improved disc vascularity.

visual outcomes. The participants' mean age (50.2 ± 7.05 years) was comparable to findings from Chatziralli et al[12] (58.5 ± 13.8 years). Most participants were male, and in cases of bilateral PDR, the eye with worse prognosis and clear media was chosen for evaluation, aligning with the methodology of Jinglan Li et al[13] but differing from Quraishy et al[14] who included both eyes. Recruitment focused on treatment-naïve patients with active PDR, without DME, consistent with studies by Halim et al[15] and Quraishy et al,[14] which also employed prospective designs. In contrast, studies by Chatziralli et al[12] and Jinglan Li et al[13] followed a retrospective approach. While Chatziralli et al[12] analyzed regression of neovascularization elsewhere (NVE) and considered the largest lesion for evaluation, this study included both neovascularization at the disc (NVD) and NVE, accounting for all present lesions. The findings suggested a trend toward slower regression of NVD compared to NVE. This observation aligns with the work of Halim et al[15] and suggests that NVD may indicate a more extensive disease process, as most NVDs were associated with NVEs. The resistance of NVD to regression may be attributed to the absence of the internal limiting membrane at the optic disc and higher density of anti-

https://doi.org/10.2147/OPTH.S575268

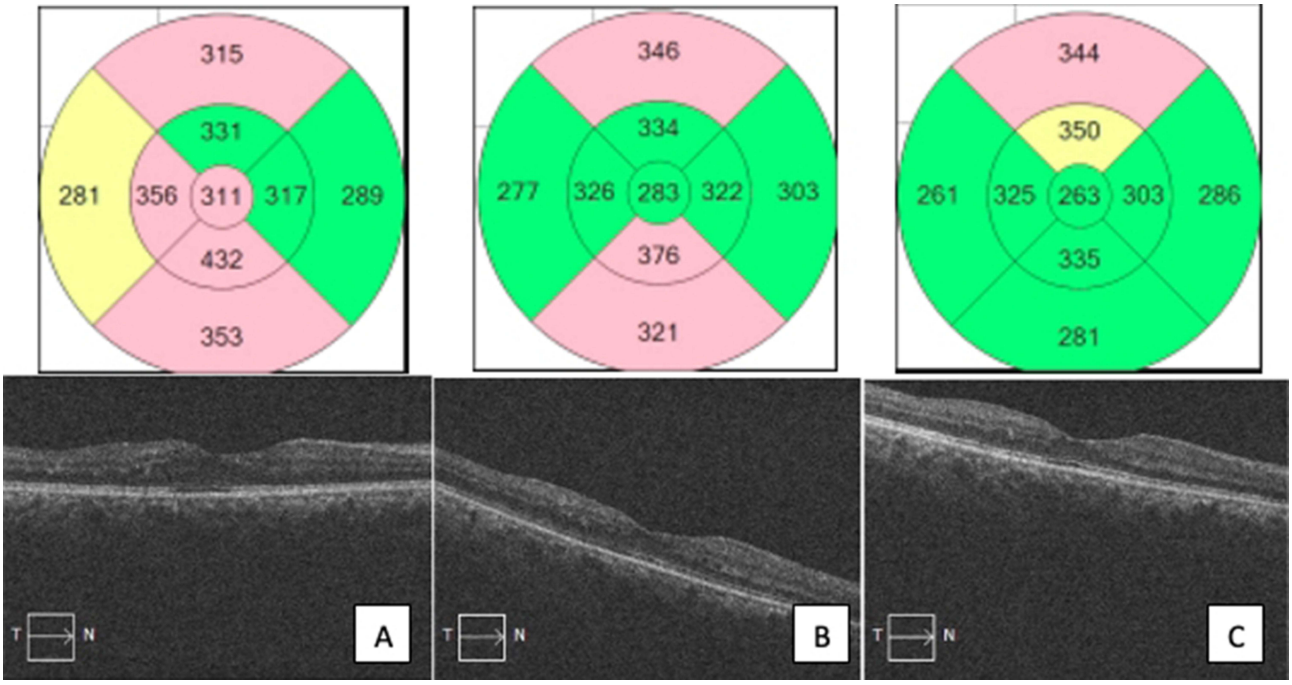

Figure 8 Optical Coherence Tomography scan showing central macular thickness (CME) with ETDRS GRID, (**A**) at baseline, (**B**) at the end of 1 month, (**C**) at the end of 3 months (decrease in CME compare to base line).

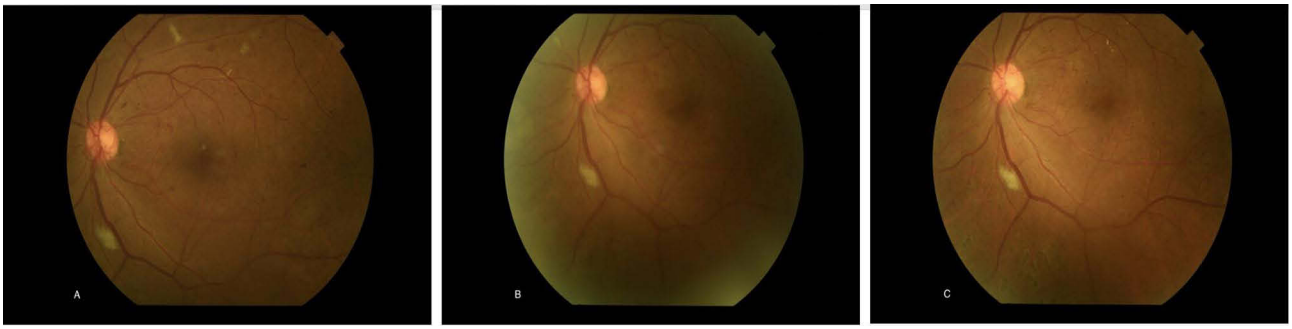

Figure 9 Fundus photographs demonstrating retinal changes during follow-up. (**A**) At baseline showing retinal changes with macular involvement. (**B**) At 1-month follow-up demonstrating partial resolution of retinal lesions with improving fundus appearance. (**C**) At 3-month follow-up showing further regression of lesions with near restoration of normal retinal architecture.

VEGF receptors within glial and retinal vessels, as previously hypothesized.[16] The peripapillary VEGF deposits may further reduce the effectiveness of VEGF suppression by PRP, consistent with findings from Muste JC et al[16] who identified NVD as a significant risk factor for the progression of PDR into vision-threatening stages after PRP.

The topographical distribution of neovascularization in this study showed a predilection for the superotemporal arcade, differing from Halim et al[15] and Jansson et al[17] who reported a nasal quadrant predilection. Temporal watershed zones have also been identified as common sites for NVE in other studies.[18–20] Feng et al,[21] using OCTA, observed that NVE regression begins as early as one week after PRP and lasts for at least three months. Their study focused exclusively on NVE and did not evaluate laser parameters or responses at different sites, unlike the present study. An important distinction of this research lies in its categorization of neovascular regression into complete and incomplete, offering a nuanced perspective compared to the binary approach of previous studies. This aligns partially with Muqit et al[22] who found 67–75% regression in mild to moderate PDR cases after 18 months of follow-up with top-up PASCAL PRP. While most studies on PRP outcomes focus on long-term data, this study assessed outcomes at three months due to practical

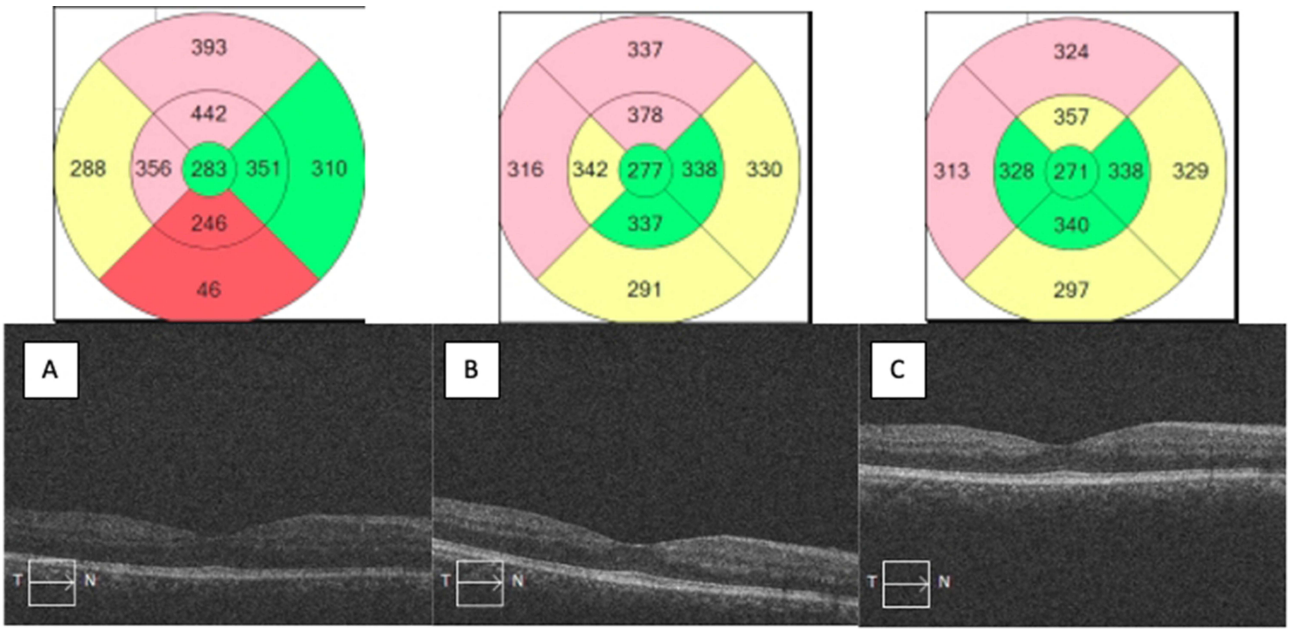

Figure 10 Macular thickness distribution with OCT structural changes illustrating progression and follow-up in CME. (**A**) Baseline showing marked sectoral retinal thickening with distorted foveal contour. (**B**) At 1-month follow-up showing moderate macular thickening with early flattening of the foveal depression. (**C**) At 3-month follow-up demonstrating relative improvement in macular contour with partial restoration of foveal architecture.

constraints. A possible association between PRP laser parameters and regression outcomes was observed; however, these associations remain exploratory and require validation in larger adequately powered studies. For instance, a 25-micron increase in laser spot size reduced the likelihood of non-regression by 36%. Spot sizes of at least 200 microns appeared more effective for NVD regression, an observation not previously reported. In the present study, we found that as the number and location of neovascularization increased, more laser spots are required for regression of NVE. Additionally, this study supports established associations between higher HbA1c levels, longer diabetes duration, and diabetic

Table 3 Depict the Clinical Characteristics According to Number of Neovascularization Sites

S. No	Variable	1 Site (n=15)	2 Sites (n=12)	3 Sites (n=3)	p-value
1	Age (years), Mean ± SD	49.2 ± 7.9	53.4 ± 5.2	42.3 ± 3.2	0.01
2	Male Gender, n (%)	12 (80%)	9 (75%)	3 (100%)	0.63
3	Duration of Diabetes (years)	8.2 ± 4.4	11.6 ± 6.9	10.6 ± 5.5	0.28
4	HbA1c (%)	8.2 ± 1.2	9.3 ± 2.3	8.7 ± 0.9	0.57
5	VA (logMAR) Pre-PRP	0.42 ± 0.28	0.35 ± 0.27	0.52 ± 0.24	0.43
6	VA (logMAR) at 3 Months	0.34 ± 0.29	0.35 ± 0.25	0.56 ± 0.26	0.12
7	CMT (μm) Pre-PRP	279 ± 21	255 ± 24	253 ± 38	0.09
8	CMT (μm) at 3 Months	284 ± 39	288 ± 50	300 ± 72	0.87
9	CME at 3 Months, n (%)	2 (13%)	3 (25%)	1 (33%)	0.62
10	Total PRP Spots	2112 ± 143	2490 ± 642	3334 ± 730	0.002
11	Spot Size (μm)	190 ± 38	175 ± 26	200	0.28

Abbreviations: VA, visual acuity; CMT, Central macular thickness; CME, Central macular edema; PRP, pan retinal photocoagulation.

https://doi.org/10.2147/OPTH.S575268

Table 4 Depicts the Univariate Logistic Regression Showing Factors Predicting Non-Regression

S. No	Variable	Interval	Univariate Regression		p-value
			OR	95% CI	NS
1	Age	1 year increment	0.98	0.8–1.2	NS
2	Gender	Male Vs. female	0.76	0.1–8.6	NS
3	Duration of DM	1 year increment	1.02	0.8–1.2	NS
4	HbA1c	1gm% increment	2.65	1.1–6.5	0.003
5	VA pre-PRP	1 line worsening	9.6	0.4–23.5	NS
6	Spot number	100 spot increment	0.82	0.6–1.2	NS
7	Spot size	25m increment	0.94	0.4–1.9	NS
8	Size of NV 0.5–1DD	Vs. <0.5DD	2.5	0.1–5.1	NS
9	NVD	Vs. no NVD	7.1	0.7–69.1	NS
11	2 Foci NV	Vs. 1 focus NV	1.88	0.5–6.8	NS

Abbreviations: VA, visual acuity; PRP, Pan retinal photocoagulation; NVD, Neovascularization of disc; NV, Neovascularization; DD, Disc diameter.

Table 5 Depicts the Logistic Regression Showing Factors Predicting Diabetic Macular Edema

S. No	Variable	Interval	Univariate Regression	
			OR	95% CI
1	Age	1-year increment	0.98	0.8–1.2
2	Gender	Vs. female	0.76	0.1–8.6
3	Duration of Diabetes Mellitus	1 year increment	1.02	0.8–1.2
4	HbA1c	1gm% increment	2.65	1.1–6.5
5	VA pre-PRP	1 line worsening	9.6	0.4–23.5
6	Spot number	100 spot increment	0.82	0.6–1.2
7	Spot size	25m increment	0.94	0.4–1.9
8	Size of NV 0.5–1 Disc Diameter	Vs. <0.5DD	2.5	0.1–5.1
9	NVD	Vs. no NVD	7.1	0.7–69.1
10	2 site neovascularization	Vs. 1 site NV	1.88	0.5–6.8

Abbreviations: NVD, Neovascularization of Disc; NV, Neovascularization; VA, Visual acuity.

retinopathy severity. The mean HbA1c level of participants (8.6%) was slightly lower than in some previous studies, such as Chirag Singh et al[23] The mean duration of diabetes (9.8 years) was consistent with findings that link longer diabetes duration to PDR development.

Visual acuity remained stable over three months, while central macular thickness (CMT) increased significantly but remained below the threshold for clinically significant macular edema. This statistically significant yet subclinical rise may reflect transient inflammatory or vascular changes following PRP and warrants careful monitoring. This differs from

findings by Eleiwa KT et al[24] who reported a decrease in CMT three months post-PRP. Mukhtar et al[25] and Muqit et al[22] found significant reductions in CMT and improved visual acuity after PASCAL treatment, while McDonald HR et al[26] observed increased macular edema within 6–10 weeks post-PRP.

This study observed that higher HbA1c levels were associated with an increased risk of DME, consistent with Moreira et al[27] who linked elevated HbA1c to clinically significant macular edema. The findings suggest that factors such as laser power and duration may contribute to post-PRP macular changes, as supported by previous reports on Argon blue-green laser treatments.

The strengths of this study include a clearly defined protocol with serial evaluation at three time points, inclusion of both neovascularization at the disc (NVD) and elsewhere (NVE), and use of standardized PRP parameters. Detailed documentation of laser spot size, power, and number of burns allowed for meaningful associations with treatment outcomes. Dual masked grading of fundus images and categorization of treatment response into complete, incomplete, persistent, or progressive regression enhanced the depth of analysis. Furthermore, topographic categorization of neovascular sites and subjective grading based on disc diameter improved spatial correlation and clinical relevance. Our study also has few limitations. The primary limitations include its small sample size, which restricted the ability to perform multivariable regression and limited the generalizability of the findings. The use of subjective visual estimation for regression assessment, without quantitative imaging tools or angiography, may introduce inter-observer variability. The study also lacked a standardized ETDRS grid for lesion localization and did not use fluorescein angiography or optical coherence tomography angiography (OCTA) to objectively verify neovascular leakage or vessel closure. Follow-up was limited to three months, potentially missing late regression or recurrence. Additionally, convenient sampling and selection of the worst eye may have introduced selection bias. These limitations restrict generalizability and necessitate cautious interpretation of associations observed. The absence of fluorescein angiography or OCT angiography limit's objective assessment of neovascular leakage and microvascular remodeling.

This study is one of the few prospective evaluations to separately analyze NVD and NVE regression following PRP and identify NVD as significantly less responsive, with a 2.3-fold higher likelihood of non-regression. It also uniquely correlates increasing laser spot size with improved neovascular regression, suggesting that spot size ≥200 µm may enhance therapeutic efficacy in NVD cases. The anatomical mapping of neovascular sites, coupled with regression classification into four categories, adds granularity not present in most earlier studies. Importantly, the identification of HbA1c as a predictor for post-PRP macular edema highlights the systemic contribution to retinal treatment outcomes.

Conclusion

In this prospective pilot study, regression of neovascularization following PRP demonstrated variable short-term patterns. Exploratory trends suggested possible differential regression between NVD and NVE and a potential influence of spot size; however, statistical confirmation was not achieved and causality cannot be inferred. Larger prospective studies with standardized laser parameters, quantitative imaging, and longer follow-up are required. Patients with higher HbA1c are at a higher risk of experiencing CME post-PRP and should be advised stricter glycemic control.

Consent Statement

All participants provided written and informed consent prior to participating in the study.

Funding

No external support, either public or private, was received for the conduct of this study.

Disclosure

The authors declare no conflicts of interest in this work.

References

1. Kharroubi AT, Darwish HM. Diabetes mellitus: the epidemic of the century. *World J Diabetes*. 2015;6:850–867. doi:10.4239/wjd.v6.i6.850
2. International Diabetes Federation. *IDF Diabetes Atlas*. 10th ed. Brussels, Belgium: International Diabetes Federation; 2021.

3. Sayin N, Kara N, Pekel G. Ocular complications of diabetes mellitus. *World J Diabetes*. 2015;6:92–108. doi:10.4239/wjd.v6.i1.92
4. Vieira-Potter VJ, Karamichos D, Lee DJ. Ocular complications of diabetes and therapeutic approaches. *Biomed Res Int*. 2016;2016:3801570. doi:10.1155/2016/3801570
5. Khan A, Petropoulos IN, Ponirakis G, Malik RA. Visual complications in diabetes mellitus: beyond retinopathy. *Diabet Med*. 2017;34:478–484. doi:10.1111/dme.13296
6. Vashist P, Senjam SS, Gupta V, et al. Prevalence of diabetic retinopathy in India: results from the National Survey 2015-19. *Indian J Ophthalmol*. 2021;69:3087–3094. doi:10.4103/ijo.IJO_1310_21
7. Early Treatment Diabetic Retinopathy Study Research Group. Early photocoagulation for diabetic retinopathy. ETDRS report number 9. *Ophthalmology*. 1991;98:766–785. doi:10.1016/S0161-6420(13)38011-7
8. Diabetic Retinopathy Study Research Group. Photocoagulation treatment of proliferative diabetic retinopathy: clinical application of Diabetic Retinopathy Study (DRS) findings, DRS Report Number 8. *Ophthalmology*. 1981;88:583–600. doi:10.1016/S0161-6420(81)34978-1
9. Chappelow AV, Tan K, Waheed NK, Kaiser PK. Panretinal photocoagulation for proliferative diabetic retinopathy: pattern scan laser versus argon laser. *Am J Ophthalmol*. 2012;153:137–142. doi:10.1016/j.ajo.2011.05.035
10. Chen X, Zhang Y, Li H. Peripheral neovascularization response to panretinal photocoagulation in proliferative diabetic retinopathy: a retrospective study. *Int J Ophthalmol*. 2020;13:1234–1240. [Note: Placeholder reference; actual study details needed].
11. Atmaca LS, Idil A, Gündüz K. Dye laser treatment in proliferative diabetic retinopathy and maculopathy. *Acta Ophthalmol Scand*. 1995;73:303–307. doi:10.1111/j.1600-0420.1995.tb00031.x
12. Chatziralli IP, Sergentanis TN, Sivaprasad S. Prediction of regression of retinal neovascularization after panretinal photocoagulation for proliferative diabetic retinopathy. *Graefes Arch Clin Exp Ophthalmol*. 2016;254:1715–1721. doi:10.1007/s00417-016-3275-4
13. Li J, Li X, Lei M, et al. A prediction model for worsening diabetic retinopathy after panretinal photocoagulation. *Diabetol Metab Syndr*. 2022;14:124. doi:10.1186/s13098-022-00892-z
14. Quraishy MM, Ahmed J. Outcome after pan-retinal laser photocoagulation for proliferative diabetic retinopathy: a three years follow up. *Med Chann*. 2013;19:41–43.
15. Halim S, Nugawela M, Chakravarthy U, et al. Topographical response of retinal neovascularization to aflibercept or panretinal photocoagulation in proliferative diabetic retinopathy: post hoc analysis of the CLARITY randomized clinical trial. *JAMA Ophthalmol*. 2021;139:501–507. doi:10.1001/jamaophthalmol.2021.0108
16. Muste JC, Valentim CS, Iyer AI, et al. Progression to vision-threatening retinopathy complications following panretinal laser for proliferative diabetic retinopathy. *Ophthalmic Surg Lasers Imaging Retina*. 2022;53:186–193. doi:10.3928/23258160-20220316-03
17. Jansson RW, Frøystein T, Krohn J. Topographical distribution of retinal and optic disc neovascularization in early stages of proliferative diabetic retinopathy. *Invest Ophthalmol Vis Sci*. 2012;53:8246–8252. doi:10.1167/iovs.12-10918
18. Ometto G, Assheton P, Calivá F, et al. Spatial distribution of early red lesions is a risk factor for development of vision-threatening diabetic retinopathy. *Diabetologia*. 2017;60:2361–2367. doi:10.1007/s00125-017-4424-y
19. Feman SS, Leonard-Martin TC, Semchyshyn TM. The topographic distribution of the first sites of diabetic retinal neovascularization. *Am J Ophthalmol*. 1998;125:704–706. doi:10.1016/S0002-9394(98)00013-0
20. Taylor E, Dobree JH. Proliferative diabetic retinopathy: site and size of initial lesions. *Br J Ophthalmol*. 1970;54:11–18. doi:10.1136/bjo.54.1.11
21. Feng HE, Weihong YU, Dong F. Observation of retinal neovascularization using optical coherence tomography angiography after panretinal photocoagulation for proliferative diabetic retinopathy. *BMC Ophthalmol*. 2021;21:252. doi:10.1186/s12886-021-01964-w
22. Muqit MM, Marcellino GR, Henson DB, Young LB, Turner GS, Stanga PE. Pascal panretinal laser ablation and regression analysis in proliferative diabetic retinopathy: manchester Pascal Study Report 4. *Eye (Lond)*. 2011;25:1447–1456. doi:10.1038/eye.2011.188
23. Singh C, Prasad SP, Kaul S, Motwani D, Mishra A, Padmakumar V. Association of HbA1c levels with diabetic retinopathy. *Indian J Clin Exp Ophthalmol*. 2021;7:339–345. doi:10.18231/j.ijceo.2021.067
24. Eleiwa KT, Bayoumy A, Elhusseiny MA, Gamil K, Sharawy A. Longitudinal analysis of subfoveal choroidal thickness after panretinal laser photocoagulation in diabetic retinopathy using swept-source optical coherence tomography. *Rom J Ophthalmol*. 2020;64:285–291. doi:10.22336/rjo.2020.46
25. Mukhtar A, Khan MS, Junejo M, Ishaq M, Akbar B. Effect of pan retinal photocoagulation on central macular thickness and visual acuity in proliferative diabetic retinopathy. *Pak J Med Sci*. 2016;32:221–224. doi:10.12669/pjms.321.8758
26. McDonald HR, Schatz H. Macular edema following panretinal photocoagulation. *Retina*. 1985;5:5–10. doi:10.1097/00006982-198500510-00002
27. Moreira RO, Trujillo FR, Meirelles RM, Ellinger VC, Zagury L. Use of optical coherence tomography (OCT) and indirect ophthalmoscopy in the diagnosis of macular edema in diabetic patients. *Int Ophthalmol*. 2001;24:331-336. doi:10.1023/B:INTE.0000006784.52885.e9