Journal of Ocular Sciences and Ophthalmology

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Research Article *Volume 5 Issue 1*

Assessment of the Effect of Single Session Panretinal Photocoagulation on Macular Thickness in Diabetic Patients

Tahir F[1], Chaudhry A[2], Akhtar FK[3], Saad M[4]* and Ahmad S[5]

[1]Senior Registrar, Al-Shifa Trust Eye Hospital Rawalpindi, Pakistan

[2]Senior Registrar, Lahore General Hospital, Pakistan

[3]Senior Registrar, Services Institute of Medical Sciences, Pakistan

[4]Resident FCPS, Al-Shifa Trust Eye Hospital Rawalpindi, Pakistan

[5]Associate Professor, Al-Shifa Trust Eye Hospital Rawalpindi, Pakistan

***Corresponding author:** Muhammad Saad, Resident FCPS, Al-Shifa Trust Eye Hospital Rawalpindi, Punjab, Pakistan, 4600, Email: saadiazam0334@yahoo.com

Received Date: April 29, 2024; **Published Date:** May 14, 2024

Abstract

Diabetic retinopathy (DR), a common microvascular complication of diabetes mellitus, represents a significant cause of vision impairment and blindness worldwide. As a cornerstone of DR management, Panretinal Photocoagulation (PRP) aims to mitigate proliferative diabetic retinopathy (PDR) but carries potential risks, including changes in macular thickness, which may exacerbate vision loss. This study assesses the impact of a single session of PRP on macular thickness in patients with PDR.

Methods: Conducted at Lahore General Hospital's Department of Ophthalmology, this quasi-experimental study evaluated macular thickness pre- and post-PRP in 100 eyes of diabetic patients aged 18-65, using the OCT-Topcon 3D for measurements. Participants underwent a standardized PRP procedure with an Argon Laser, and macular thickness data were analyzed using SPSS, focusing on changes documented at one week post-treatment.

Results: The study demonstrated a statistically significant increase in macular thickness post-PRP ($p<0.001$). The average change in macular thickness was 13.38±8.93µm. Subgroup analyses across various demographic and clinical parameters confirmed consistent patterns of macular thickening, notably within different age groups and durations of PDR.

Discussion: The findings suggest PRP induces a measurable increase in macular thickness, likely due to inflammatory responses and alterations in retinal blood flow, emphasizing the need for careful patient selection and monitoring. These results underscore the importance of using OCT as a crucial tool in pre- and post-PRP evaluations to mitigate the risk of macular edema and potential vision loss. Future research should focus on long-term outcomes of PRP, exploring systemic factors such as diabetes control that may influence treatment efficacy.

Conclusion: This study confirms that PRP, while effective in controlling neovascularization in PDR, must be balanced against the risk of induced macular edema. Careful monitoring of macular thickness is essential to optimize patient outcomes and prevent vision deterioration following PRP treatment.

Keywords: Hypertension; Central Retinal Vein Occlusion; OCT Macula

Introduction

The worldwide prevalence of diabetes has been increasing over the years. In 2019, it was reported that about 9.3% or 463 million people had diabetes across the world. It is projected to increase further to 10.2% and 10.9 % of world population in 2030 and 2045, respectively [1]. Diabetic retinopathy (DR) is the most common micro vascular complication of diabetes mellitus and is vitally important cause of disability and blindness among the working-age population in the world [2].

DR is characterized by a range of retinal vascular abnormalities [3]. Without any interventions, the risk of developing some vision-threatening complications is high like proliferative diabetic maculopathy (PDR) and diabetic maculopathy [4]. Long-term hyperglycemia causes vascular endothelial dysfunction resulting in loss of endothelial cells and pericytes. Damaged blood vessels leak fluid and lipids onto the macula, a condition called macular edema, which makes the macula swell and blurs the vision [5].

The management of PDR has changed significantly over the last decades. Panretinal photocoagulation is considered to be one of the cornerstones of PDR treatment. This modality works through the application of laser burns to the peripheral retina in decreasing the ischemic drive, hence reducing the stimulus for neovascularization [6].

The primary lasers used for laser photocoagulation to treat proliferative diabetic retinopathy were argon blue-green and krypton, later being succeeded by diode lasers [7]. Presently, short pulse duration lasers are being used in standard clinical practice. These have the benefit of reducing treatment time as well as improving safety. Some studies state that PRP does not result in macular edema , particularly when used by the pattern scan lasers , while other insist that the treatments with shorter pulse durations are not as effective in regressing retinal neovascularization as those using longer pulse durations [8,9].

Despite being effective for the condition, PRP is not free from complications. A significant concern following PRP is the variation of macular thickness that can lead to macular edema and the subsequent deterioration of BCVA. Macular edema is reported to occur in 25% - 43% of the eyes after PRP and is thought to be the result of injury from the laser PRP and thus to a retinal inflammation and increased vascular permeability [8,10,11].

Methodology

This study was conducted as a quasi-experimental at the Department of Ophthalmology, Lahore General Hospital, Lahore, over six months. Pre- and post-treatment results of macula thickness within the group of patients were, thus, the primary focus in order to determine the effects of PRP. The sample size was calculated using the Open EPI Info calculator, resulting in a total of 100 eyes.

The study populations were adults aged 18-65 years from either sex who had been diagnosed with diabetes for at least five years. The inclusion criteria required that participants were diagnosed with visible proliferative diabetic retinopathy with treatment-naïve in the last year, which was diagnosed through a slit-lamp examination with a 78D lens according to the approved ETDRS guidelines. However, the exclusion criteria comprised past intraocular or laser surgery, macular thickness of over 220 microns on OCT at baseline and those patients who had a media opacity that precluded OCT imaging, had uncontrolled diabetes with an HbA1c level above 7%, or had a history of intraocular inflammation.

After obtaining approval of the ethical committee and informed consent from the participants, data was collected in a standardized manner. The OCT machine (OCT- Topcon 3D) was used to measure thickness of macula at baseline. Tropic amide 1% was then applied for pupillary dilatation. Argon Laser panretinal photocoagulation was performed by a single experienced surgeon to standardize the treatment effect. OCT was then repeated one week after PRP was done to assess the effect of treatment on macular thickness. The data was analyzed using SPSS version 20. The quantitative result that was collected included macular thickness, and the descriptive result was summarized using measures of central tendency including the mean and the standard deviation. The primary outcome, which involved changes in macular thickness before and after treatment, was evaluated using a paired t-test. Results were deemed statistically significant as the corresponding p-value was ≤ 0.05. The other results including age of the patient, duration of PDR, and gender of the patients were sub-analysed to assess the influence of the said factors on the outcome of treatment, that is, the change in macular thickness.

Results

A total of 100 cases were included in this study during the study period of six months. Patients ranged between 20-65 years of age. Mean age of the patients was 49.60±9.21 year. Mean change in macular thickness was 13.38±8.93µm. 68 cases (68%) were male while remaining 32 cases (32%) were female. Out of 100 cases, 72 cases (72%) were having duration of PDR 5-10 years and 28 cases (28%) had duration of PDR > 11 years. Preoperative macular thickness was 207.23±8.51 and postoperative macular thickness was 220.61±13.13 with p value ($p<0.001$). Stratification with regard to age, gender and duration of PDR was carried out and presented in Table 1.

Stratification	Category	Pre-Operative Mean ± SD	Preoperative Mean ± SD	P value
Age (Year)	20-40	210.68±7.91	222.59±10.89	P<0.001
	41-65	206.26±8.46	220.05±13.71	P<0.001
Gender	Male	206.94±8.10	221.13±12.25	P<0.001
	Female	207.82±9.39	219.55±14.92	P<0.001
Duration of PDR	5-10 Year	206.75±8.78	219.58±13.27	P<0.001
	> 11 Year	208.46±7.79	223.25±12.63	P<0.001

Table 1: Combined Stratification: Macular Thickness (µm).

The results of subgroup analyses performed within the study were enlightening. It demonstrated a notable increase in macular thickness following panretinal photocoagulation (PRP) treatment across various stratifications. As shown in Figure 1, in the age groups, individuals aged 20-40 showed an increase in macular thickness from a pre-operative mean of 210.68±7.91 µm to a post-operative mean of 222.59±10.89 µm. Similarly, those aged 41-65 experienced an increase from 206.26±8.46 µm to 220.05±13.71 µm post-treatment. Regarding the duration of PDR, patients with disease duration of 5-10 years saw their macular thickness increase from 206.75±8.78 µm to 219.58±13.27 µm, and those with more than 11 years from 208.46±7.79 µm to 223.25±12.63 µm as shown in Figure 2. When considering gender, males exhibited an increase from 206.94±8.10 µm to 221.13±12.25 µm, and females from 207.82±9.39 µm to 219.55±14.92 µm as shown in Figure 3. These changes are statistically significant with p-values less than 0.001 in all categories, indicating a consistent pattern of macular thickening post-PRP across different demographic and clinical groups.

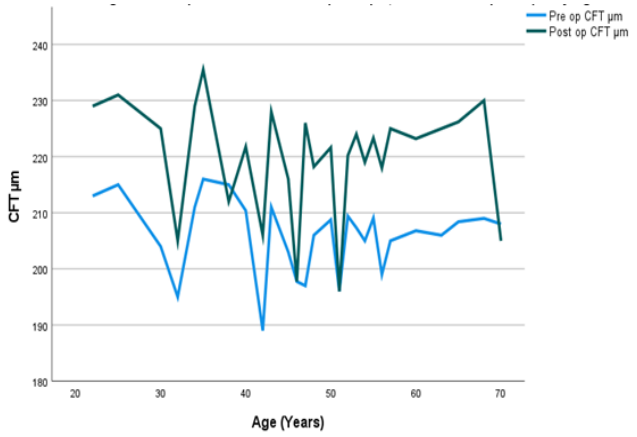

Figure 1: Multiple Line Means of Pre op CFT µm by age.

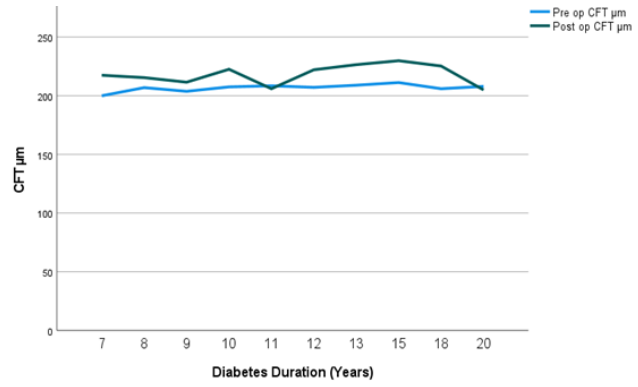

Figure 2: Multiple Line Mean of Pro op CFT µm, Mean of Post op CFT µm by Diabetes Duration.

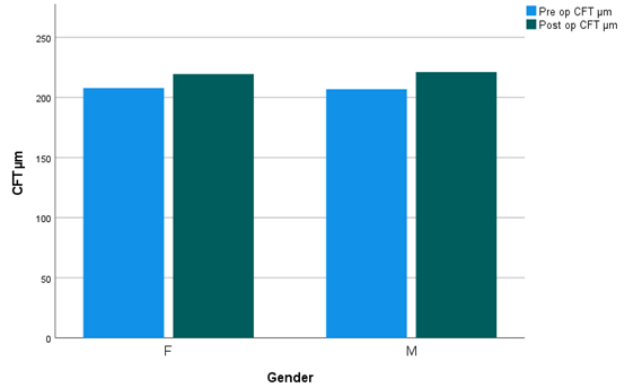

Figure 3: Simple Bar Mean of Pre op CFT µm, Mean of Post op CFT µm by Gender.

Discussion

This study evaluated the effect of a single session, conventional PRP on central foveal thickness in patients

with newly diagnosed PDR without center-involving macular edema as confirmed by OCT before performing PRP. In this cohort, there was a statistically significant increase in central foveal thickness, documented through OCT, at 1 week follow-up. No other adverse effects related to PRP were noted.

Since inflammation is a prominent part of the pathogenesis of DME, it is reasonable that PRP would raise the levels of inflammatory markers in the vitreous. The inflammatory reaction of a thermal burn from the laser would likely irritate the targeted area enough to incite a certain level of breakdown of the blood-retinal barrier [11]. The fluid buildup in the macula could also be due to the alteration of the retina's blood flow as a result of PRP. PRP induces a systemic increase in retinal oxygenation, thereby alleviating the hypoxia [12]. However, without the appropriate means to repair the vasculature as well, this may lead to the blood vessels leaking and fluid filling the macula.

This has significant implications in clinical practice. PRP has remained a mainstay in the management of PDR [6]. However, ophthalmologists have to balance the benefit of neovascularization control against the risk of macular edema. Particularly, it would be essential to exercise care in patients who already displayed some macular thickening or had a high risk of DME. The use of OCT has been especially important as a monitoring tool, including at the pre-PRP and post-PRP stages [13]. When macular edema is detected early, it can be addressed with interventions such as intravitreal corticosteroids or anti-VEGF agents [14].

Previous literature reveals a relation between induction of macular edema post PRP with the power and duration of laser treatment [15]. Pattern scan laser photocoagulators (PASCAL) have recently been introduced which can deliver multispot arrays of laser at pulse duration of 20ms. The advantages of this laser delivery system comprise lesser time required to complete the treatment and better patient comfort than that done using conventional Argon blue green laser where the duration is usually 100 millisecond [16]. In the present study, a statistically significant mean increase in central foveal thickness of 13.38μm was seen at 1 week follow-up, with an average of 2450 laser spots delivered. 49 out of 100 cases (49%) had an increase of ≥15 μm after PRP at one week, which fulfilled the definition of significant change in macular thickness.

Watanachai et al. performed a prospective case study on 40 eyes of 33 consecutive patients who received a single session of multispot, 20-millisecond panretinal photocoagulation. On average, a total of 2750 laser spots were applied to each patient, with a mean laser power of 399 mW. The follow-up data showed that central subfield foveal thickness increased significantly by an average of 24 μm at 4 weeks and 17.4 μm by 12 weeks [17].

The decision to assess macular thickness using Optical Coherence Tomography (OCT) one week after Panretinal Photocoagulation (PRP) treatment is strategically chosen to capture the immediate post-procedural changes and the early onset of potential complications such as macular edema. This timeframe is crucial because it allows for the detection of acute inflammatory responses and initial vascular changes before more adaptive physiological responses can occur. It provides a snapshot of the direct impact of PRP on the retinal structure, which is essential for evaluating the efficacy and safety of the treatment protocol.

However, while this study focuses on short-term outcomes, it inherently suggests the necessity for extended monitoring periods to fully understand the long-term effects of PRP on macular thickness and visual acuity. The underlying mechanism of PRP involves inducing a controlled burn to reduce ischemia-driven neovascularization. This process can alter vascular endothelial growth factor (VEGF) levels, which play a critical role in regulating vascular permeability and angiogenesis. Over time, the reduction in VEGF levels post-PRP might lead to significant changes in macular edema and overall retinal health.

Limitations

This study has its limitations. The observed lower incidence of macular edema compared to previous studies could be attributed to our smaller sample size. Furthermore, the reduced occurrence of macular edema might also be linked to the absence of risk factors for macular edema prior to PRP therapy.

The follow up period for this study was short; nevertheless, it provides valuable information regarding the prognosis. The results of this study were compared to those of related studies when possible, but due to variation in study design, direct comparisons were limited.

The significance of Panretinal Photocoagulation (PRP) in managing proliferative diabetic retinopathy is well recognized, particularly for its role in modifying disease progression and managing complications such as neovascularization. However, the associated alterations in macular thickness and their implications on visual outcomes necessitate a deeper examination. While this study has provided initial insights into the short-term effects of PRP on macular thickness, the varying degrees of macular edema reported post-treatment highlight the need for a more comprehensive understanding of these changes over a prolonged period. Long-term observational studies could play a crucial role in this context, helping to delineate the durability of PRP effects on macular

thickness and visual acuity over time. Such studies would not only aid in validating the initial findings but also contribute to refining treatment protocols to optimize patient outcomes, potentially including the adjustment of laser parameters or the integration of adjunctive therapies to better manage the risks of macular edema and vision loss. This approach could ultimately lead to more personalized and effective management strategies for patients with proliferative diabetic retinopathy.

Conclusion

Our study demonstrated significant changes in macular thickness ($p<0.001$) among patients with proliferative diabetic retinopathy (PDR) treated with panretinal photocoagulation (PRP), despite initially normal macular thickness. These findings underscore the necessity of a balanced approach to PDR treatment. While PRP effectively inhibits neovascularization, it must be carefully managed to mitigate the risk of macular edema. Utilizing Optical Coherence Tomography (OCT) for both pre- and post-PRP assessments is critical for timely detection of any increase in macular thickness, thereby reducing the risk of vision loss.

Patients should be informed of the potential for macular edema, which may necessitate adjunctive treatments such as intravitreal pharmacotherapy or additional laser interventions. Understanding individual factors that influence changes in macular thickness after PRP could greatly enhance treatment precision and safety.

To build on these insights, future research should include long-term studies that monitor changes in macular thickness and visual acuity over time, considering how systemic factors like diabetes management and hypertension impact PRP outcomes. Such studies will be crucial for developing more effective, patient-specific treatment strategies for diabetic retinopathy.

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