Real-world Outcomes and Predictors of Vision Loss after Panretinal Photocoagulation for Diabetic Retinopathy: Five-year Follow-up

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ABSTRACT

Introduction: Diabetic retinopathy is a leading cause of vision loss in Fiji, where treatment options beyond panretinal photocoagulation (PRP) remain limited. In this context, evaluating longterm outcomes of PRP can provide critical insights in patient management.

Objective: To evaluate real-world long-term outcomes and predictors of vision loss following PRP for severe non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) in a resource-constrained setting.

Methodology: Retrospective study was done using five-year follow-up data of eyes treated exclusively with PRP at the Pacific Eye Institute, Fiji, between January 2010 and December 2015. Patients with advanced PDR, coexisting retinal pathology, or adjunctive therapies were excluded. Visual acuity, retinopathy grading, and systemic factors were assessed. Statistical analyses included Chi-square tests, independent samples t-tests, and generalised estimating equations.

Result: A total of 516 eyes (91 NPDR, 425 PDR) from 283 patients were included. At five years, 68% of PDR eyes achieved stability, 19% remained active, and 13% progressed to advanced PDR. Among NPDR eyes, 17.6% progressed to active PDR and 7.7% to advanced PDR. The difference in progression between NPDR and PDR eyes was significant at two years ($p < 0.001$) but not at five years ($p = 0.317$). Overall, eyes lost 2.7 lines of logMAR visual acuity; NPDR eyes lost more vision (3.9 lines) from baseline than PDR eyes (2.5 lines, $p = 0.059$). Poor glycaemic control, older age, and unstable retinopathy were significant predictors of vision loss ($p \leq 0.01$).

Conclusion: Panretinal photocoagulation remains essential for managing PDR, achieving longterm stability in most eyes. In severe NPDR, however, its use requires careful risk–benefit assessment. Importantly, access to intravitreal antiVEGF injections and vitrectomy should also be globally prioritised, as many eyes progress to advanced PDR and experience vision loss in the absence of adjuvant therapy despite laser treatment.

Key words: Diabetes; diabetic complications; panretinal photocoagulation; proliferative diabetic retinopathy; vitreous haemorrhage.

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INTRODUCTION

Fiji, a middle-income South Pacific nation, has one of the world's highest diabetes prevalence, reported at 29.6% by its Ministry of Health. (Snowdon and Tukana, 2011). Along with having one of the highest mortality rates due to diabetes, the country is also facing significant public health challenges associated with diabetic complications. One of the major microvascular complications of the disease is diabetic retinopathy (DR) which is reported to be increasing at an alarming rate in the country (Damato et al., 2014; Bhatta et al., 2024).

Proliferative diabetic retinopathy (PDR) presents a substantial risk of blindness if left untreated. Panretinal photocoagulation (PRP) is the standard treatment, often applied even at the severe nonproliferative diabetic retinopathy (NPDR) stage to prevent progression. However, PRP may be insufficient to avert vision loss in some patients. (Early Treatment Diabetic Retinopathy Study Research Group, 1991; Chew et al., 2003). Unfortunately, Fiji has limited options for alternative treatment modalities. Intravitreal Anti-Vascular Growth Factor (anti-VEGF) injections are not covered by the public health system, making them financially inaccessible for many patients. The first vitreoretinal service in the Pacific Island countries has only recently been established. Consequently, patients who did not respond to PRP often had no choice but to accept the natural progression of the disease.

This study was thus conducted to investigate the clinical course and prognosis of eyes with severe NPDR and PDR following PRP in a real-world scenario where other treatment adjuvants are not available. Although randomised controlled trials have established the efficacy of PRP in mitigating the progression of diabetic retinopathy and preventing vision loss, long-term real-world data in resource-limited settings—remain scarce. Furthermore, we also analysed key factors influencing the outcome of the treatment.

METHODOLOGY

This was a single-centre, retrospective, and observational study carried out at the Pacific Eye Institute (PEI) in Suva, Fiji. All patients who had PRP for severe NPDR and PDR at PEI between January 2010 and December 2015 were included in this study.

Patients with advanced PDR (significant vitreous haemorrhage obstructing the fundus view or tractional retinal detachment) prior to treatment, as well as those with any other coexisting retinal pathology were excluded from the study. A very small subset of patients who received intravitreal anti-VEGF injections or underwent vitreoretinal surgery abroad were also excluded. Those individuals who failed to attend a minimum of two follow up clinics every year for five consecutive years were excluded from the study.

Unaided and best-corrected visual acuity (BCVA) was assessed using a Snellen chart at six meters. After mydriasis, all patients underwent retinal photography by trained nurses using Canon CR-2 PLUS AF non-mydriatic fundus camera. Comprehensive ophthalmic examinations were performed by ophthalmologists. Retinopathy grading was done according to Diabetes Retinal Screening Guidelines: Pacific Islands

(Diabetes Working Group, The Fred Hollows Foundation New Zealand, 2010) Patients with PDR were advised PRP. Selected NPDR cases also received PRP based on disease activity and risk of poor follow-up. PRP was performed by ophthalmologists after obtaining written informed consent. Panretinal photocoagulation was performed using a frequency doubled Neodymium-doped Yttrium Aluminium Garnet (Nd:YAG) green laser (532 nm) through a Volk lens and slit lamp biomicroscope by Lightmed LIGHTlas 532 laser machine. Standard treatment involved 1200–1600 burns (300–500 µm spot size, 35–100 ms duration), spaced half to one burn width apart, covering the retina from arcades to equator while sparing the posterior pole. Treatment was usually completed in two sessions per eye. Patients were monitored monthly until stabilisation, then every four months, with additional burns applied if disease remained active.

At enrolment (Year 0), the study eyes were categorised into two groups: severe NPDR subgroup and PDR subgroup. At end point evaluation in year two and year five, the eyes were reclassified as having stable retinopathy, active disease or advanced PDR. Eyes without active vascular fronds and vitreous haemorrhage after laser were considered to have stable disease. If the new vessels were still active or there was fresh vitreous haemorrhage (without significant obstruction of fundus view for laser), the eyes were classified as having active disease. Eyes with significant vitreous haemorrhage obstructing the fundus view and those with macula involving tractional retinal detachment were defined as having advanced PDR.

Patient data were extracted from records, assigned unique IDs, deidentified in Excel, cleaned, and exported to SPSS V25 for analysis. Visual outcomes were assessed using the LogMAR conversion of the Snellen's chart. Associations of laser treatment with disease progression and visual outcomes were assessed using Chi-square and independent sample t-tests, respectively, while generalised estimating equations evaluated the influence of demographic and clinical factors.

The research conducted in this study adhered to the ethical guidelines set forth by the Declaration of Helsinki and was approved by the College of Medicine, Nursing and Health Sciences- College Human Health Research Ethics Committee (CMNHS-CHHREC) of the Fiji National University (Reference number: CHHREC ID: 059.21, dated: 10.03.2022).

RESULT

This study encompassed a total of 516 eyes from 283 patients. Out of 516 eyes, 425 eyes had PDR and 91 eyes had severe NPDR (Table 1). On average, PDR took approximately 11 years to develop after the diagnosis of diabetes, while severe NPDR took around nine years. There was statistically significant association ($p < 0.001$) of hypertension with PDR as higher number of PDR (49%) eyes were associated with hypertension, compared to those with NPDR (33%). At baseline, the average visual acuity was 0.374 for severe NPDR and 0.638 for PDR eyes.

Table 1: Baseline characteristics for the study population, n (%).

Characteristics	Number (percent) of cases		
Age (years)			
≤50	14 (5)		
51-70	189 (66.7)		
>70	80 (28.3)		
Sex			
Male	118 (41.7)		
Female	165 (58.3)		
Ethnicity			
Fijian-Indian	231 (81.6)		
Itaukei	46 (16.3)		
Others	6 (2.1)		
Duration of diabetes	**Severe NPDR eyes**	**PDR eyes**	**Total eyes**
≤10 years	55 (60.4)	218 (51.3)	273 (52.9)
11-20 years	32 (35.2)	171 (40.2)	203 (39.3)
21-30 years	4 (4.4)	36 (8.5)	40 (7.8)
Total eyes	91	425	516
Hypertension	**Severe NPDR eyes**	**PDR eyes**	**Total eyes**
Yes	61 (67.0)	215 (50.6)	276 (53.5)
No	30 (33.0)	210 (49.4)	240 (46.5)
Total eyes	**91**	**425**	**516**

Most of the patients had poor diabetic control throughout the study period (Table 2). At baseline, 213 patients (41.3%) had good glycaemic control, which improved modestly to 285 (55.2%) after five years. Eyes of cases with poorer control of blood sugar levels showed higher counts of blindness when compared to cases with good control of blood sugar levels at all points of evaluation. At the end of five years, 14.4% (n=41) of eyes with good control of blood sugar had blindness (VA<6/60) compared to 33.2% (n=73) of eyes with poor control and 40% (n=4) of eyes with very poor control of blood sugar levels ($p \leq 0.01$).

When assessed at two years after initial PRP, 67 eyes (73.6%) with NPDR and 212 eyes (50%) with PDR showed stability of disease increasing to 68 eyes (74.7%) in NPDR and 289 eyes (68%) in PDR at the end of five years (Table 3). At the end of five years, 81 eyes (19%) with PDR were still having active disease and 55 eyes (13%) had progressed to advanced PDR. Even with early PRP, 16 eyes (17.6%) with NPDR ended up with unstable PDR and seven eyes (7.7%) progressed to advanced PDR at the end of 5 years. There was a statistically significant ($p < 0.001$) difference in the number of eyes that attained disease stability after getting laser for NPDR compared to PDR at the end of two years. However, the difference was not significant at the end of five years ($p = 0.317$).

Table 2: Visual acuity of treated eyes in relation to average blood sugar level.

Year of Laser		Year 0			Year 2			Year 5		
Visual Acuity	CBG Control*	Good	Poor	Very Poor	Good	Poor	Very Poor	Good	Poor	Very Poor
6/6-6/18	Number of eyes	129	170	20	145	126	6	158	73	2
	% of total study eyes	25	32.9	3.9	28.1	24.4	1.2	30.6	14.1	0.4
<6/18-6/60	Number of eyes	61	67	6	56	85	4	86	74	4
	% of total study eyes	11.8	13.0	1.2	22.6	16.5	0.8	16.7	14.3	0.8
<6/60	Number of eyes	23	34	6	23	67	4	41	73	4
	% of total study eyes	4.4	6.6	1.2	4.4	13.0	0.8	7.9	14.1	0.8
Total	Number of eyes	213	271	32	224	278	14	285	220	10
	% of total study eye	41.3	52.5	6.2	43.4	53.9	2.7	55.2	42.6	1.9

Table 3: Diabetic retinopathy progression status at two and five years after laser treatment.

Evaluation endpoints	DR grading at baseline	Retinopathy status at evaluation endpoints, n (%)			Total	Chi-square test (p- value)
		Stable DR	Active PDR	Advanced PDR		
Year 2	NPDR	67 (73.6)	22 (24.2)	2 (2.2)	91	<0.001
	PDR	212 (49.9)	169 (39.8)	44 (10.3)	425	
Year 5	NPDR	68 (74.7)	16 (17.6)	7 (7.7)	91	0.317
	PDR	289 (68)	81 (19)	55 (13)	425	

The mean change in logMAR is -0.394 in severe NPDR and -0.245 in PDR suggesting worsening of vision in both groups (Table 4). There is no significant difference in the change in logMAR between the two groups over five years after laser treatment when analysed by independent t sample test (p =0.059).

Age, blood sugar control and stability of diabetic retinopathy were significantly associated with visual outcome at 5th year after laser treatment as shown by generalised estimating equation (Table 5). Eyes with worsening retinopathy suffered more significant vision loss than those that stabilised with treatment with loss of 29.75 letters in unstable disease. Interestingly, eyes under poor control of blood glucose control demonstrated a loss of vision by 10.65 letters. Additionally, vision loss was significantly associated with older age, with each increase in patient age correlated with loss of 0.65 letters. Notably, gender, ethnicity, and duration of diabetes were not linked to vision loss after PRP in this study.

Table 4: Changes in logMAR visual acuity (VA) for NPDR and PDR eyes after laser.

Baseline DR grading	Number of eyes	logMAR visual acuity			Change in logMAR at study endpoints		
		Year 0	Year 2	Year 5	Year 0-Year 2	Year 2-Year 5	Year 0-Year 5
Severe NPDR	91	0.374	0.515	0.769	-0.141	-0.253	-0.394
PDR	425	0.638	0.768	0.883	-0.130	-0.115	-0.245
Total patients	516	0.592	0.724	0.864	-0.132	-0.140	-0.272
P-value (Independent samples T- test) for change in logMAR visual acuity between PDR and NPDR groups between given time periods.					0.864	0.038	0.059

Table 5. Generalised estimating equation summarising the association between different variables and logMAR.

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	Degrees of freedom	p-value
(Intercept)	-1.140	0.2654	-1.660	-0.620	18.455	1	<0.001
Age (Continuous)	0.013	0.0040	0.005	0.021	10.692	1	0.001
Sex	-0.008	0.0595	-0.124	0.109	0.017	1	0.896
Ethnicity (Categorical)	0.010	0.0294	-0.048	0.068	0.117	1	0.732
DM Duration (categorical decades)	0.008	0.0444	-0.079	0.095	0.031	1	0.861
CBG Control at Year 5 (good vs poor vs very poor)	0.213	0.0559	0.103	0.323	14.513	1	<0.001
DR grade (Severe NPDR vs PDR)	-0.013	0.0670	-0.145	0.118	0.040	1	0.842
DR stability (Stable vs active PDR vs Advanced PDR)	0.595	0.0544	0.488	0.702	119.520	1	<0.001
(Scale)	0.420						

DISCUSSION

One of the remarkable findings in this study was the significant disparity in ethnic composition among the study participants. Indo-Fijians constituted approximately 231 (82%) cases of the study group, despite representing only around 38% of the total population (Fiji Bureau of Statistics, 2007). A previous study conducted in Fiji also reported higher prevalence of diabetes among Indo-Fijians compared to the indigenous Fijian Itaukei population (Morrell et al., 2016). Indo-Fijians also constitute most patients seeking care at diabetes clinics in the country (Bhikoo et al., 2017). Further investigation is necessary to understand the various factors contributing to this notable disparity in diabetes and diabetic retinopathy presentation between these two major ethnic groups in Fiji.

From the time of diabetes diagnosis, progression to severe NPDR and PDR occurred at an average of nine and eleven years, respectively. Nevertheless, 25 eyes (approximately 5%) presented with severe NPDR or PDR at the time of initial evaluation. The International Diabetes Federation (2019) Atlas revealed that undiagnosed diabetes is more prevalent in low- and middle-income countries, and in Fiji, 53% of diabetics are unaware of their condition. This finding suggests that a significant proportion of treatment-requiring diabetic retinopathy patients

may remain undiagnosed in the community, risking irreversible blindness.

A higher incidence of hypertension in PDR cases was noted compared to that in severe NPDR cases (49% vs. 33%, respectively). This observation aligns with findings from various landmark studies, which have consistently shown that hypertension is a risk factor for both the onset and progression of retinopathy (Klein et al., 1989; Nørgaard et al., 1991, UK UKPDS Group, 1998a). This study further demonstrated that poor capillary blood glucose control (CBG >10 mmol/L) was associated with a higher incidence of blindness compared to good control (CBG <10 mmol/L) at all evaluation points. The UKPDS Group Report (1998b) also emphasised the significance of strict blood glucose management in reducing the risk of microvascular complications.

In this study, the difference in the number of eyes progressing to advanced PDR between eyes treated with laser for severe NPDR and PDR was statistically significant at two years. This result is expected, as severe NPDR eyes have less advanced disease compared to PDR eyes initially; therefore, they should take longer to progress to advanced PDR. However, this difference was not significant at five years, and more eyes in the severe NPDR group progressed to advanced PDR than the PDR group between the second and fifth years. This finding suggests that performing early laser treatment alone for severe NPDR does not prevent additional eyes from developing advanced PDR over a longer time frame, compared to PRP done after development of PDR. Early PRP may, however, be applicable for patients with poor follow-up or compliance, in whom timely diagnosis of early PDR may not be possible. The Early Treatment Diabetic Retinopathy Study (1991) and Diabetic Retinopathy Study (1987) also did not provide strong evidence for early photocoagulation, but they showed borderline significance of early laser treatment in older patients with Type II diabetes.

The higher percentage of eyes with PDR achieving stable retinopathy at five years, compared to two years after initiating PRP treatment, suggests the possibility of achieving stability even at a later disease stage with additional interventions. The role of diabetes control and associated comorbidities may also be crucial, as more patients in our study demonstrated better diabetic control at five years (55%) compared to the initial (41%) and two-year follow-up (43%) periods.

Various studies have consistently identified the duration of diabetes, hyperglycaemia, and hypertension as important predictors of deteriorating diabetic retinopathy and sight-threatening diabetic retinopathy (STDR) (Rajalakshmi, 2020; Mersha, 2020; Kohner 1998; Liu, 2017). However, when assessing outcomes after PRP treatment, it was found that the duration of diabetes and the presence or absence of hypertension were not associated with progressive vision loss in this study. However, this study only looked at presence or absence of hypertension and didn't account for the effect of blood pressure control in progression of the disease.

Despite laser treatment, the study eyes in average lost 2.7 lines of logMAR visual acuity over five years. The absence of anti-VEGF treatment might be one of the reasons for

progressive vision loss, as anti-VEGF agents have been established to improve visual function and stabilise proliferative diabetic retinopathy in diabetic patients (Sun et al., 2019; Cai and Bressler, 2017). Unlike the findings of Lövestam Adrian et al., (2003), NPDR eyes in our study lost 1.5 more lines of logMAR visual acuity from baseline than PDR eyes with significant loss in vision occurring between the second- and fifth-years post-laser. In NPDR eyes, vision loss was most probably due to progressive maculopathy without intravitreal antiVEGF therapy whereas in PDR, baseline vision was also reduced by vitreous haemorrhage that could have improved with treatment, accounting for the observed disparity. These findings highlight the importance of ensuring regular follow-up, even after early PRP in NPDR, as some patients continue to face risks of vision loss and disease progression in the long run.

Some limitations are worth noting in this study. Firstly, the PDR and NPDR groups were imbalanced in terms of sample size. Secondly, this study did not explore the effects of cataracts or maculopathy on vision, as these factors were not specifically analysed. Additionally, this study relied only on the average of random blood sugar results as a measure of diabetic control, rather than assessing HbA1c levels. Lastly, this study was unable to evaluate the impact of other potential confounding factors, such as cardiovascular diseases, chronic kidney diseases, dyslipidaemia and blood pressure control, on the results. Despite the acknowledged limitations, notable strength of the study lies in its uninterrupted long-term follow-up after PRP providing valuable data on the effectiveness of standalone laser treatment in managing diabetic retinopathy cases, which unfortunately is the only treatment available in many parts of the developing world.

CONCLUSION

This study shows that over two-thirds of eyes at risk of vision loss from diabetic retinopathy can achieve long-term disease stability with PRP alone in real-world settings. Thus, laser treatment facilities remain indispensable for managing PDR. Yet, as patients continue to experience gradual vision loss and nearly one-fifth progress to advanced PDR despite PRP, it is imperative to make adjuvant therapies, such as intravitreal anti-VEGF injections and vitrectomy, affordable and globally accessible. Decisions to treat severe NPDR with PRP should be individualised, considering the availability and accessibility of these adjunctive options and risks of lost follow-ups.

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