Clinical Ophthalmology

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ORIGINAL RESEARCH

Micropulse Transscleral Cyclophotocoagulation for the Management of Diverse Glaucoma Types: A Multicenter Short-Term Real-World Study

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Video abstract

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Purpose: To evaluate the safety and effectiveness of micropulse transscleral cyclophotocoagulation (MP-TSCPC) in patients with various types of glaucoma by assessing intraocular pressure (IOP) reduction, medication burden, and the potential influence of diagnosis, prior surgeries, or comorbidities on treatment success.

Patients and Methods: This retrospective, multicenter study included 101 eyes treated with MP-TSCPC using the IRIDEX Cyclo G6 MP3 laser. Follow-up was performed for at least 12 months. The primary outcomes were IOP reduction and changes in the number of hypotensive medications. The secondary outcomes included complication rates and visual acuity stability. Success was defined as IOP reduction ≥20% or IOP between 6 and 21 mmHg, with or without medication. Statistical analyses included paired t-tests and Cox regression to assess subgroup influence.

Results: Baseline intraocular pressure (IOP) was 26.19 ± 6.77 mmHg and decreased to 14.40 ± 6.10 mmHg at 12 months (Δ = −11.76 ± 8.03 mmHg; ≈ −45%; $p<0.0001$). Mean logMAR visual acuity changed from 0.53 ± 0.64 preoperatively to 0.63 ± 0.72 post-operatively ($p < 0.001$). No significant differences in treatment success were found among the glaucoma subtypes, previous ocular surgeries, or comorbidities (all $p > 0.05$). Visual acuity remained stable in most patients, with only two cases of loss of light perception. Severe complications were rare, and no cases of phthisis bulbi or hypotony were observed.

Conclusion: MP-TSCPC safely provides sustained IOP control and medication reduction across diverse glaucoma types, supporting its role as a versatile alternative for both refractory and functional eyes with glaucoma. The real-world, multicenter nature of this study enhances its external validity, although its retrospective design and 12-month follow-up limit long-term generalizability.

Keywords: glaucoma, micropulse laser, transscleral cyclophotocoagulation, intraocular pressure, real-world data, diode laser, glaucoma treatment

Introduction

Glaucoma is a chronic, progressive optic neuropathy characterized by the loss of retinal ganglion cells and their axons, leading to irreversible visual field loss. It remains the leading cause of irreversible blindness worldwide, with an estimated 80 million

https://doi.org/10.2147/OPTH.S555181
Received: 21 July 2025
Accepted: 1 December 2025
Published: 8 January 2026

people affected in 2020 and projections exceeding 110 million by 2040, according to recent World Health Organization and meta-analytic data.[1,2] These trends underscore the growing global burden, particularly in aging populations and low- to middle-income regions. Elevated intraocular pressure (IOP) is the most important modifiable risk factor for disease progression, and its control is the primary target of all therapeutic strategies.[3,4]

A wide spectrum of treatment modalities is available to reduce IOP, including topical medications, laser procedures, minimally invasive glaucoma surgery (MIGS), filtering surgeries, and cyclodestructive procedures. While MIGS has gained popularity for its safety and early stage applicability, its efficacy in advanced and refractory cases remains limited.[4–6] Among the cyclodestructive options, continuous-wave transscleral cyclophotocoagulation (CW-TSCPC) has long been used for such challenging eyes but is associated with significant complications, including inflammation, hypotony, and phthisis bulbi.[7–9]

Micropulse transscleral cyclophotocoagulation (MP-TSCPC) has emerged as a safer and more versatile treatment. This technique uses the same 810 nm diode laser as CW-TSCPC but delivers energy in short, intermittent micropulses separated by "off" periods, permitting tissue cooling and reducing collateral thermal damage. Experimental and animal studies have shown that this duty-cycle modulation confines the thermal effect to the pigmented ciliary epithelium, sparing adjacent structures and maintaining aqueous humor outflow homeostasis.[10,11]

MP-TSCPC is increasingly being offered not only for refractory or end-stage glaucoma but also for earlier disease stages and diverse etiologies, including uveitic, congenital, aphakic, and neovascular glaucomas. Furthermore, recent meta-analytic data suggest that cyclophotocoagulation, both continuous-wave and endoscopic, can provide meaningful IOP control even in childhood glaucoma, expanding the potential indications of CPC techniques in pediatric populations.[12,13]

Although several clinical series have reported favorable outcomes, there is limited multicenter, real-world evidence assessing whether clinical factors, such as glaucoma subtype, prior ocular surgery, or systemic/ocular comorbidities, influence MP-TSCPC success. Most prior studies were single-center or focused on selected populations only. Our study addresses this gap by analyzing a large, heterogeneous cohort across multiple Brazilian centers, thereby expanding the external validity and offering a pragmatic view of MP-TSCPC performance in diverse clinical scenarios.

Material and Methods

Study Design and Ethical Approval

This retrospective, longitudinal, multicenter study was designed to evaluate the effectiveness and safety of MP-TSCPC in patients with different types of glaucoma. Data were collected from four ophthalmology centers in Brazil: Hospital de Olhos CBV – Vision One (Brasília, DF), Hospital Oculare (Belo Horizonte, MG), HR Oftalmologia (Curitiba, PR), Grupo OPTY – HCLOE Oftalmologia Especializada (São Paulo, SP), and Instituto Ciência Brasil. This study was approved by the Institutional Ethics Committee of the OPTY Group (HCLOE Specialized Ophthalmology Clinic) under protocol number 48417221.6.0000.0068 and adhered to the principles of the Declaration of Helsinki. All patients provided written informed consent prior to the treatment. Clinical data were retrospectively extracted from medical records, anonymized, and stored in encrypted files accessible only to the research team. Patient confidentiality was rigorously protected in accordance with the Brazilian General Data Protection Law (Lei Geral de Proteção de Dados [LGPD], Federal Law No. 13.709/2018).

Study Population

The study included patients with various glaucoma subtypes who underwent MP-TSCPC between 2020 and 2022 at four ophthalmology centers in Brazil. A clinical diagnosis of glaucoma was confirmed by a glaucoma specialist based on a comprehensive evaluation, including intraocular pressure measurement, slit-lamp biomicroscopy, gonioscopy, optic nerve head assessment, and corresponding visual field and/or optical coherence tomography (OCT) findings consistent with glaucomatous damage.

A total of 120 patient records were reviewed. Nineteen eyes were excluded (15 due to <12 months of follow-up and 4 due to missing baseline data), resulting in 101 eyes from 87 patients included in the final analysis. A flow diagram illustrating the patient inclusion and exclusion criteria is shown in Figure 1.

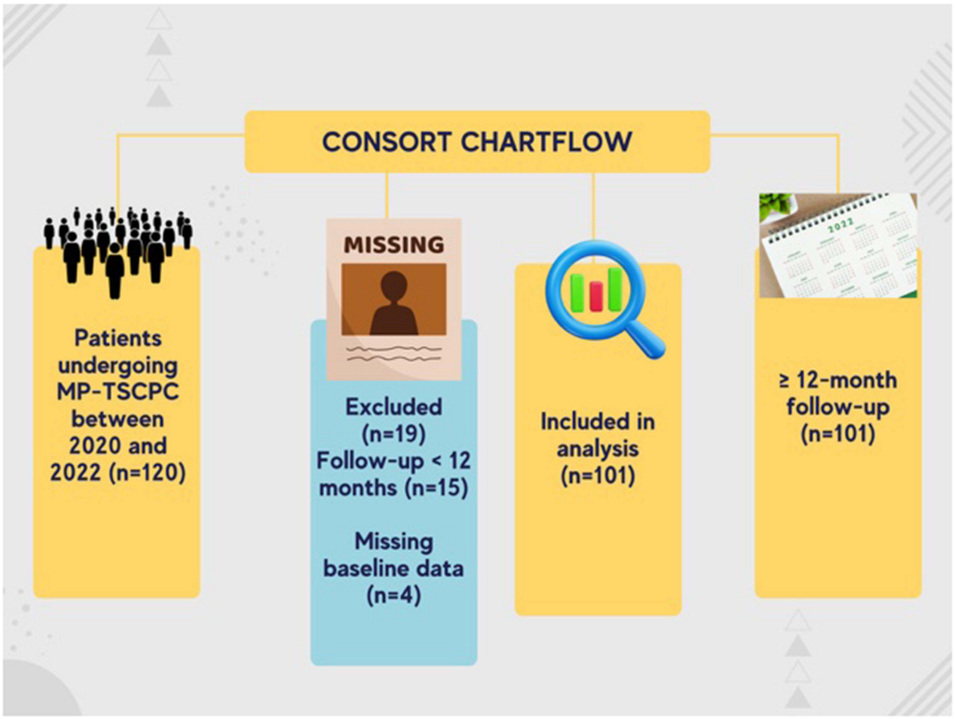

Figure 1 Flowchart showing the inclusion and exclusion of patients in this multicenter real-world study of MP-TSCPC. From 120 medical records initially screened, 19 eyes were excluded (15 for <12 months of follow-up and 4 for missing baseline data), resulting in 101 eyes from 87 patients in the final analysis.

The inclusion criteria were as follows: patients of any age with a clinical diagnosis of glaucoma confirmed by a glaucoma specialist; availability of complete medical records; and a minimum of 12 months of postoperative follow-up.

The exclusion criteria were eyes with less than 12 months of follow-up, missing baseline data, or concomitant ocular surgery during the observation period.

Both eyes were included only when each independently met all the inclusion criteria and had complete baseline and follow-up data. Sensitivity analyses confirmed that the direction and magnitude of the results remained unchanged when the sample was restricted to one randomly selected eye per patient. No patients were excluded or deferred from treatment because of prostaglandin-associated periorbitopathy, as this condition was not documented in any of the reviewed clinical records.

Surgical Procedure

All procedures were performed by experienced glaucoma specialists using an IRIDEX Cyclo G6 MP3 laser (IRIDEX Corp., Mountain View, CA, USA) with a first-generation MP3 probe. Laser power and duty cycle were standardized at 2000 mW and 31.3%, respectively, while treatment duration ranged from 100 to 320 s depending on glaucoma severity and surgeon discretion. Peribulbar anesthesia was performed using a mixture of lidocaine 2% and bupivacaine 0.5% (1:1 ratio), or ropivacaine 0.75%, typically totaling 5–8 mL, administered through a 25-gauge needle in the inferolateral eyelid margin before laser application.

Although treatment time varied slightly between centers, all used identical energy settings and probe motion techniques, minimizing inter-operator variability. These differences were acknowledged as study limitations.

Postoperative Management

Following the procedure, all patients received topical corticosteroids (prednisolone acetate 1% or equivalent) four times daily for 30 days and atropine 1% twice daily for two weeks. Additional medications were prescribed at the discretion of the treating physician, and glaucoma medications were tapered based on the IOP response and clinical course.

https://doi.org/10.2147/OPTH.S555181

Data Collection and Outcomes

Baseline demographic and clinical data were collected from medical records, including age, sex, race, type of glaucoma, baseline IOP, number of topical medications, best-corrected visual acuity (BCVA; logMAR), prior ocular surgeries, and comorbidities. Follow-up data were collected at 1, 3, 6, and 12 months postoperatively.

The primary outcomes were the mean IOP reduction from baseline at 12 months and the change in the number of glaucoma medications. Treatment success was defined according to two independent criteria: IOP reduction ≥ 20% from baseline at two consecutive visits and IOP between 6 and 21 mmHg at two consecutive visits.

Each criterion was analyzed separately, and eyes meeting either criterion were considered successful in the corresponding Kaplan–Meier survival analyses.

Success was further classified as complete (meeting the criterion without medication) or qualified (meeting the criterion with or without medication). Failure was defined as the absence of these criteria at two consecutive follow-up visits, loss of light perception, or the need for additional glaucoma surgery during follow-up. The secondary outcomes included postoperative complications and changes in visual acuity.

As the data were retrospectively extracted from clinical charts, potential sources of bias included incomplete documentation, variability in measurement techniques across centers, and inconsistent follow-up intervals. To mitigate these effects, only cases with complete datasets at predefined time points were included.

Statistical Analysis

Normality was tested using the Skewness–Kurtosis test. Normally distributed variables, such as age and baseline IOP, were analyzed using paired Student's t-tests, whereas non-normally distributed variables (eg, number of medications) were compared using the Wilcoxon signed-rank test. Categorical variables, such as complication rates, were analyzed using the chi-square or Fisher's exact test, as appropriate. The choice of tests is reflected in the Results section for each outcome.

Categorical variables were expressed as absolute frequencies and percentages, and continuous variables were reported as means ± standard deviation (SD) or medians with interquartile ranges (IQR), depending on the data distribution using the skewness-kurtosis test. Paired Student's t-tests were used for normally distributed continuous variables, and Wilcoxon signed-rank tests were used for non-normally distributed data. The chi-square or Fisher's exact test was used to compare categorical variables.

Kaplan-Meier survival analysis was performed to estimate the cumulative success rates according to the two criteria. Cox proportional hazards models were used to assess the influence of potential predictors of surgical success, including the type of glaucoma, previous ocular surgery, and the presence of comorbidities. Statistical significance was set at $p < 0.05$. For major continuous outcomes, mean changes were reported with corresponding 95% confidence intervals and *p*-values to improve the interpretability of effect size precision.

All statistical analyses were conducted using Stata Statistical Software (Release 13; StataCorp, College Station, TX, USA).

Results

A total of 101 eyes from 87 patients with different types of glaucoma were included in this study. The baseline demographic and clinical characteristics are summarized in Table 1.

The mean age of the cohort was 59.41 ± 20.34 years (range 2–89), with 41.6% females. The most frequent diagnosis was primary open-angle glaucoma (POAG), comprising 65.35% of cases. All the causes of the disease are shown in Table 1.

Intraocular Pressure and Medication Burden

MP-TSCPC resulted in a statistically significant reduction in IOP at all follow-up time points. The mean baseline IOP was 26.19 ± 6.77 mmHg (95% CI 24.85–27.52), which decreased to 14.40 ± 6.10 mmHg (95% CI 13.72–15.15) mmHg at 12 months ($p < 0.0001$), representing a mean IOP reduction of 11.76 ± 8.03 (95% CI 10.17–13.34) mmHg (45.1% from baseline). This reduction was consistently observed across all glaucoma subtypes.

Table 1 Baseline Demographic of the Study Population

Number (eyes)	
	101
Age (mean ± SD)	
	59.41 ± 20.34
Gender n (%)	
Female	42 (41.58)
Male	59 (58.42)
Eye diagnostics n (%)	
Primary Open Angle Glaucoma	66 (65.35)
Congenital	8 (7.92)
Post silicon vitrectomy	7 (6.93)
Uveitis	5 (4.95)
Aphakia	4 (3.96)
Primary Angle Closure Glaucoma	3 (2.97)
Post corneal transplant	3 (2.97)
Normal Tension Glaucoma	2 (1.98)
ICE syndrome	1 (0.99)
Trauma	1 (0.99)
Neovascular glaucoma	1 (0.99)
Clinical diagnostics n (%)	
Hypertension	58 (57.43)
Diabetes	25 (24.75)
Cardiopathy	10 (9.90)
Thyroid disease	8 (7.92)
Pneumopathy	4 (4.00)
Rheumatic disease	2 (2.00)
Preoperative eyedrops (number of drugs, mean ± SD)	
	3.37 ± 0.63
Preoperative IOP (mmHg, mean ± SD)	
	26.19 ± 6.77

Abbreviations: IOP, intraocular pressure; SD, standard deviation; ICE, iridocorneal endothelial syndrome.

In parallel, the mean number of antiglaucomatous medications decreased significantly from 3.37 ± 0.63 (95% CI 3.25–3.50) at baseline to 1.08 ± 1.44 (95% CI 0.75–1.41) at 12 months ($p < 0.0001$), corresponding to a mean reduction of 2.26 ± 0.18 medications per patient. A substantial proportion of eyes (28.7%) remained medication-free at the final

https://doi.org/10.2147/OPTH.S555181

follow-up, indicating the potential of MP-TSCPC to reduce the pharmacologic burden. Figure 2 illustrates the distribution of IOP values over time, demonstrating a sustained reduction following MP-TSCPC.

The mean baseline IOP and medication counts were analyzed according to the glaucoma subtype. At baseline, the mean IOP (mmHg) was 27.2 ± 9.1 in primary open-angle glaucoma (POAG), 25.8 ± 8.7 in secondary glaucoma, 26.6 ± 7.4 in congenital glaucoma, 24.9 ± 7.8 in angle-closure glaucoma, and 22.8 ± 6.5 in normal-tension glaucoma (NTG).

At 12 months, the IOP values were 14.3 ± 5.8, 14.6 ± 6.4, 13.9 ± 6.2, 15.1 ± 5.9, and 14.0 ± 4.9, all representing statistically significant reductions from baseline ($p < 0.001$ for each subtype).

The mean reduction in IOP ranged from 10.5 mmHg (NTG) to 12.9 mmHg (POAG) in the study.

The mean number of medications decreased from 3.3 ± 0.6 at baseline to 1.1 ± 1.4 at 12 months across all subtypes, with no significant inter-group difference in medication reduction ($p = 0.41$, ANOVA).

Treatment Success and Survival Analysis

According to Criterion 1 (≥20% IOP reduction), success was achieved in 67.3% of eyes, and Criterion 2 (IOP between 6 and 21 mmHg) was met by 77.2% of eyes at 12 months. Kaplan-Meier survival analysis demonstrated that the cumulative probability of achieving both criteria remained stable throughout the 1-year follow-up period (Figure 3).

Success was complete (without medications) in 23.7% of eyes and qualified (with medications) in 53.5% of eyes. A total of 22 eyes (21.8%) met neither criterion and were classified as failures. Among these, 6 underwent further surgical

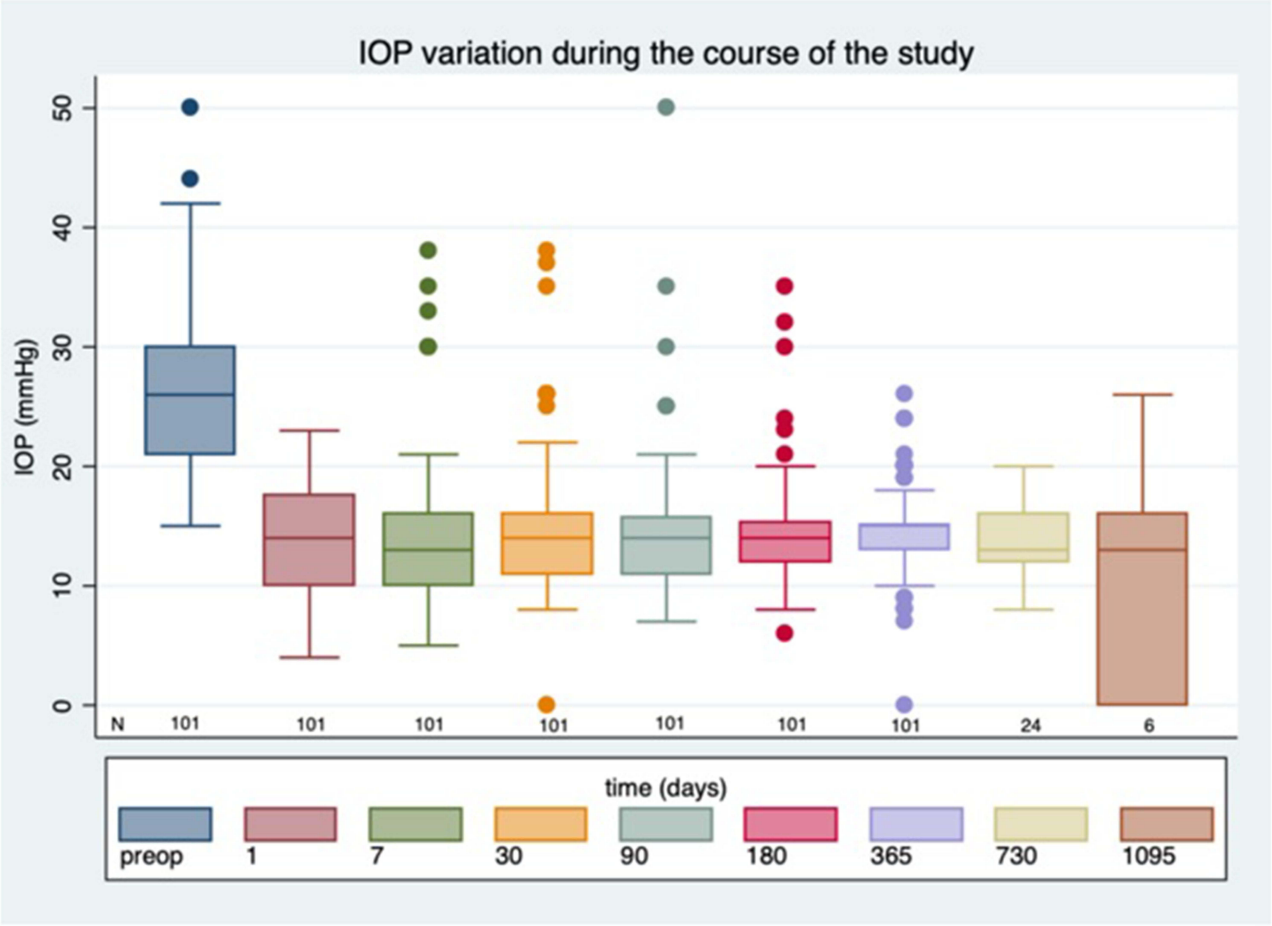

Figure 2 A marked and sustained reduction in IOP was observed from baseline (preoperative) through all postoperative timepoints following micropulse transscleral cyclophotocoagulation (MP-TSCPC). Boxes represent interquartile ranges, horizontal lines indicate medians, whiskers denote 1.5 × IQR, and dots represent outliers. The number of eyes analyzed at each follow-up visit is displayed below each box. A total of 101 eyes were followed for up to 12 months, 24 eyes up to 24 months, and 6 eyes up to 36 months.

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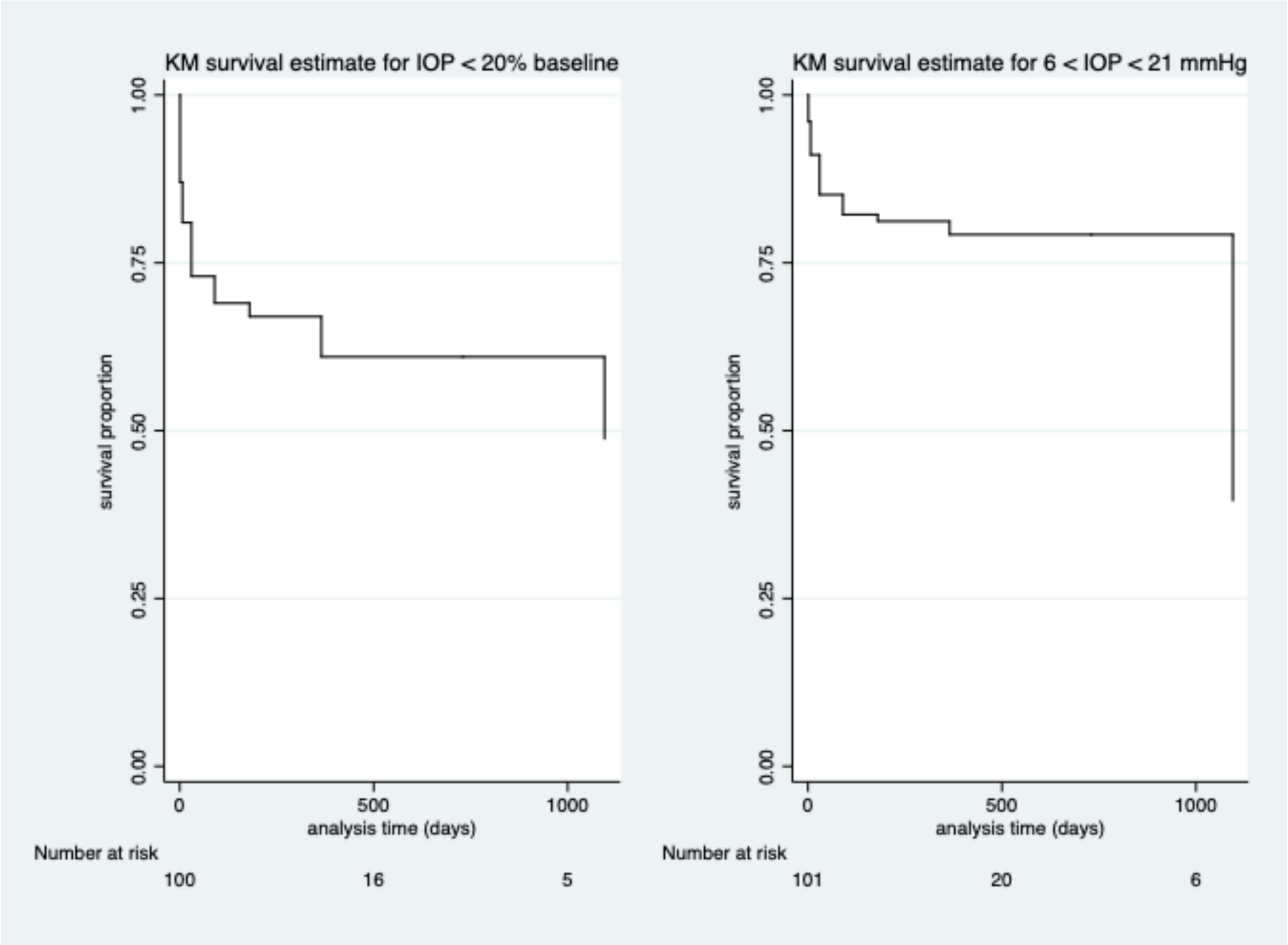

Figure 3 Kaplan–Meier survival curves showing cumulative probability of surgical success after micropulse transscleral cyclophotocoagulation (MP-TSCPC). Success was defined by two criteria: Criterion 1, ≥20% intraocular-pressure (IOP) reduction from baseline at two consecutive visits; and Criterion 2, IOP between 6 mmHg and 21 mmHg at two consecutive visits. Eyes that underwent additional glaucoma surgery or had incomplete follow-up (<12 months) were censored at their last recorded visit.

intervention during follow-up. In the Kaplan–Meier analysis, eyes that underwent additional glaucoma surgery or had incomplete follow-up (<12 months) were censored at their last recorded visit.

Visual Acuity

The mean logMAR BCVA changed from 0.53 ± 0.64 preoperatively to 0.63 ± 0.72 at the final follow-up. Although this difference was statistically significant ($p = 0.0006$), the clinical impact was limited, with most patients showing a variation of less than two lines on the Snellen chart. Visual acuity improved in 19.8% of eyes, remained stable in 60.3% of eyes, and worsened in 19.9% of eyes. In most cases, VA decline was related to advanced glaucoma or comorbidities, such as corneal edema or macular degeneration. No patient was lost to follow-up due to postoperative complications or death.

Complications

Severe complications were rare in this study. Two eyes (1.98%) lost light perception during follow-up due to neovascular glaucoma progression and the other due to uveitic glaucoma. Three eyes (2.97%) developed corneal decompensation, and one (0.99%) presented with cystoid macular edema. Minor adverse effects included keratitis and hyposphagma in six eyes (5.9%), which resolved with topical treatment. No cases of hypotony or phthisis bulbi were observed. Transient IOP elevation in the early postoperative period was managed with topical beta-blockers and carbonic anhydrase inhibitors, whereas no specific intervention was required for mild and short-term hypotony in a few cases.

https://doi.org/10.2147/OPTH.S555181

The frequency and types of postoperative complications are summarized in Table 2.

Kaplan–Meier survival analysis demonstrated that the cumulative probability of success was maintained throughout the 12-month follow-up, reinforcing the durability of the hypotensive effect of MP-TSCPC. More than half of the eyes sustained a ≥20% reduction in IOP, while over 75% maintained an IOP between 6 and 21 mmHg (Figure 3). The stability observed in the survival curves suggests that MP-TSCPC may offer sustained efficacy, potentially reducing the need for repeated interventions within the first postoperative year.

Subgroup Analyses

Cox proportional hazards regression was used to evaluate whether glaucoma type, previous ocular surgery, or clinical comorbidities influenced the treatment success (Table 3). No statistically significant associations were found between any variable and either success criterion. However, subgroup comparisons for less frequent glaucoma types and prior surgeries were exploratory and limited by small sample sizes; this limitation is explicitly noted in the Discussion section.

Table 2 The Postoperative Complications

	n (%)	Cumulative (%)
No complication	86 (85.15)	85.15
Corneal de-epithelialization	1 (0.99)	86.14
Conjunctivitis	1 (0.99)	86.14
Corneal decompensation	3 (2.97)	90.10
Cystoid macular edema	1 (0.99)	91.09
Retinal detachment	1 (0.99)	92.08
Loss of light perception	2 (1.98)	94.06
Other	6 (5.94)	100.00
Total	101	100.00

Table 3 Predictive Factors for Treatment Success After Micropulse Transscleral Cyclophotocoagulation Identified by Cox Regression

Categorical Variables	Cox Proportional Hazards Regression (p-value)	
	Outcome 1 (Drop 20% Initial IOP)	Outcome 2 (6<IOP<21 mmHg)
Diagnosis		
	0.56	0.42
Previous surgery		
SLT or ALT	0.80	0.40
Intravitreal injection	0.96	0.55
Cataract surgery	0.92	0.26
Refractive surgery	0.33	0.50
Corneal transplant	0.44	0.45

(*Continued*)

Table 3 (Continued).

Categorical Variables	Cox Proportional Hazards Regression (p-value)	
	Outcome 1 (Drop 20% Initial IOP)	**Outcome 2 (6<IOP<21 mmHg)**
Vitreoretinal surgery	0.75	0.63
Trabeculectomy	0.87	0.23
Needling	0.29	0.46
Ahmed tube implant	0.89	0.64
MIGS	0.31	0.15
Trabeculectomy revision	0.42	0.94
Clinical comorbidity		
Hypertension	0.75	0.063
Diabetes	0.31	0.97
Cardiopathy	0.22	0.99
Pneumopathy	0.52	0.32
Rheumatic disease	0.74	0.61
Thyroid disease	0.29	0.26

Abbreviations: SLT, Selective laser trabeculoplasty; ALT, Argon laser trabeculoplasty; MIGS, Minimally invasive Glaucoma Surgery.

Discussion

In this multicenter, retrospective study, micropulse transscleral cyclophotocoagulation (MP-TSCPC) achieved a consistent and clinically relevant IOP reduction across diverse glaucoma subtypes, accompanied by a significant decrease in the number of medications. The addition of a subtype-specific analysis confirmed that this efficacy was comparable among primary open-angle, secondary, congenital, and angle-closure glaucoma, reinforcing the generalizability of the findings to heterogeneous, real-world populations.

The observed mean IOP reduction of approximately 12 mmHg and the average decrease of two medications at 12 months are in line with previously published international cohorts, including Zaarour et al,[12] de Crom et al,[14] and Garcia et al.[15] The mean IOP reduction of 11.76 mmHg observed at 12 months corresponded to an average 45.1% decrease from baseline, representing a clinically relevant reduction across the wide range of preoperative pressures in this cohort (baseline IOP 26.19 ± 6.77 mmHg).

Importantly, the present analysis provides additional evidence that MP-TSCPC maintains safety and effectiveness even in eyes previously treated surgically, with similar outcomes regardless of prior trabeculectomy or tube-shunt procedures.

The consistency of outcomes among glaucoma types suggests that the micropulse technique, by modulating energy delivery and minimizing collateral thermal injury, may offer a broader therapeutic range than traditional continuous-wave cyclophotocoagulation.[5–10,16] This expands its potential role not only for refractory disease but also as an adjunctive or intermediate option in eyes with useful vision or early surgical indication.[17–19]

From a methodological perspective, the updated diagnostic definitions, standardized anesthesia techniques, and inclusion of 12-month follow-up across all centers strengthen the external validity of our conclusions. The addition of effect size reporting (means with 95% CIs) facilitates the interpretation of clinical relevance beyond statistical significance.

Our study demonstrated a mean IOP reduction of 11.76 ± 8.03 mmHg and a decrease of 2.26 medications at 12 months, which is consistent with previously reported outcomes in multicenter and international cohorts, including those

of Aquino et al,[20] Tan et al,[21] Yelenskiy et al,[22] and Garcia et al.[15] Zaarour et al[12] and de Crom et al[14] reported success rates exceeding 70% at one year following a single MP-TSCPC session, aligning with our cumulative success of 77.2% under the IOP 6–21 mmHg criterion. The reduction in medication burden further emphasizes the potential of MP-TSCPC to minimize dependence on polypharmacy, consistent with outcomes observed across heterogeneous populations in Europe and the Middle East.[20,21]

Importantly, this procedure exhibited a favorable safety profile. No cases of phthisis bulbi or chronic hypotony were observed, and severe complications occurred in < 5% of eyes. These findings corroborate previous literature from multiple centers and including Yelenskiy et al[22] and Garcia et al[15] - demonstrating that the micropulse delivery mode minimizes collateral thermal damage by modulating energy dispersion and preserving adjacent structures.[2,11,22,23] In contrast to CW-TSCPC, which is associated with more frequent vision-threatening complications5–10, MP-TSCPC has emerged as a viable option even in eyes with useful vision or earlier disease stages.[17–19]

Subgroup analysis did not reveal any statistically significant association between surgical success and baseline glaucoma diagnosis, previous surgical intervention, or the presence of systemic/ocular comorbidities. This contrasts with the findings of Yelenskiy et al[22] who reported higher success in eyes with primary open-angle glaucoma compared with those with neovascular glaucoma. This finding also differs from that of Garcia et al[15] who found lower efficacy in previously operated eyes. Our findings suggest that MP-TSCPC may offer consistent results across a broad spectrum of clinical scenarios when standardized protocols and experienced surgeons are involved.

Although visual acuity remained stable in most cases, approximately one-fifth of eyes (19.9%) experienced some degree of visual decline, primarily associated with advanced glaucoma, uveitis, or corneal decompensation rather than the procedure itself.

This aligns with reports by Williams et al[17] and Emanuel et al[24] who noted that visual acuity changes post-MP-TSCPC are more often attributable to disease progression or comorbidities than to the procedure itself.

The absence of standardized protocols regarding energy settings, sweep duration, and postoperative care in the MP-TSCPC literature remains a challenge. Despite this, our real-world data reflect consistent outcomes across multiple centers and surgeons using comparable parameters. The ability to personalize energy titration based on disease severity and ocular phenotype is one of MP-TSCPC's key advantages.[11]

Our findings are consistent with those of previous multicenter studies showing that MP-TSCPC provides significant IOP reduction and medication burden relief with a favorable safety profile.[20–22,25] However, unlike earlier single-center studies, our real-world, multicenter design encompassed a broad spectrum of glaucoma types and comorbidities, thereby strengthening the external validity of our findings.[19,21,25] This broader applicability suggests that MP-TSCPC can serve as an intermediate option between medical therapy and incisional surgery, especially in patients unsuitable for MIGS or trabeculectomy.

Despite these strengths, several limitations must be acknowledged. First, the retrospective design introduces potential selection bias and incomplete data capture. Second, the involvement of multiple centers and surgeons may have introduced inter-operator variability in probe handling and sweep duration, although laser parameters were otherwise standardized. Third, functional severity, including visual-field and OCT-based progression data, was not systematically available across all centers, limiting the assessment of structure–function correlation. This limitation has been explicitly acknowledged and should be addressed in future prospective studies. Fourth, as all patients were Brazilian, generalizability to other ethnic or healthcare settings may be limited. Finally, the sample size constrained subgroup analyses for rarer glaucoma types, which should therefore be interpreted as exploratory.

Future investigations should include prospective, randomized controlled trials with standardized imaging endpoints and longer follow-up to evaluate long-term durability and retreatment needs. Additionally, cost-effectiveness analyses and focused studies in special populations—such as pediatric, uveitic, and post-keratoplasty glaucoma—are warranted to optimize patient selection and refine treatment algorithms. Our findings are consistent with previous multicenter series showing that MP-TSCPC provides significant IOP reduction and medication burden relief with a favorable safety profile.[20–22,25]

Conclusion

Micropulse transscleral cyclophotocoagulation (MP-TSCPC) provided consistent intraocular-pressure reduction, decreased medication burden, and a favorable safety profile across diverse glaucoma types in this multicenter real-world study. Comparable efficacy was observed among primary open-angle, secondary, congenital, and angle-closure glaucoma, and outcomes were similar regardless of prior ocular surgery. The standardized technique and inclusion of multiple centers strengthen the generalizability of these results, supporting MP-TSCPC as a safe and effective intermediate option between medical and incisional therapy. Further prospective, randomized, and cost-effectiveness studies are warranted to refine treatment parameters and guide patient selection.

Disclosure

The authors declare that they have not received any financial support, material assistance, or professional writing help related to this study. No funding was obtained from public, commercial, or non-profit organizations, and there are no conflicts of interest to disclose.

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