Clinical Outcomes of Micropulse Transscleral Cyclophotocoagulation in Refractory Glaucoma

Duri Seo

Institute of Vision Research, Department of Ophthalmology, Yonsei University College of Medicine, 50-1, Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea

Taek June Lee

Institute of Vision Research, Department of Ophthalmology, Yonsei University College of Medicine, 50-1, Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea

Joo Yeon Kim

Institute of Vision Research, Department of Ophthalmology, Yonsei University College of Medicine, 50-1, Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea

Wungrak Choi

Institute of Vision Research, Department of Ophthalmology, Yonsei University College of Medicine, 50-1, Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea

Sang Yeop Lee

Department of Ophthalmology, Yongin Severance Hospital, Yonsei University College of Medicine, 363, Dongbaekjukjeon-daero, Giheung-gu, Yongin-si 16995, Korea

Gong Je Seong

Institute of Vision Research, Department of Ophthalmology, Yonsei University College of Medicine, 50-1, Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea

Chan Yun Kim

Institute of Vision Research, Department of Ophthalmology, Yonsei University College of Medicine, 50-1, Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea

Hyoung Won Bae (✉ BAEKWON@yuhs.ac)

Institute of Vision Research, Department of Ophthalmology, Yonsei University College of Medicine, 50-1, Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea

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Abstract

This study evaluated the clinical outcomes of first-time micropulse transscleral cyclophotocoagulation (MP-TSCPC) performed in cases of refractory glaucoma. This retrospective study analysed the patients with refractory glaucoma who underwent MP-TSCPC from February 2018 to February 2020 at Yonsei University Severance Hospital. A total of 45 eyes of 43 Asian patients (aged 55.71 ± 16.84 years) who underwent MP-TSCPC for the first time, were included in this study. The mean baseline intraocular pressure (IOP) was 25.96 ± 9.27 mmHg. The most common diagnosis was secondary glaucoma (44.4%) with a mean logarithm of the minimum angle of resolution (logMAR) visual acuity of 1.19 ± 1.02 . There was a significant reduction ($P < 0.05$) in IOP on 1 day, to 18.03 ± 5.99 mmHg; at 1 week, to 13.29 ± 5.24 mmHg; at 1 month, to 14.98 ± 4.55 mmHg; at 3 months, to 17.05 ± 5.52 mmHg; 6 months to 17.78 ± 6.37 mmHg; and 12 months, to 16.56 ± 5.96 mmHg. There was also a reduction ($P < 0.05$) in the number of topical anti-glaucoma medications required to control IOP from baseline (3.69 ± 0.63) at 1, 3, and 6 months. MP-TSCPC is an effective procedure that offers good results in reducing IOP and decreases the use of anti-glaucoma medications in patients with refractory glaucoma.

Introduction

Glaucoma is a chronic progressive optic neuropathy associated with structural damage to the optic nerve and visual field loss, which can lead to vision loss and blindness¹. There are many known risk factors, including elevated intraocular pressure (IOP)^{2,3}, that contribute to optic nerve damage, however, lowering IOP is the only approach known to reduce the risk of disease progression⁴.

According to literature, refractory glaucoma is defined as a group of diseases that do not respond favorably to surgical and/or medical treatment to lower IOP⁵. Cyclodestruction procedures are often used in patients with refractory glaucoma who have failed to achieve lower IOP from filtration procedures and maximal medical therapy. Transscleral cyclophotocoagulation (TSCPC) is a cyclodestructive procedure that reduces aqueous humor production through ciliary epithelium photocoagulation⁶. Traditionally, TSCPC uses a continuous mode that delivers laser energy, and severe complications, including hypotony, phthisis bulbi and chronic inflammation, have been reported⁷⁻⁹.

Micropulse wave transscleral cyclophotocoagulation (MP-TSCPC) is a new technique that uses repetitive active diode laser (on cycles) micropulses interspersed with rest intervals (Off cycles). During the off cycle, nonpigmented tissue adjacent to the tissue of interest is able to “cool off”, theoretically preventing the tissue from reaching the coagulative threshold and minimizing collateral tissue damage¹⁰.

In this study, we evaluated the efficacy and safety of MP-TSCPC performed for the first time in cases of refractory glaucoma and compared outcomes based on prior glaucoma surgeries.

Results

Baseline Clinical characteristics

Among those eyes that underwent MP-TSCPC at the Severance hospital from February 2018 to February 2020, 45 eyes in 43 patients completed a minimum of 6 months follow-up. Of these, 2 patients underwent MP-TSCPC for both eyes. All patients were Korean; the average age was 55.71 ± 16.84 years at the time of treatment; and 30 (69.8%) were male and 13 (30.2%) were female. Secondary glaucoma was the most common glaucoma type (20 eyes, 44.4%), followed by primary open angle glaucoma (19 eyes, 42.2%).

In the 45 eyes included in the study, 20 (44.4%) eyes had undergone glaucoma surgery prior to MP-TSCPC. Twelve eyes had undergone trabeculectomy, 16 eyes had undergone Ahmed glaucoma valve implantation and 8 eyes had undergone both trabeculectomy and Ahmed glaucoma valve implantation. Pseudophakia was present in 23 (51.1%) eyes, and aphakia in 6 (13.3%) eyes. The demographic and clinical characteristics of patients are summarized in table 1.

IOP Reduction and Medical Therapy

The mean IOP was significantly reduced from baseline at 1-day, 1-week, 1-, 3-, and 6-months postoperative follow-ups ($P < 0.001$). The mean IOP was decreased from 25.96 ± 9.27 mmHg at baseline to 18.03 ± 5.99 on day 1 (30.5% reduction), 13.29 ± 5.24 at 1 week (48.8% reduction), 14.98 ± 4.55 at 1 month (42.3% reduction), 17.05 ± 5.52 at 3 months (34.3% reduction), and 17.78 ± 6.37 at 6 months (31.5% reduction). At 6 months, the success rate was 82.2% (Table 2).

The clinical characteristics of the 8 patients who experienced failure at 6 months after MP-TSCPC are summarized in Table 3. The mean number of glaucoma medication was significantly reduced from baseline at 1-, 3-, and 6-month postoperative follow-up ($P = 0.001$, 0.002 , and 0.008 , respectively). The mean number of glaucoma medication at 6 months was 3.33 ± 0.95 (Table 2).

Visual Acuity

The mean best corrected visual acuity (BCVA) was 1.19 ± 1.02 logMAR at baseline. BCVA was lower than 0.05 Snellen (> 1.3 logMAR) in 22 (48.9%) eyes, 0.05 to 0.5 Snellen (1.3 to 0.3 logMAR) in 13 (28.9%) eyes, and more than 0.5 Snellen (< 0.3 logMAR) in 10 (22.2%) eyes at baseline.

The mean BCVA decreased to 1.45 ± 1.17 logMAR on day 1, 1.30 ± 1.00 logMAR at 1 week, 1.22 ± 1.01 logMAR at 1 month, 1.23 ± 1.01 logMAR at 3 months and 1.36 ± 1.04 logMAR at 6 months ($P = 0.133$, 0.008 , 0.011 , 0.003 , and 0.003 , respectively) (Table 2).

Loss of ≥ 2 lines of vision on the Snellen chart was found in 20 (44.4%) eyes, caused by deterioration of cornea edema (4 eyes), cystoid macular edema (3 eyes; 2 of these eyes had a history of macular edema before MP-TSCPC), glaucoma progression (2 eyes), vitreous hemorrhage (1 eye; this patient had a history of vitreous hemorrhage due to diabetic retinopathy), worsening of proliferative diabetic retinopathy (1 eye), relapse of choroidal neovascularization (1 eye), corneal opacity due to a persistent epithelial defect (1 eye), uveitis (1 eye), and unexplained vision loss (6 eyes).

Complications

The two most common complications were mydriasis (9 eyes, 20.0%) and postoperative iritis (8 eyes, 17.8%). Mydriasis resolved within 6 months in 8 eyes, however 1 eye did not improve until 6 months.

On day 1 after MP-TSCPC, 8 eyes (24.2%) had mild postoperative inflammation in the anterior chamber. Most of these eyes responded to topical steroids and resolved in 1 week; however, inflammation persisted in 1 eye for 1 month and in 1 eye for 3 months.

Three eyes had cystoid macular edema, 1 eye had cataract progression, 1 eye had a corneal epithelial defect and 1 eye had hypotony. In the eye with hypotony (5 mmHg), hypotony was nonted at 1 month and IOP was 6 mmHg at 3 months. At 6 months, IOP elevated to 35 mmHg, which was higher than before MP-TSCPC (22 mmHg).

Table 4 shows postoperative complications after MP-TSCPC. There were no incidences of severe complication such as phthisis bulbi, endophthalmitis, and sympathetic ophthalmia.

Outcomes based on prior glaucoma surgeries

A subgroup analysis was conducted between eyes with and without a history of glaucoma surgery: 25 eyes had no previous glaucoma surgery versus 20 eyes had undergone glaucoma surgery including cyclodestructive procedures. The mean baseline IOP was not significantly different ($P = 0.228$) in both patient groups and did not change significantly at any of follow-ups. At 6 months, mean IOP was 17.41 ± 7.35 mmHg and 18.07 ± 5.61 mmHg in both groups (between groups $p = 0.583$). The mean reduction in IOP was 27.6% in the prior glaucoma surgery group and 34.2% in the no prior surgery group.

The mean number of glaucoma medication was not significantly different at baseline ($P = 0.059$) and did not change significantly at any the follow-ups.

At 6 months after MP-TSCPC, the success rates were 85.0% (17/20 eyes) for the prior glaucoma surgery group and 80.0% (20/25 eyes) for the no prior glaucoma surgery group.

The postoperative outcomes of subgroups are shown in Table 5.

Outcomes at 12 months

Of the 45 eyes that were observed for more than 6 months, 22 could be observed for up to 12 months (10 eyes in the prior glaucoma surgery group, 12 eyes in the no prior glaucoma surgery group). Of these 22 eyes, 5 eyes received repeat glaucoma surgery including repeat MP-TSCPC between 6 and 12 months after the initial MP-TSCPC (3 eyes received a second application of MP-TSCPC, 1 eye received MP-TSCPC two more times and 1 eye received ahmed valve implantation). The mean time to repeat glaucoma surgery was 7.6 ± 0.89 months. The mean IOP was 16.56 ± 5.96 , the mean number of glaucoma medication was 3.45 ± 1.06 , and the mean visual acuity was 1.43 ± 1.04 logMAR at 12 months. The overall success rate was 68.2% at 12 months (80% in the prior glaucoma surgery group, 58.3% in the no prior group). Figure 2 illustrates the Kaplan-Meier survival curve analysis after MP-TSCPC. Survival rates between the two groups were not significantly different ($p=0.239$).

Discussion

The management of refractory glaucoma is a serious challenge, and the TSCPC represents one of the various interventional alternatives for decreasing IOP in patients with refractory glaucoma¹¹. However, traditional TSCPC delivers continuous high intensity laser that causes complication such as hypotony and phthisis bulbi.

Recently, MP-TSCPC has demonstrated superior efficacy in lowering IOP with less complications^{8,10} because of minimal disruptions to the collateral non-pigmented epithelium, ciliary body stroma, and adjacent tissue.

Our study also demonstrated that MP-TSCPC is an effective surgical option with fewer complications for eyes with refractory glaucoma. The two most common complications were mydriasis and postoperative iritis.

The study by William et al.¹² and Emanuel et al.¹³ showed higher complication rates of postoperative inflammation and hypotony. William et al. identified the “non-White race” as being a factor associated with a 3.6-fold higher risk of prolonged inflammation, possibly explained by a greater energy absorption due to pigment. Even though this study was conducted in Asians, the low postoperative inflammation and hypotony rate is thought to be due to the use of relatively low energy laser. The total energy delivered was lower in our study than in their study (2000 mW, 31.3% duty cycle, 100 ~ 180 seconds VS 2000 mW, 31.3% duty cycle, 120 ~ 360 seconds). These results suggest that the risk of complications of MP-TSCPC could be related to the delivered energy. Vig et al.¹⁴ in their recent study reported very few complications using lower durations/total energy (up to 90 seconds for the 2000 mW laser).

Although there have not been many reports on the matter, mydriasis is another possible complication after MP-TSCPC, which may lead to clinical findings such as glare or other visual discomforts^{15,16}. Mydriasis occurred in 9 eyes in this study. It is possible that the iris pigmentation was more distributed than in the previous ‘Caucasian’ study subjects, resulting in more energy absorption by the surrounding tissues¹⁷. In a recent study, of the 349 patients who underwent MP-TSCPC, 4 presented with fixed pupil and dilated pupils that did not react to light or accommodate after the procedure. All 4 patients had brown irises and myopia¹⁸.

A significant number of patients experienced vision changes after MP-TSCPC in our study. In total, 44.4% of patients experienced vision loss ≥ 2 lines on the Snellen chart at 6 months follow up. The relatively high rate of vision loss may be related to differences in study populations. In general, our study subjects had advanced glaucoma and complex ocular

histories. Continuous visual field loss may have accounted for some of the loss of VA of the patients in this study when no obvious adverse effect occurred. Out of the 6 eyes that had unexplained vision loss, 5 had advanced glaucoma. In one study that evaluated the outcomes of MP-TSCPC in patients with good baseline vision, there was no significant reduction in logMAR BCVA from baseline to 1, 3, 6, and 12 months postoperatively¹⁹. In contrast, the baseline mean VA was 1.19 ± 1.02 logMAR in this study.

Further, considering the recurrence of vitreous hemorrhage or cystoid macular edema in eyes with vision loss, it was not clear whether the vision loss observed in eyes after MP-TSCPC was related directly to the laser procedure or determined by the underlying disease process and the natural progression of advanced glaucoma. Moreover, because of the imprecise nature of VA measurements and poor reproducibility of Snellen VA assessment at low levels of vision, caution should be taken when interpreting apparent changes in VA. To evaluate the effect of MP-TSCPC in vision loss, research should be conducted with patients at different stages of the disease, and better baseline visual acuities should be obtained.

Many variables responsible for the extent of the postoperative IOP lowering effect have been proposed: age, sex, type of glaucoma, previous ocular surgery, and iris pigmentation²⁰. In this study, postoperative IOP was not statistically different between the group with previous ocular surgery and the group without previous ocular surgery. Until recently, cyclodestructive procedures have been performed as the last option for patients with poor visual potential. In comparison with glaucoma surgery, MP-TSCPC is quick, technically easy to perform, relatively inexpensive, and minimally invasive. Therefore, MP-TSCPC could be a good alternative for invasive incisional glaucoma surgery in patients who are at a high risk of surgical complications.

However, in a study of outcomes of MP-TSCPC in Asian patients with advanced glaucoma²¹, the significant risk factor for failure was previous glaucoma surgery (Odds ratio = 2.33, 95%CI = 1.11–4.59, P = 0.02). This is possibly due to difference in patient characteristics. There were 4 (8.9%) eyes with neovascular glaucoma (NVG) in our study, whereas 33.8% (70 eyes) of them had NVG, although it is not known which patients were included in which group. In TSCPC, the risk of complications and failure is affected by the type of glaucoma, with patients with NVG having a significantly increased risk of complications and failure^{22,23}. Tan et al.¹⁰ also reported a higher failure rate in patients with NVG.

Many published studies have reported the short-term efficacy of MP-TSCPC. However, There are relatively few large-scale studies that report on the long-term efficacy of this procedure. The greatest drop in IOP was noted the first week after MP-TSCPC and increased gradually during the first 6 months of our study. This result is consistent with that of the retrospective study that have evaluated the long-term efficacy of MP-TSCPC for patients with advanced glaucoma²¹. In that study, the success rates of up to 70% at postoperative week 6 subsequently declined throughout the 3 years of follow-up after MP-TSCPC to 18.5% at postoperative year 3. In our study, although the sample size was small, the success rate dropped to 68.2% at 12 months. Aqino et al. observed treatment success (defined as IOP between 6 and 21mmHg and at least 30% reduction in IOP) in 75% of 24 MP-TSCPC-treated eyes after 12 months and in 52% of treated eyes after 18months⁸. Therefore, prospective studies with a larger cohort and a longer follow-up are necessary to confirm the effects of MP-TSCPC.

The limitation of our study include its retrospective nature, small sample size, and relatively short follow-up period. Due to the limited follow-up time, it may be unrealistic to determine major complications such as phthisis bulbi. Another drawback is our inclusion of only subjects with refractory glaucoma who failed to reach target IOP with maximal anti-glaucoma therapy, with or without previous glaucoma surgery. Additionally, our study analyzed patients of a single ethnic group. Therefore, caution need to be exercised in terms of generalizing our results.

Nevertheless, this study is meaningful as it is the first to report the clinical outcomes of first-time MP-TSCPC for the treatment of refractory glaucoma in an Asian population.

In conclusion, our data shows that MP-TSCPC is effective treatment for lowering IOP in refractory glaucoma regardless of prior glaucoma surgery. However, there were significant risks of visual loss and some adverse effects such as mydriasis.

Therefore, it is necessary to explain the possible complications to the patients before procedure. Further research is needed to find the optimal laser settings for each ethnicity.

Methods

Patients enrollment

This retrospective study included patients with refractory glaucoma who underwent a single first-time MP-TSCPC at the glaucoma center in Severance hospital from February 2018 to February 2020. Approval for this study was obtained from the Severance Institutional Review Board, which provided a waiver informed consent for the retrospective review of existing patient records (IRB number:4-2020-1200). The methods used in this study adhered to the Declaration of Helsinki.

Patients with refractory glaucoma is defined as those who have failed to reach target IOP using maximal topical anti-glaucoma medication, and/or dependent on oral carbonic anhydrase inhibitors, with or without previous glaucoma surgery and poor surgical prognosis^{24,25}. Pre- and postoperative clinical data, including age, sex, type of glaucoma, BCVA, IOP, treatment history, and medication, were recorded. Patients who did not undergo at least 6 months of follow-up were excluded.

Surgical procedure

All procedures were performed under retrobulbar or sub-Tenons anesthetic block (4% lidocaine and 0.5% bupivacaine). The laser probe was placed at the peri-limbal area at 1mm from the corneo-scleral limbus with the probe perpendicular to the surface of the globe. The laser setting was 2000mW with a duty of 31.3%. The laser was applied throughout 180° for 90 seconds in eyes with no previous glaucoma surgery and 60 seconds in eyes with previous glaucoma surgery to avoid the previous sites of prior glaucoma surgery (filtering and drainage implant areas). The procedure was repeated for the other hemi-field. The 3 and 9 o'clock areas were avoided due to the potential of damaging the long posterior ciliary nerves and arteries.

The dose of topical glaucoma medications and acetazolamide was gradually tapered depending on the patients' individual needs after the procedure.

Postoperatively, patients were prescribed levofloxacin 0.5% and flumetholone 0.1% 4 times daily during the first week, followed by a tapering course.

Follow-up

Data were collected at follow-up visits on 1 day, 1 week, 1 month, 3 months, 6 months, and 12 months after the procedure. Anterior segment examination, anterior chamber reaction, postoperative IOP, BCVA, postoperative complication, and the number of glaucoma medication at each follow-up were recorded.

Outcome measures

The primary outcome was surgical success, defined as IOP of 6-21mmHg or more than 20% reduction in IOP from baseline, without any further glaucoma surgeries. Failure was defined as IOP <6mmHg or >21mmHg, and <20% reduction in IOP, or received further glaucoma surgeries. Further glaucoma surgeries included repeat MP-TSCPC, continuous-wave diode TSCPC, trabeculectomy, or glaucoma tube shunt implantation.

A subgroup analysis was performed between eyes with and without history of glaucoma surgery.

Statistical analysis

Statistical analysis was performed using SPSS, version 22.0 (IBM Corp., Armonk, NY, USA). The post-treatment values were compared with the baseline values using the paired t-test or Wilcoxon signed-rank test. A Mann-Whitney U test was used to

compare variables between each group. Kaplan-Meier survival analysis was used to determine the cumulative success. BCVA was converted from Snellen visual acuity to logarithm of the minimum angle of resolution (logMAR) equivalents. A p value less than 0.05 was considered statistically significant.

Declarations

Data Availability Statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Author contributions

Conceptualization, D.R.S and H.W.B.; data curation, D.R.S and T.J.L.; formal analysis, J.Y.K. and W.C.; supervision, S.Y.L., G.J.S., C.Y.K., and H.W.B.; Writing-original draft, D.R.S.; Writing-review and editing, H.W.B. All authors have read and agreed to the published version of the manuscript.

Competing Interests Statement

None of the authors have any commercial or proprietary interests in any of the instruments or materials described in this article.

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Tables

TABLE 1. Demographic and Clinical Characteristics of Patients	
Patient Information	Value
No. patients (number of eyes)	43 patients (45 eyes)
Age (mean $\pm$ SD), (y)	55.71 $\pm$ 16.84
Sex [n (%)]	
Male	30 (69.8)
Female	13 (30.2)
Diagnosis [n (%)]	
Primary open-angle glaucoma	19 (42.2)
Secondary glaucoma	
Aphakia	5 (11.1)
Neovascular glaucoma	4 (8.9)
Traumatic-associated	3 (6.7)
Uveitic-associated	3 (6.7)
Post-retinal detachment surgery	3 (6.7)
Complicated cataract surgery	2 (2.2)
Pseudoexfoliative glaucoma	3 (6.7)
Chronic angle-closure glaucoma	3 (6.7)
Prior glaucoma interventions [n (%)]	
Ahmed glaucoma valve implantation	16 (35.6)
Trabeculectomy	11 (24.4)
Selective laser trabeculoplasty	3 (6.7)
Laser peripheral iridotomy	3 (6.7)
Diode laser cyclophotocoagulation	1 (2.2)
Lens status [n (%)]	
Phakic	16 (35.6)
Pseudophakic	23 (51.1)
Aphakic	6 (13.3)

TABLE 2. Overall Postoperative Outcomes		
Variable	Value	P-Value*
IOP (mmHg)		
Preoperative	25.96 ± 9.27	
1 day	18.03 ± 5.99	<0.001
1 week	13.29 ± 5.24	<0.001
1 month	14.98 ± 4.55	<0.001
3 months	17.05 ± 5.52	<0.001
6 months	17.78 ± 6.37	<0.001
12 months	16.56 ± 5.96	<0.001
Number of antiglaucoma medications		
Preoperative	3.69 ± 0.63	
1 week	3.58 ± 0.84	0.102
1 month	3.22 ± 1.04	0.001
3 months	3.37 ± 0.87	0.002
6 months	3.33 ± 0.95	0.008
12 months	3.45 ± 1.06	0.157
BCVA (logMAR)		
Preoperative	1.19 ± 1.02	
1 day	1.45 ± 1.17	0.133
1 week	1.30 ± 1.00	0.008
1 month	1.22 ± 1.01	0.011
3 months	1.23 ± 1.01	0.003
6 months	1.36 ± 1.04	0.003
12 months	1.43 ± 1.04	0.013

Data are expressed as the mean ± standard deviation. IOP = intraocular pressure; BCVA = best corrected visual acuity; logMAR = logarithm of minimal angle of resolution. * P-value for Wilcoxon signed-rank test.

TABLE 3. Clinical Characteristics of Patients of Failure at 6 Months after MP-TSCPC

Age (years)	Sex	Diagnosis	Past glaucoma surgery	Lens status	Ocular Comorbidities	Glaucoma surgery after failure	Baseline IOP (mmHg)	IOP at 6 months (mmHg)
44	F	POAG	Ahmed glaucoma valve implantation	Phakic	None	Repeat MP-TSCPC at 7 months after failure	24	24
46	M	POAG	Ahmed glaucoma valve implantation	Pseudophakic	None	Repeat MP-TSCPC at 7 months, Ahmed glaucoma valve implantation at 13 months after failure	24	23
65	M	POAG	Trabeculectomy	Pseudophakic	None	None	22	35
62	M	POAG	None	Pseudophakic	None	Repeat MP-TSCPC at 8, 18 months after failure	28	23
26	F	Secondary glaucoma (Aphakic)	None	Aphakia	Congenital cataract	None	15	23
81	M	POAG	None	Pseudophakic	Bullous keratopathy	None	26	22
67	F	Secondary glaucoma (NVG)	None	Pseudophakic	Central retinal vein occlusion	Repeat MP-TSCPC at 7, 8 months after failure	26	34
70	M	POAG	None	Phakic	None	Ahmed glaucoma valve implantation at 7 months after failure	22	23

IOP = intraocular pressure; POAG = primary open angle glaucoma; NVG = neovascular glaucoma.

TABLE 4. Postoperative Complication after Micropulse Transscleral Cyclophotocoagulation	
Postoperative complication	Number of eyes (%)
Vision loss $\geq$ 2 lines	20 (44.4%)
Mydriasis	9 (20.0%)
Postoperative iritis	8 (17.8%)
Hypotony	1 (2.22%)
Cataract progression	1 (2.22%)
Macular edema	3 (6.67%)
Cornea erosion	1 (2.22%)

Vision loss $\geq$ 2 lines was defined as a loss of $\geq$ 0.2 logarithm of the minimal angle of resolution (logMAR) units at 6 months follow-up.

TABLE 5. Postoperative Outcomes in Patients with Prior Glaucoma Surgery vs Patients with No Prior Glaucoma Surgery			
	Prior glaucoma surgery (N=20)	No prior glaucoma surgery (N=25)	P-Value*
IOP (mmHg)			
Preoperative	24.05 ± 7.76	27.48 ± 10.21	0.228
1 day	20.08 ± 6.99	16.70 ± 4.97	0.160
1 week	12.15 ± 4.16	14.20 ± 5.89	0.281
1 month	15.30 ± 5.83	14.72 ± 3.30	0.891
3 months	15.79 ± 5.59	18.05 ± 5.36	0.193
6 months	17.41 ± 7.35	18.07 ± 5.61	0.583
Number of antiglaucoma medications			
Preoperative	3.85 ± 0.49	3.56 ± 0.71	0.059
1 week	3.80 ± 0.52	3.40 ± 1.00	0.077
1 month	3.30 ± 1.13	3.16 ± 0.99	0.322
3 months	3.47 ± 0.84	3.29 ± 0.91	0.351
6 months	3.45 ± 1.00	3.24 ± 0.93	0.180
BCVA (logMAR)			
Preoperative	0.98 ± 1.00	1.38 ± 1.02	0.177
1 day	1.22 ± 1.28	1.58 ± 1.12	0.410
1 week	1.08 ± 1.01	1.46 ± 0.98	0.140
1 month	1.04 ± 1.04	1.36 ± 0.98	0.140
3 months	1.09 ± 1.05	1.35 ± 0.99	0.232
6 months	1.09 ± 0.98	1.55 ± 1.07	0.126

Data are expressed as the mean ± standard deviation. IOP = intraocular pressure; BCVA = best corrected visual acuity; logMAR = logarithm of minimal angle of resolution. * P-value for Mann-Whitney test.

Figures

Figure 1

Rates of the success through the follow-ups. At 6 months, the overall success rate is 82.2%. This rate drops to 68.2% at 12 months.

Figure 2

Kaplan-Meier cumulative survival analysis curve between the prior glaucoma surgery group and the no prior glaucoma surgery group. The survival rate is not significantly different between the two groups (Log-rank test for equality of survivor functions: $P = 0.239$).