Original Article

Effectiveness of Micropulse Transscleral Cyclophotocoagulation (MP-TSCPC) Using the Longer Duration Protocol in Lowering IOP in Patients with Glaucoma

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Imran Ghayoor[1], Rida Ather[2], Munira Shakir[3], Nazish Khan[4], Salman Azmi[5]

[1, 2,3]Liaquat National Hospital, Karachi [4,5]Hashmani Eye Hospital, Karachi

ABSTRACT

Purpose: To evaluate the short-term effectiveness and associated predictors of intraocular pressure (IOP) reduction following micropulse transscleral cyclophotocoagulation (MP-TSCPC) in patients with glaucoma.

Study Design: Prospective observational study.

Place and Duration of Study: Conducted at Liaquat National Hospital, Karachi, from July 12, 2024, to January 13, 2025.

Methods: Patients with uncontrolled glaucoma undergoing MP-TSCPC were enrolled. IOP was measured at baseline, 1 month, and 3 months post-procedure. Treatment effectiveness was defined as a ≥20% reduction in IOP without need for further surgical intervention. Friedman test and Wilcoxon signed-rank tests assessed changes over time. Categorical associations were examined using chi-square test, and predictors of effectiveness were analyzed via univariate and multivariable logistic regression.

Results: A total of 97 eyes were analyzed. Median baseline IOP was 20 mmHg (IQR: 17–31), which significantly reduced to 16 mmHg (IQR: 14–22) at 1 month and 14 mmHg (IQR: 11–17) at 3 months ($p < 0.001$). Treatment was effective in 76 eyes (78.4%). Male gender ($p < 0.001$), longer glaucoma duration ($p = 0.03$), and moderate severity ($p = 0.038$) were significantly associated with effectiveness. In multivariable regression, only male gender remained an independent predictor (aOR = 10.59, 95% CI: 2.11–53.21, $p = 0.004$).

Conclusion: MP-TSCPC significantly lowered IOP at 1 and 3 months. Approximately four-fifths of patients achieved effective outcomes, with male gender being a strong predictor of success. The procedure appears safe and beneficial for short-term glaucoma control.

Keywords: Micro pulse Transscleral Cyclophotocoagulation, Intraocular Pressure, Glaucoma, Risk Factors.

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Correspondence: Rida Ather
Liaquat National Hospital, Karachi
Email: ridaather100@gmail.com

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INTRODUCTION

Glaucoma is a leading cause of irreversible blindness globally, affecting millions of people across all age groups, particularly with increasing age.[1,2] It is a chronic, progressive optic neuropathy characterized by structural damage to the optic nerve head and associated visual field loss, ultimately leading to permanent visual impairment if left untreated.[3] Among the many identified risk factors, elevated intraocular pressure (IOP) is the most significant and the only modifiable factor known to slow disease progression when effectively controlled.[4]

In 2020, an estimated 4.14 million people were living with glaucoma, highlighting its substantial

global impact.[5] A recent meta-analysis has revealed pooled prevalence of glaucoma in South Asian population as 2.1%.[6] A study from Pakistan reported that among individuals who were attending glaucoma clinic as suspected cases, 9.36% were found positive for glaucoma.[7] Current treatment strategies aim to reduce IOP through either reducing aqueous humor production or increasing its outflow. These include pharmacologic therapy (topical and oral), laser procedures, and surgical interventions such as trabeculectomy, minimally invasive glaucoma surgeries (MIGS), and glaucoma drainage devices.[8]

Transscleral cyclophotocoagulation (TSCPC) is a cyclodestructive laser procedure that targets the ciliary body to reduce aqueous production and lower IOP.[9] TSCPC is performed in two forms: the traditional continuous-wave (CW-TSCPC), which is effective but associated with higher rates of complications such as hypotony, phthisis bulbi, and intraocular inflammation; and micro pulse TSCPC (MP-TSCPC), which delivers laser energy in repetitive on-and-off cycles, allowing tissue cooling and reducing collateral damage.[10]

Numerous studies have been conducted so far however the findings are still debatable.[9,11,12]In addition, there is a lack of local data evaluating the effectiveness of the longer-duration protocol in the Pakistani population. Therefore, this study is conducted with the aim of assessing the effectiveness of MP-TSCPC using a longer-duration protocol in reducing IOP among patients with glaucoma. By examining its clinical efficacy and safety profile, the study seeks to inform evidence-based practice and support the broader use of this technique as a minimally invasive and sustainable approach to glaucoma management.

METHODS

This descriptive study was conducted at Liaquat National Hospital, Karachi, over a six-month period from 12th of July, 2024to 13thJanuary, 2025. Ethical approval was obtained from the institute **(Reference No. 1041-2024-LNH-ERC)** whereas signed informed consent was obtained from the eligible participants.

Adult patients between 18 and 60 years of age and either gender were included. The inclusion criteria were further defined as patients with a pre-treatment best-corrected visual acuity (BCVA) of 20/60 or worse, diagnosed with glaucoma exhibiting an IOP of >18 mmHg despite maximum tolerated topical and/or oral anti-glaucoma medications, and were willing to complete a minimum follow-up of six months. Patients with or without prior incisional glaucoma surgery were considered eligible, provided their baseline IOP exceeded 21 mmHg while on at least one anti-glaucoma medication. Patients were excluded if they had undergone glaucoma laser or incisional surgery within the last two months, had significant conjunctival scarring, very thin sclera, or a small palpebral aperture that could hinder the procedure. Additional exclusion criteria included pre-existing ocular conditions such as active uveitis or infections, prior ocular trauma, severe scleral thinning, or recent use of antimetabolites or excessive cautery. Any ocular surgery in the study eye within the last three months also warranted exclusion.

A sample size of 97 was calculated using the WHO sample size calculator (developed by K.C. Lun, University of Singapore), based on an expected treatment effectiveness of 85.7% reported by Wasim et al,[13] with a 95% confidence level and a 7% margin of error. Non-probability consecutive sampling was employed to recruit eligible patients who presented during the study period.

Operational definitions were clearly established. Effectiveness of treatment was defined as achieving an IOP between 6 and 18 mmHg at the final follow-up visit, with at least a 20% reduction from baseline, regardless of the use of medications. The longer-duration MP-TSCPC protocol used in this study involved delivering micro pulse laser energy via the IRIDEX Cyclo G6 system with an MP3 probe. Treatment was applied to the upper and lower hemispheres (avoiding the 3 and 9 O'clock positions to prevent neurovascular damage), with each hemisphere receiving 135 seconds of treatment for a total of 270 seconds. The laser emitted 810 nm wavelength energy at 2000 mW power, using a duty cycle of 31.3%, comprised of 0.5 ms "on" and 1.1 ms "off" intervals. The target IOP for each patient was individually determined by the ophthalmologist based on baseline IOP, glaucoma severity, and the expected treatment response.

Severity of glaucoma was classified clinically based on IOP and optical coherence tomography (OCT) findings. Mild glaucoma was defined as an IOP up to 21 mmHg with minimal cupping (cup-to-disc ratio <0.5) and intact retinal nerve fiber layer (RNFL). Moderate glaucoma included patients with IOP

between 21 and 30 mmHg and moderate cupping (C:D ratio 0.5–0.7). Severe glaucoma was characterized by IOP above 30 mmHg with significant optic nerve cupping (C:D ratio >0.7). Confounding ocular conditions were also defined: ocular hypertension (OHT) was defined as IOP of >21 mmHg on at least two occasions without any associated optic nerve or visual field abnormalities.

Data collection began after obtaining approval from the College of Physicians and Surgeons Pakistan (CPSP) and written informed consent from each participant. All patients underwent comprehensive ophthalmologic evaluation including BCVA measurement (converted to decimal form), anterior segment examination with slit-lamp biomicroscopy, fundus examination with a 78 or 90 diopter lens, and IOP measurement using Goldmann applanation tonometry. MP-TSCPC was performed under peribulbar anesthesia using 3–5 ml of lidocaine. The laser probe was applied in a sweeping motion over the superior and inferior hemispheres, avoiding the horizontal meridians, with treatment duration of 135 seconds per hemisphere (total 270 seconds). Laser parameters included 810 nm wavelength, 2000 mW power, 31.3% duty cycle, and micro pulse delivery.

Post-procedural management included topical Fluorometholone QID for three weeks, adjusted according to the treating physician's clinical judgment. Patients were followed up at one month and three months post-treatment. At each follow-up, assessments included BCVA, IOP measurement, number of anti-glaucoma medications, and any need for oral acetazolamide. The primary outcome was the change in IOP from baseline to one and three months, both in absolute terms and as a percentage reduction. Secondary outcomes included reduction in the number of medications and the incidence of any postoperative complications. All relevant demographic and clinical data, including age, gender, type and severity of glaucoma, previous glaucoma procedures, and laser treatment parameters were recorded using a structured data collection form.

Statistical analysis was conducted in R (RStudio). Repeated measures of non-normal continuous data were compared using the Friedman test; when significant, post-hoc pairwise Wilcoxon signed-rank tests with Holm–Bonferroni adjustment were applied. Categorical associations were examined with the χ^2 test or Fisher's exact test, as appropriate. Treatment effectiveness was modeled with logistic regression: variables with $p<0.20$ on univariate analysis (or strong clinical relevance) were entered into the multivariable model. Multicollinearity was checked using variance inflation factors, model calibration with the Hosmer–Lemeshow test, and discrimination with the area under the ROC curve. Results are reported as median (IQR) or n (%), and odds ratios (ORs) with 95% confidence intervals. All tests were two-sided, with $p<0.05$ considered statistically significant.

RESULTS

Of 97 patients, the median age of the patients was 30 (18-67) years. There were 43 (44.3%) males and 54 (55.7%) females. The median duration of glaucoma was 3 (2-13) years. Primary glaucoma was observed in 66 (68%) and secondary glaucoma in 31 (32%) patients. The severity levels of glaucoma showed that 55 (56.7%) patients had advanced glaucoma, 40 (41.2%) had moderate glaucoma, and 2 (2.1%) had mild glaucoma. The baseline Snellen visual acuity showed that 26 (26.8%) patients presented with visual acuity of 20/60, 16 (16.5%) with 20/80, and 14 (14.4%) with 20/125. The left side of the eye was affected in 37 (38.1%) patients while the right eye in 60 (61.9%) patients. Previous surgeries were reported in 10 (10.3%) patients.

The median pre-operative IOP was 20 mmHg (IQR: 17–31), which decreased to 16 mmHg (IQR: 14–22) at 1 month and 14 mmHg (IQR: 11–17) at 3 months post-procedure. The Friedman test showed a significant difference across timepoints ($p < 0.001$), with all Wilcoxon signed-rank post-hoc comparisons also significant ($p < 0.001$) (Figure 1).

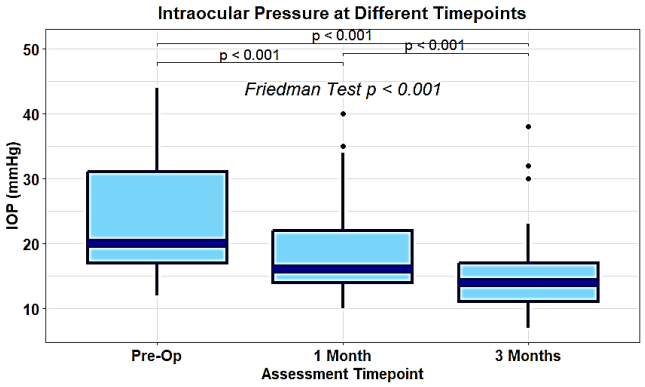

Figure 1: *Boxplot showing intraocular pressure (IOP) at Pre-Op, 1 Month, and 3 Months. A significant difference was observed using the Friedman test ($p < 0.001$), and all pairwise comparisons using Wilcoxon signed-rank post-hoc tests were also significant ($p < 0.001$).*

Effectiveness was observed in 76 (78.4%) cases. Gender showed a statistically significant association with treatment effectiveness ($p < 0.001$), with a higher proportion of effective outcomes among males (95.3%) compared to females (64.8%). Similarly, duration of glaucoma was significantly associated ($p = 0.03$), with higher effectiveness in patients with more than 3 years (87.5%) of disease compared to ≤3 years (69.4%). Severity of glaucoma also showed significance ($p = 0.038$), with moderate cases showing higher effectiveness (90%) than advanced cases (69.1%). No significant associations were observed for age, type of glaucoma, laterality of eye, or history of previous surgery (Table 1).

In univariate regression analysis, male gender (OR = 11.13, 95% CI: 2.42–51.15, $p = 0.002$), shorter duration of glaucoma (≤3 years) (OR = 3.09, 95% CI: 1.08–8.82, $p = 0.035$), and advanced severity (OR = 4.25, 95% CI: 1.31–13.81, $p = 0.016$) were significantly associated with treatment effectiveness. However, in the multivariable model, only gender remained significantly associated (aOR = 10.59, 95% CI: 2.11–53.21, $p = 0.004$), while duration and severity lost significance after adjustment (Table 2).

Table 1: *Comparison of effectiveness with general characteristics of the patients (n=97).*

Variables	Total n	Effectiveness (≥20% reduction in IOP from baseline) Yes n (%)	No n (%)	p-value
Age, years				
≤30	51	40 (78.4)	11 (21.6)	0.984
>30	46	36 (78.3)	10 (21.7)	
Gender				
Male	43	41 (95.3)	2 (4.7)	<0.001
Female	54	35 (64.8)	19 (35.2)	
Duration of Glaucoma, years				
≤3	48	42 (87.5)	6 (12.5)	0.030
>3	49	34 (69.4)	15 (30.6)	
Type of Glaucoma				
Primary Glaucoma	66	55 (83.3)	11 (16.7)	0.082
Secondary Glaucoma	31	21 (67.7)	10 (32.3)	
Severity of Glaucoma				
Advanced	55	38 (69.1)	17 (30.9)	0.038
Moderate	40	36 (90.0)	4 (10.0)	
Mild	2	2 (100)	0 (0)	
Side of Eye				
Left	37	28 (75.7)	9 (24.3)	0.615
Right	60	48 (80.0)	12 (20.0)	
Previous Surgery				
Yes	10	10 (100)	0 (0)	0.112
No	87	66 (75.9)	21 (24.1)	

Table 2: *Regression analysis of factors associated with effectiveness (≥20% reduction in IOP from baseline).*

	Univariate Analysis OR (95% CI)	p-value	Multivariable Analysis aOR (95% CI)	p-value
Gender				
Male	11.13 (2.42-51.15)	0.002	10.59 (2.11-53.21)	0.004
Female	Ref		Ref	
Duration of Glaucoma, years				
≤3	3.09 (1.08-8.82)	0.035	2.81 (0.60-13.19)	0.189
>3	Ref		Ref	
Severity of Glaucoma				
Advanced	4.25 (1.31-13.81)	0.016	1.04 (0.18-6.04)	0.964
Mild/Moderate	Ref		Ref	

DISCUSSION

This study evaluated the IOP reduction and factors influencing effectiveness following MP-TSCPC in patients with various types of glaucoma. A significant IOP reduction was observed at both one and three months post-procedure, with median values decreasing from 20 mmHg at baseline to 14 mmHg at three months. The Friedman test confirmed a statistically significant difference across timepoints ($p < 0.001$), and all pairwise Wilcoxon signed-rank comparisons were significant, suggesting robust procedural efficacy. These findings are consistent with previous literature. Tekeli and Köse demonstrated that varying durations of MP-TSCPC (160–240 seconds) effectively reduced IOP while preserving visual acuity, particularly in eyes with good baseline vision.[14] Similarly, Hooshmand et al, reported durable IOP control with both initial and repeat MP-TSCPC procedures in adult glaucoma patients, with median reductions of 4–8 mmHg sustained over several months.[15] While no ideal parameters have been established for treatment with MP-TSCPC, numerous studies have assessed the efficacy with variable duration treatments (80-120s per hemisphere, (160-240s) in reducing the IOP by 20-40%.[9]

In the current study, male gender and longer duration of glaucoma (>3 years) were significantly associated with greater effectiveness on univariate analysis. However, only male gender remained a significant predictor on multivariable analysis. This contrasts with some earlier studies that did not find gender as a significant predictor of treatment response.[15] The observed gender difference may reflect differential patterns in adherence, anatomical variation, or underlying disease severity.

Although severity of glaucoma and duration were significant in univariate models, their associations diminished upon adjustment. This may imply that while these factors initially appear influential, their effects are mediated through other variables or that our sample lacked sufficient power to confirm significance. The high success rates (>75%) observed align with data from Rajendrababu et al, who reported favorable short-term outcomes whether MP-TSCPC was used as a primary or adjunctive therapy.[16] Moreover, real-world multicenter data from Laruelle et al, further affirmed the utility of MP-TSCPC in advanced and refractory glaucoma, though complications such as transient hypotony were occasionally reported.[17]

While the previous study[18] demonstrated that systemic factors such as diabetes status influenced visual function, our current findings on MP-TSCPC highlight that patient-related characteristics, particularly gender, can also serve as significant predictors of ocular outcomes.

The safety profile in our study was favorable, with no major vision-threatening complications observed. This echoes findings from earlier reports, where MP-TSCPC consistently demonstrated fewer adverse events compared to continuous-wave CPC sessions.[19,20] Notably, Emanuel et al, reported inflammatory responses in ~46% at 3 months and vision loss in ~41% of cases.[21] Our lower complication rate may reflect stricter energy protocols and careful patient selection.

There are several limitations in the current study. First, this study had a limited follow-up duration of three months, which may not capture long-term outcomes or late complications. Secondly, IOP was used as the sole marker of success; visual field progression or need for additional interventions were not assessed. Third, the sample was drawn from a single tertiary center, limiting generalizability. Longitudinal studies with extended follow-up are needed to evaluate the durability of MP-TSCPC in different subtypes of glaucoma and its impact on visual function. Stratification by energy settings and repeat treatments could also refine clinical protocols.

CONCLUSION

MP-TSCPC demonstrated significant IOP reduction within three months post-procedure, with male gender emerging as an independent predictor of effectiveness. These findings support the use of MP-TSCPC as a safe and effective treatment modality in diverse glaucoma populations.

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Patient's Consent: Researchers followed the guidelines set forth in the Declaration of Helsinki.

Conflict of Interest: Authors declared no conflict of interest.

Ethical Approval: The study was approved by the Institutional review board/Ethical review board **(No.1041-2024-LNH-ERC).**

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Authors Designation and Contribution

Imran Ghayoor; Professor: *Concepts, Design, Data acquisition, Manuscript editing, Manuscript* review.

Rida Ather; Resident: *Concepts, Design, Literature search, Data acquisition, Data analysis, Manuscript preparation, Manuscript editing, Manuscript review.*

Munira Shakir; Professor: *Concepts, Data acquisition, Manuscript editing, Manuscript review.*

Nazish Khan; Consultant Ophthalmologist: *Literature search, Data analysis, Statistical analysis, Manuscript preparation, Manuscript editing, Manuscript review.*

Salman Azmi; Consultant Ophthalmologist: *Literature search, Data analysis, Statistical analysis, Manuscript preparation, Manuscript editing, Manuscript review.*