Efficacy of Micropulse Trans-scleral Cyclophotocoagulation in Lowering Intra-ocular Pressure and Reducing Anti-glaucoma Medications among Cambodian Glaucoma Patients

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Abstract

Objective: The micropulse trans-scleral cyclophotocoagulation has been predominantly utilized to reduce intraocular pressure (IOP) in cases of refractory glaucoma. This laser treatment has been extensively used in refractory cases with potentially poor vision, as well as across various type and severities of glaucoma. This study aims to assess the treatment outcomes of micropulse cyclophotocoagulation in Cambodian glaucoma patients.

Materials and Methods: This retrospective study included 14 patients. The review of medical records encompassed pre- and post-treatment variables such as IOP, the amount of anti-glaucoma medications used, visual acuity, pain levels, and complications over 14 months. The primary outcome was categorized as success or failure, where success was defined as achieving an IOP between 6- and 21-mmHg and a minimum 30% reduction in IOP at the final follow-up, with/without the use of medications.

Results: The mean age of patients in this study was 52.36 ± 9.98 years. The mean intraocular pressure prior to treatment was 41.00 ± 12.26 mmHg, decreasing to 21.60 ± 8.11 mmHg (41.56% reduction) at 12 weeks and 16.94 ± 5.46 mmHg (56.04% reduction) at 24 weeks ($p < 0.001$), with a success rate of 86%. Before treatment, the average number of anti-glaucoma drugs was 3.45 ± 0.89 (2 to 5 drugs). By weeks 12 and 24, that number had dropped to 1.85 ± 1.19 (1 to 3 drugs) and 1.46 ± 1.15 (none to 3 drugs), a drop of 2, $p < 0.001$. Only 3 eyes (22.43%) have complications, yet there is no apparent change in visual acuity.

Conclusions: This micropulse trans-scleral cyclophotocoagulation is an effective procedure for lowering pressure at any stage of disease and reducing anti-glaucoma medications while avoiding invasive surgeries.

Keywords: Efficacy, Glaucoma, Cyclophotocoagulation, Anti-glaucoma medications, Intra-ocular pressure

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Introduction

Glaucoma ranks among the leading causes of irreversible blindness globally.[1,2] Treatment for glaucoma includes pharmacological agents, laser therapy, and surgical interventions aimed at lowering intraocular pressure. Surgery is necessary to preserve optic nerve function when medication is unable to control intraocular pressure. Laser therapy, on the other hand, is gaining popularity as a way to improve intraocular pressure control and stop further harm to the visual nerves in glaucoma.[1-3] In 2010, the World Health Organization (WHO) estimated that 39 million individuals globally are blind, while 285 million experience visual impairment. In 2020, overall blindness decreased by 15.40%, as reported by WHO; however, the prevalence of visual impairment and avoidable blindness increased by 31.50% and 10.80%, respectively.[2,4] In 2019, glaucoma accounted for 8.30% of avoidable blindness in Cambodia [Rapid Assessment of Avoidable Blindness 2019].

MicroPulse® is a laser delivery modality for laser photocoagulation that allows for precision control of photo thermal effects.[5] Micropulse technology was employed to denature the target tissue while minimizing collateral tissue damage in a novel form of trans-scleral diode laser cyclophotocoagulation (CPC). Micropulse diode laser technology has effectively treated various retinal diseases, such as diabetic retinopathy and maculopathy. The micropulse diode laser CPC is anticipated to provide intraocular pressure-lowering efficacy similar to traditional diode CPC, while minimizing pain and inflammation. The micropulse CPC is a revolutionary trans-scleral diode laser CPC platform that, in comparison to conventional CPC, has a higher safety profile. It has been mentioned in a number of current trending peer-reviewed articles and researches, making it one of the most reputable and reliable sources of clinical data,[6-15] with IOP reductions ranging from 20 to 50%.

Glaucoma is a major cause of blindness in Cambodia. According to national standards, reducing avoidable blindness and improving quality of life can be achieved through cost-effective and less complicated procedures. The micropulse CPC represents a novel technology that provides effective pressure regulation with minimal side effects, but there is insufficient evidence about its efficacy and safety regarding this laser therapy in our resource-constrained clinical setting. The purpose of this study was to assess the effectiveness of micropulse CPC in lowering the pressures of glaucoma patients in Cambodia. Additionally, the study sought to determine how the micropulse CPC affected changes in the amount of anti-glaucoma medications needed, pain levels, visual acuity, the frequency of complications, and its adverse effects on the patients.

Materials and Methods

Study Site and Study Design

This study employed a retrospective, observational chart review of patients who underwent micropulse P3® cyclophotocoagulation (MP3 CPC) at the Department of Ophthalmology, Khmer-Soviet Friendship Hospital, Cambodia.

Study Population, Eligibility Criteria and Study Tools

In our study, 14 out of 27 patients (14 eyes) were conveniently chosen. This review examined a duration of 14 months, spanning from 1st March 2018 to 1st May 2019. Cambodian patients diagnosed with glaucoma and aged 18 years or older are eligible if they meet the specified criteria: (1) a patient who is a poor candidate for filtering surgery, (2) deterioration due to rapid progression of glaucomatous damages (as demonstrated by fundus photography of the optic disc and/or peri-metric visual field status), (3) intolerance to medical therapy or poor compliance, and (4) inadequate control of IOP (22 mmHg or more) despite maximally tolerated medical therapy.

The exclusion criteria are as follows: (1) patients exhibiting significant scleral thinning, defined as thinning exceeding one clock hour as observed through scleral trans-illumination; (2) patients with a history of conventional trans-scleral cyclophotocoagulation; (3) patients who have undergone any intraocular surgery within 2 months prior to enrollment; and (4) patients who declined retreatment for improved IOP control following the failure of the initial procedure.

Medical records of the patients have been reviewed using the tools as structured questionnaires which were developed by the researcher based on previous literature reviews.[6,8,9,12-14]

Statistical Analysis

Double-checked data was imported into Microsoft Excel 2016 (Windows 8), and statistical analysis was conducted using STATA v. 14.2. Analysis was done using a single-factor ANOVA and the student's paired *t*-test. A *p*-value < 0.05 were considered statistically significant.

Ethical Considerations

The study was officially approved by the *institutional review board* of the University of Health Sciences and Khmer-Soviet Friendship Hospital, Kingdom of Cambodia, and adhered to the tenets of the Declaration of Helsinki. Patient information was anonymized and kept confidential.

Laser Setting

A treatment session involving micropulse trans-scleral cyclophotocoagulation was conducted in the affected eye, utilizing the MicroPulse® P3 Glaucoma Device (MP3) powered by the CYCLO G6™ Glaucoma Laser System (IRIDEX Corp., Mountain View, CA, USA).[15]

The following laser setting was used by a single certified glaucoma specialist using a fixed treatment protocol and standardized procedure described extensively in previous literatures: Laser settings were programmed as follows: A 2,000 mW infrared diode laser operates at an average wavelength of 810 nm in micropulse delivery mode. The micropulse "on" duration is 0.5 ms, while the "off" time is 1.1 ms, resulting in a duty cycle of 31.33%. The laser probe was employed in a continuous sliding or painting motion from 9:30 to 2:30 and from 3:30 to 8:30. The probe shall consistently be positioned perpendicular to the limbus, with its edge placed directly on the limbus, and the fiberoptic tip located 1.5-2 mm posterior to the limbus. The MP3 probe was applied with consistent pressure across the upper hemisphere of the affected eye, positioned 1.5-2 mm posterior to the limbus. Continuous sweeps were conducted for 10 seconds each, totaling 90 seconds, from the 9:30 to 2:30 position (superior hemisphere). The 10-second sweeps were subsequently repeated across the inferior hemisphere for 80 seconds, specifically from the 3:30 to 8:30 clock position, resulting in a total treatment duration of 170 seconds. This corresponds to 62,500 micro-pulses administered over a 0.5 ms on period and a 1.1 ms off period, resulting in a duty factor of 31.3%. A total of 62.6 J of energy was received by each eye. There was no established procedure for the sweeping action during application, whether fast or slow. Areas where previous filtering operations had occurred were excluded. No modifications will be made to treatment duration, irrespective of iris color or the severity of glaucoma. In the operating theatre, each case was conducted by one glaucoma specialist at a time. Prior to the procedure, 3 mL of 2 percent lidocaine hydrochloride (100 mg/5 mL) for retro-bulbar anesthesia and 1 mL for peri-bulbar anesthesia were administered.

Patients received tobramycin-dexamethasone ointment and were patched for a day following surgery. Topical prednisolone acetate 1% (PredForte eye drop) was administered six times a day for five days to all patients. Additionally, oral acetaminophen-caffeine 500-65 mg and topical prednisolone acetate 1% and acetazolamide 250 mg (Diamox 250) were administered three times a day for five days as prescribed, but were tapered off after. In the first week after surgery, topical prednisolone was lowered to four times daily; from weeks three to six, it was lowered to once or three times daily as needed. Prior to treatment, all necessary anti-glaucoma drugs were not stopped and gradually lowered until the pressure was well under control.

Clinical and Therapeutic Measurements

Clinical evaluation

Data on age, sex, previous medical history, visual acuity, baseline IOP, prior use of anti-glaucoma medications, etiology and severity of glaucoma, findings from slit-lamp examinations, pain levels, and complications related to laser treatment were extracted from medical records. All measurements were done by a single glaucoma surgeon.

- Visual acuity was assessed using the Snellen E-chart to determine the best-corrected visual acuity (BCVA), subsequently converted to LogMAR.

- Intraocular pressure: The IOP reading was recorded from the scale and documented in the medical records. Baseline IOP was measured using an air-puff tonometer, with subsequent measurements taken at each follow-up. Two measurements taken with a 5-minute interval were averaged. The average of two measurements taken at five-minute intervals was collected.
- Anti-glaucoma medications were initially decreased in medical therapy, and if intraocular pressure reduction was insufficient, adjustments were made, starting with oral acetazolamide.
- Glaucoma severity was assessed utilizing the American Academy of Ophthalmology's glaucoma severity scale, along with evaluations of visual field defects and/or clinical examination of the optic disc head.
- Grading of pain: The patient's level of pain was noted, and extra peri-bulbar anesthetic was given intraoperatively or as needed. The severity of eye pain, assessed using the verbal analog scale, was derived from a previous study.[15] Pain scoring utilized a verbal analog scale as outlined in previous studies[15,16] described as follow:

None	no subjective feeling of pain.
Mild	pain tolerable and not requiring the use of oral analgesia.
Moderate	pain tolerable with regular use of oral analgesia.
Severe	pain despite regular dosing of oral analgesia.

Follow-up evaluation

- The main outcome measures included intraocular pressure at 1, 3, 6, 12, and 24 weeks following the intervention; changes in anti-glaucoma medication at 12 and 24 weeks; visual acuity at the last visit; complications and the need for any further surgery during the 24-week period; and pain experiences.
- The follow-up period extended from the day after treatment to six months later. The follow-up period spanned from the first day post-procedure to six months postoperatively.

Criteria for Success

- IOP between 6- and 21-mmHg and at least 30% decrease in IOP at the 24-week end-of-treatment (with or without IOP-lowering medications) considered successful.
- Failures were defined as any need for additional surgery, the increase in intraocular pressure at 12 weeks, any subsequent complications, or an increase in anti-glaucoma medications.
- The second treatment session was based on a less than 30% decrease in IOP from baseline after three months on two consecutive follow-up appointments spaced one week apart. After the initial treatment session, re-treatment was conducted at least 6-8 weeks later, or on the 12th week. Using the same standards as the second treatment, the third treatment was administered when required.

Results

This study enrolled a total of 27 individuals (27 eyes). Thirteen patients were removed from the study, including three who had G-Probe CPC treatment, one who received cyclocryocoagulation (CCC), and nine who were placed on the waiting list (*Table 1*).

Table 1: Summarized Evaluated Parameters at Various Visits

Variables	Baseline	Day 1	Week 1	Week 3	Week 6	Week 12	Week 24
No. Eyes	14	14	14	14	14	14	14
Retreatment	-	0	0	0	0	0	1
Lost to follow-up	-	0	0	0	0	0	0
IOP Mean (SD) mmHg	41.00 (12.26)	14.29 (8.35)	14.65 (6.89)	18.32 (11.90)	22.51 (8.18)	21.60 (8.11)	16.94 (5.46)
Percentage of IOP decrease (%)	-	64.87	62.83	53.77	41.57	41.56	56.04
Percentage of patients with IOP decrease (%)	-	100	100	93	93	93	100
Percentage of procedure success (%)	-	100	100	86	64	43	86
No. anti-glaucoma drops mean (SD)	3.45 (0.89)	2.61 (0.91)	2.22 (1.06)	2.15 (1.10)	2.61 (1.12)	1.85 (1.19)	1.46 (1.12)
Mean BCVA (logMAR)	3.26	3.26	3.26	3.26	3.26	3.26	3.26

Baseline Characteristics

This study had 14 patients, including 9 women (64%) and 5 men (36%). The average age is 52.36 ± 9.98 years (ranging from 42 to 75 years). Among 14 eyes, 5 are right-sided (35.71%) and 9 are left-sided (64.29%). Five eyes (35.71%) had undergone phacoemulsification more than six months prior; two eyes (14.29%) had undergone trabeculectomy +/- mitomycin-C supplemented on the same laterality, and the remaining eight eyes (57.14%) had never undergone intraocular intervention. The predominant type of open-angle glaucoma includes the majority of patients, with 8 eyes (POAG, 57.14%), followed by 4 eyes with neovascular glaucoma (NVG, 28.57%) and 2 eyes with primary angle-closure glaucoma (PACG, 14.29%) (*Table 2*).

In terms of severity, 6 eyes were classified as severe (42%), 5 eyes as moderate (37%), and 3 eyes were deemed mild (21%). No severe cases were observed in either the PACG or NVG subgroups. In PACG, there was one mild case and one moderate case, whereas the NVG subgroups reported one mild case and three moderate ones. In comparison, there were one mild case, one moderate case, and six severe cases in POAG.

Table 2: Baseline Characteristics

No. patients (number of eyes)	14 patients (14 eyes)
Age [mean (± SD)] (y)	62.36 (± 9.98)
Gender [n (%)]	
Female	9 (64.29%)
Male	5 (35.71%)
Laterality [n (%)]	
Right	5 (35.71%)
Left	9 (64.29%)
Diagnosis [n (%)]	
Primary open-angle glaucoma	8 (57.14%)
Primary angle-closure glaucoma	2 (14.29%)
Neovascular glaucoma	4 (28.57%)
Prior history of ocular procedures (n* = 15 eyes)	
None	8 (57.18%)
Prior trabeculectomy	2 (14.29%)
Prior cataract surgery	5 (35.71%)

**A patient previously received cataract surgery and trabeculectomy to control intra-ocular pressure in more than 6 months before proceeding micropulse cyclophotocoagulation.*

Main Outcome

A success rate of 86% was achieved by lowering the mean IOP from 41.00 ± 12.26 mmHg before therapy to 21.60 ± 8.11 mmHg ($p < 0.001$) at 12 weeks and 16.94 ± 5.46 mmHg ($p < 0.0001$) at 24 weeks. At weeks 12 and 24, the overall pressure dropped by 41.56% and 56.04%, respectively. The mean IOP was much lower at 3 and 6 months after treatment compared to the baseline IOP ($p < 0.001$).

Secondary Outcomes

Effects on Anti-glaucoma Drugs

Initially, the average number of drugs was 3.45 ± 0.89 (ranging from 2 to 5 drugs) and decreased to 1.85 ± 1.19 (ranging from 1 to 3 drugs, $p = 0.984$) and 1.46 ± 1.15 (ranging from none to 3 drugs, $p = 0.339$) at weeks 12 and 24, respectively, resulting in a mean reduction of 2 drugs, $p < 0.0001$ at all follow-up visits (*Table 3*).

Table 3: Mean number of anti-glaucoma drugs pre-treatment and at various follow-ups

No. Drug Required	Baseline IOP	Day 1	Week 1	Week 3	Week 6	Week 12	Week 24
Range (Min-Max)	2-5	1-4	1-4	1-4	0-4	0-3	0-3
Mean (± SD)	3.45 (± 0.89)	2.61 (± 0.91)	2.22 (± 1.06)	2.15 (± 1.10)	2.16 (± 1.12)	1.85 (± 1.19)	1.46 (± 1.12)
p-value	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Note: The p-value was calculated using Student's paired t-test of pressure at each visit comparing to the baseline pressure.

Pain Level, Visual Acuity and Complications

Pain was reported by 4 patients (28.57%); however, it was completely manageable and no further anesthetic was needed. Only three patients (21.43%) said they had mild pain on the first day after surgery, but it went away after that or by the end of the first week. All individuals reported the absence of moderate or severe pain. Visual acuity did not significantly alter during the research, despite several adjustments. Visual acuity prior to treatment varied from 1.00 to 0.78 logMAR. None of the patients had lost any vision by the last appointment. Only three complications (22.43%) are present: Three of the eyes (7.14%) experienced vitreous hemorrhage, choroidal effusion, and hyphema. All three patients had reduced vision, but once the problem was treated, their BCVA returned to baseline.

Retreatment and Success Rate

All patients experienced mild conjunctival hyperemia and anterior chamber reaction 1+ on the first day following surgery. Eleven eyes (78.57%) had these resolved by the second week after therapy. Scleral perforation or thinning, phthisis bulbi, endophthalmitis, sympathethic ophthalmia, or prolonged anterior chamber inflammation (> 2 weeks) were not found. But after the treatment, the remaining three eyes (21.43%) experienced persistent complications. Additionally, one eye (7.14%) developed hyphema following laser treatment in a patient with neovascular glaucoma, which resolved five weeks postoperatively. One eye (7.14%) developed choroidal effusion following laser treatment, which resolved by week 12 after intensive compensating treatment, resulting in stable and adequate pressure control without the need for additional laser sessions. In contrast, another eye (7.14%) experienced vitreous hemorrhage, which completely resolved after 9 weeks of treatment.

Among the 14 patients treated with MP3 CPC, only 1 patient (7.14%) necessitated additional laser intervention at the 15-week follow-up for sufficient pressure control, and the pressure remained adequately low at the final visit. Each eye underwent a maximum of two treatment sessions. All eyes needed, on average, 1.07 sessions over the study period to get a satisfactory level of IOP control at the 24-week follow-up. A retreatment session was considered no earlier than 3 months (12 weeks) following the initial treatment for patients who did not respond during 2 consecutive follow-up assessments.

The number of patients experiencing reduced pressure fluctuated during the study period. This condition was consistent for three consecutive follow-ups until week 1, and then it started to drop to 86% (n = 12), 64% (n = 9), and 43% (n = 6) at weeks 3, 6, and 12, respectively. At day 1 post-operatively, it was static in 12 out of 14 patients. At the end of the study, only 86% (n = 12 at week 24) achieved satisfactory results with at least 30% less pressure than baseline.

The overall success rate for the study period was 86% (n = 13). The largest failure rate, after adjusting for diagnoses, was noted around week 12 after surgery. This was mostly because of the higher pressure prior to procedure (usually greater than 40 mmHg). For patients with mild to moderate glaucoma, the most reducing effects on IOP were observed in 8 out of 14 eyes. One patient (7%, n = 1) received a second treatment

at the 15-week follow-up, resulting in adequate pressure control thereafter. Patients with more severe ocular conditions and/or significantly elevated IOP prior to treatment showed a lower response rate compared to those in the early stages (*Figure 1*).

ANNEXES:

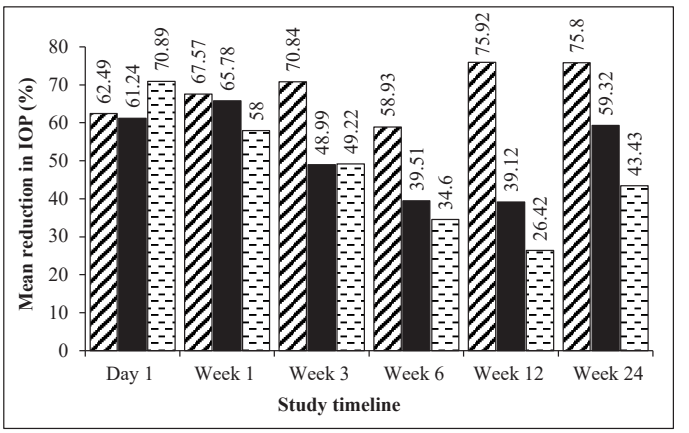


Figure 1: Mean reduction of IOP at various timeframes according to each severity sub-groups

Discussion

Our retrospective study demonstrated that this MP3 CPC is both effective and safe for patients with mild to severe glaucoma. At the 1-week follow-up, the success rate was 100%. At the 12-week follow-up, it dropped to 43%, and at the final follow-up, 24 weeks later, it rose to 86%. Anti-glaucoma medication usage significantly decreased over various follow-up periods, from 3.46 ± 0.84 at baseline to 1.46 ± 1.12 at the 24-week follow-up, indicating a mean reduction of 1.93 ± 1.12, or 55.83%. Three patients experienced complications; however, none encountered serious adverse effects after receiving optimal treatment. After just one patient needed a second laser treatment session, the pressure was quickly under control.

Continuous-wave CPC has historically been used to treat eye pain and patients with decreased visual potential and advanced glaucoma. Consequently, it has been used as a last resort to treat severe refractory glaucoma.[17] In glaucoma patients with a wide spectrum of glaucoma severity, MP3 CPC has long been shown to be effective in reducing pressure and reducing the requirement for anti-glaucoma medications. Particularly, more recent studies have examined the effectiveness and safety of MP3 CPC as a potential treatment option for glaucoma patients who have strong visual acuity at an early stage of the condition.[18, 19] Multiple studies have evaluated the success rate and safety profile associated with the application of MP3 CPC (*Table 4*).[6-9,11-15]

In 2024, Murtaza *et al*.[20] found that 52.9% of 153 eyes had a 20% or greater IOP decline from start to finish (OHT 59.1%; early POAG 58.7%; moderate POAG 45.7%; severe POAG 50.0%). This was lower than our success rate, however our patient population had a greater diversity of glaucoma forms. Nevertheless, the cohort's topical medication and drug class counts remained unchanged. In contrast to our study, 8 eyes (5.2%) needed incisional procedures toward the end, whereas 22 eyes (14.4%) needed retreatment, resulting in a 1.26 mmHg IOP drop.

Fili *et al*.[22] assessed 22 moderate to advanced open-angle glaucoma patients (30 eyes) in a 2022 comparative observational clinical investigation. Out of 15 micropulse laser-treated eyes, 53.3% had success (IOP reduction > 30%) at 12 months. The micropulse diode laser power used was 2,500 mW, which was higher than our study, however it also had a greater effect in reducing the number of eye drops and postoperative reactions. By contrast, Bernardi *et al*.[23] compared micropulse and continuous wave CPC in 2022. With success criteria matching our study, the micropulse diode laser achieved 87.5% over 12 months. This study also showed that IOP lowering always improves visual acuity.

Table 4: Evaluated Parameters of Different Relevant Peer-Reviewed Studies

Authors	Glaucoma severity	Sample size	Mean age ± SD (years)	Laser setting (Each hemisphere)	IOP (mean reduction, %)	Pressure at baseline (mmHg)	Pressure at final visit (mmHg)	p-Value	Reduction of anti-glaucoma drug (average)	Main outcome (Success rate)	Treatment sessions (mean)	Follow-up length
Our study	Mild to severe	14 eyes	62.36 ± 9.98	2,000 mW (80-90 s)	56.04%	41.00 ± 12.26	16.59 ± 5.46	< 0.001	2 (3.45 to 1.46)	84%	1.07	6 months
Zemba, et al.	-	17 eyes	-	2,000 Mw (100-120 s)	-	28.3 ± 8.2	16.4 ± 4.6	0.3	2.5 ± 0.6 to 2.3 ± 0.9	71%	-	6 months
Fili, et al.	Moderate to advanced	15 eyes	77.77 ± 10.97	2,500 mW	-	17.75 ± 6.92	12.63 ± 3.90	< 0.0013	2.67 ± 0.87 to 1.47 ± 1.20	53.3%	-	12 months
Bernardi, et al.	Moderate to advanced	47 eyes	68.9 ± 13.3	2,000 mW (2,500 ms per spot)	31.1%	21.7 ± 7.2	15.7 ± 4.8	0.005	Reduction 7.14% (2.9 ± 1.4 to 2.6 ± 1.2)	87.5%	-	12 months
Abdelrahman, et al.	-	24 eyes	55.6 (44 to 79)	2,000 Mw (90 s)	23%	34.71 ± 10.3	26.7 ± 12	0.34	2.6 ± 1 to 2.1 ± 1.3	33.3%	-	12-19 months
Aquino, et al.	Refractory	48 patients	63.5	2,000 mW (100 s)	52%	36.5	20.0	0.70	-	52%	-	18 months
Emmanuel, et al.	Refractory	84 eyes	74 ± 16	1,939 mW* (319 s)*	41.2%	27.7 ± 10.3	16.3 ± 9.5	< 0.001	1.35 (3.3 to 1.9)	-	-	4.3 months*
Kuchar, et al.	Refractory	19 eyes	71.2 ± 12.5	2,000 mW (100-240 s)	41%	37.9	22.7	-	0.7 (2.6 to 1.9)	73.7% (1st) 89.5% (2nd)	-	60.3 days*
Cecilia, et al.	Refractory	14 patients	59.9 ± 15.7	2,000 mW (100 s)	39%	43.3 ± 16.8	24.8 ± 11.0	-	0.7 (1.8 to 1.1)	67%	-	78 months*
Chew et al.	Mild to moderate	12 eyes	63.5 ± 15.7	2,000 mW (100 s)	35.9%	22.3 ± 4.5	17.0 ± 3.4	< 0.05	0.8 (3.2 to 2.4)	63.6%	-	4.8 months*

Table 4: Evaluated Parameters of Different Relevant Peer-Reviewed Studies (Cont.)

Authors	Glaucoma severity	Sample size	Mean age ± SD (years)	Laser setting (Each hemisphere)	IOP (mean reduction, %)	Pressure at baseline (mmHg)	Pressure at final visit (mmHg)	p-Value	Reduction of anti-glaucoma drug (average)	Main outcome (Success rate)	Treatment sessions (mean)	Follow-up length
Zaarour, et al.	Moderate to severe	75 eyes	55.5 ± 22.9	2,000 mW (90 s)	35.4%	26.01 ± 6.92	14.78 ± 5.32	< 0.001	-	66.0%	-	15 months
Tan, et al.	Refractory	40 eyes	63.2 ± 16.0	2,000 mW (100 s)	35%	40.1 ± 11.6	24.6 ± 9.1	< 0.001	0.8 (2.1 to 1.3)	72.7%	1.3	16.2 months
Lee, et al.	Moderate to refractory	36 eyes	60.6 ± 17.7	2,000 mW (160 s)	33.2%	28.41 ± 8.32	18.98 ± 6.45	< 0.0001	0.5 (3.0 to 2.5)	72.2%	-	12 months
Noecker, et al.	Mild to moderate	95 patients	-	2,000 mW (90 s)	30.3%	25.1 ± 5.3	17.5 ± 5.1	0.004	1.6 (3.0 to 1.4)	-	-	12 months*
Radcliffe, et al.	Mild to late-stage	48 eyes	-	2,000-2,250 mW (50-90 s)	29.8%	25.8	17.1	0.027	0.9 (3.3 to 2.4)	29.8%	-	3 months
Masis et al.	Mild to late-stage	57 patients	67.0 ± 9.4	2,000-2,500 mW (90 s)	28.9%	23.9 ± 8.0	17.0 ± 6.0	0.002	0.2 (3.5 to 3.3)	-	-	21.5 months*

**Calculated as mean.*

Adbelrahman *et al*.[23] also found that micropulse CPC reduced pressure 71% of the time without problems. However, Zemba *et al*.[24] found 33.3% success after a year. The number of anti-glaucoma drug reductions was similar to our data. The micropulse CPC group's mean number rose from 2.6 at baseline to 1.7 at 3 months to 2.1 at 12 months.

Aquino *et al*.[8] studied 48 refractory glaucoma patients for 18 months. Participants' mean age was 63.50 years, and intraocular pressure dropped 52% (from 36.5 to 20.0 mmHg, p = 0.70). The overall success rate was 52% at 2,000 mW for 100 seconds in each hemisphere. Moreover, Tan *et al*.[15] studied refractory glaucoma. The study followed 40 eyes for 18 months (mean 16.3 months) under the same settings. Emanuel *et al*.,[9] who followed 84 eyes for 4.3 months, revealed the initial outcomes of micropulse CPC in refractory glaucoma. The average patient age was 74. The mean IOP decrease was 41.2% (27.7 ± 10.3 to 16.3 ± 9.5 mmHg, p < 0.001), while the mean medication reduction was 1.35 (3.3 to 1.9 medicines), both lower than our study. Primary findings showed mean pressures of 15.5 mmHg at 6 months and 18.0 at 12 months. Despite the laser setting being longer (160 s vs. 80-90 s), it has a similar mean power (1,999 mW vs. 2,000 mW).

Cecilia *et al*.,[26] included 14 refractory glaucoma patients with a mean age of 59.9 years. Over 78 months, pressure dropped 39% on average. Success was 67%, with a mean medication reduction of 0.7, from 1.8 to 1.1 per patient. Each hemisphere received 2,000 mW for 100 seconds. Kuchar *et al*.,[6] found 73.7% success in the first session and 89.5% in the second session in 19 refractory glaucoma eyes. The laser power averaged 2,000 mW, although the duration was 100–240 seconds. Averaging 60.3 days, the follow-up is far less than our study's 6 months. Our study had a 52.36-year mean age, although the patient cohort had 71.2 years. Over the study, hypertension dropped 41% and drug drops averaged 1.35 (ranging from 2.6 to 1.9 medicines).

Chew *et al*.,[13] reported a 35.9% pressure drop in 12 eyes with mild to moderate glaucoma with an average age of 63.5 years, with the same laser parameters as our trial. The mean follow-up was 4.8 months, shorter than our study (at least 6 months). Average drug use dropped 0.8, from 3.2 to 2.4. However, Lee *et al*.[8] found a 12-month success rate of 72.2% versus 84% in 36 eyes with moderate to refractory glaucoma. The laser strength is the same, but it lasts 160 s instead of 80–90 s in each hemisphere. The mean pressure drop was 33.2% (28.41 ± 8.32 to 18.98 ± 6.45 mmHg), lower than the 56.04% reduction in our study. Final visit pressure was higher than baseline pressure.

Noeker *et al*.[12] studied 95 mild-to-moderate glaucoma patients with the same laser power and time parameters as our study, which only reduced pressure by 30.3% (from 25.1 ± 5.3 to 17.5 ± 5.1 mmHg, p = 0.004) during a mean follow-up of 12 months. A further study by Radcliffe *et al*.[14], 48 eyes with mild to late-stage glaucoma saw a 29.8% decline in pressure in 3 months (from 25.8 to 17.1 mmHg, p = 0.027). Total success was 29.8%. Zaarour *et al*.[27] found that using the same parameters (2,000 mW, 90 s per hemisphere) on 75 moderate-to-severe glaucomatous eyes led to a 35.4% reduction in intraocular pressure (from 26.01 ± 6.92 to 14.78 ± 5.32, p < 0.001) and a 66% success rate over 15 months. Ling *et al*.[28] found that micropulse trans-scleral cyclophotocoagulation lowers intraocular pressure for 12 months in a systematic study. We noticed that IOP reduction loses effectiveness with time, requiring retreatment in some patients.

Strength and Limitations

This study is among the first and most thorough in Cambodia on a wide range of topics related to modern glaucoma laser therapy, including evidence-based treatment outcomes. The patient's inclusion is rigorously adhered to by the selection criteria. Therefore, factors such age, gender, glaucoma diagnosis and/or severity, laterality, or prior surgical history were necessary for nearly all of the patients who got this laser therapy throughout this time period. Complete data was also needed for the study because no follow-up information from the participants was lost during the course of the six months. Lastly, this is the first study of its kind in Cambodia, and this procedure is effectively applied to treat individuals with different stages of glaucoma shows that the new non-invasive method is

effective. However, the small sample size and retrospective nature were also drawbacks. The data was collected at a single tertiary medical center. Certain information was excluded, including the differing methods of counting drugs in oral, topical, and fixed combination preparations. Furthermore, the family history of illnesses linked to glaucoma was not sufficiently documented. Consequently, additional research involving a larger and more randomly assigned sample size is necessary, along with a prospective evaluation of the MP3 CPC in other tertiary centers. Additionally, since our study only collected data up to six months after treatment, longer follow-up periods will be necessary in future studies to assess laser therapy's duration and success rate as well as the prevalence of late problems. Finally, the laser parameters are pre-programmed and comply with the IRIDEX guidelines.

Despite some controversies, modifications to treatment protocols (power, duration, and/or method) may be necessary as the MP3 CPC laser gains popularity as a treatment modality in order to determine improved efficacy and safety while preserving a safety profile similar to the currently studied protocols. To sum up, a small sample size and a convenient sampling method might not accurately reflect the fully defined results of the whole population, but they might accurately reflect the efficacy and further detailed understanding of this laser therapy in a similar setting within our study.

Conclusion

In glaucoma of any stage and/or type, micropulse cyclophotocoagulation is a safe and effective laser treatment for lowering pressure and avoiding more invasive surgical procedures. The aforementioned technique improves safety and efficacy and, consequently, intraocular pressure management outcomes. It is also repeatable, has a greater success rate, and has less intra-operative complications than other conventional laser procedures.

Conflict of Interest Declaration

The authors claim that the research had no commercial or financial conflicts of interest.

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