Micropulse Cyclophotocoagulation: Initial Results in Refractory Glaucoma

Matthew E. Emanuel, MD, Davinder S. Grover, MD, MPH,**
Ronald L. Fellman, MD, David G. Godfrey, MD,* Oluwatosin Smith, MD,**
Michelle R. Butler, MD, Helen L. Kornmann, MD, PhD,**
*William J. Feuer, MS,† and Swati Goyal, MBBS**

Purpose: The purpose of this study is to evaluate the use of micropulse transscleral cyclophotocoagulation (MP-TSCPC), a new and increasingly popular treatment, in patients with uncontrolled glaucoma.

Methods: A retrospective chart review was performed for all patients who underwent a MP-TSCPC at the Glaucoma Associates of Texas.

Results: A total of 84 eyes were treated with MP-TSCPC in this study with a mean follow-up time of 4.3 months. The mean age of treated patients was 74 years and 48 (57%) were female. Preoperatively, mean intraocular pressure (IOP) was 27.7 mm Hg and mean number of ocular antihypertensive medications used was 3.3. Mean postoperative IOP at months 1, 3, 6, and 12 were lowered to 16.3 mm Hg (41.2% reduction), 14.6, 13.0, and 11.1 mm Hg, respectively. Postoperative ocular antihypertensive medication use was also lowered to 1.9, 2.0, 2.0, and 2.3 medications at months 1, 3, 6, and 12, respectively. Five patients required further laser or surgical intervention for adequate IOP control. Complications included hypotony, IOP spike, hyphema, serous choroidal detachment, persistent inflammation, and vision loss. At 3 months, inflammation was still present in 46% of eyes and vision loss of at least 1 line was present in 41% of eyes.

Conclusions: MP-TSCPC is effective at lowering IOP and decreasing the need for ocular antihypertensive medications. Eyes with limited visual potential or at high risk for incisional glaucoma surgery can successfully be treated with MP-TSCPC as a reasonable and effective alternative to traditional CPC. These results present short-term data and both longer follow-up and further studies are necessary.

Key Words: glaucoma, laser, micropulse, cyclophotocoagulation, intraocular pressure

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Glaucoma is a progressive optic neuropathy and is the leading cause of irreversible blindness worldwide.[1] Treatment of glaucoma aims to lower the intraocular pressure (IOP) by using medications, lasers, and incisional surgery.[2] In eyes with refractory glaucoma, patients with poor visual potential, and patients who are not good surgical candidates, transscleral cyclophotocoagulation (TSCPC) is commonly used to reduce IOP. TSCPC decreases the IOP through the continuous delivery of diode laser to destroy the ciliary body, thereby decreasing aqueous production.[3] Studies have demonstrated that the IOP-lowering effect of TSCPC is correlated with number of laser spots applied.[4] However, this efficacy must be balanced with the potential complications of TSCPC, as some studies have shown that the risk of complications increases with higher energies.[5] Complications associated with TSCPC include prolonged intraocular inflammation, pain, intraocular hemorrhage, hypotony, phthisis bulbi, decreased vision, and rarely sympathetic ophthalmia.[6,7] The severity of these complications are felt to be secondary to the collateral damage surrounding tissues, including the ciliary muscles, nonpigmented epithelium, and ciliary body stroma.[8]

Micropulse TSCPC (MP-TSCPC; IRIDEX, CYCLO G6 Glaucoma Laser System, Mountain View, CA) offers a variation of traditional TSCPC to treat glaucoma. With this system, short bursts of energy (on-cycle) deliver energy to the targeted tissue, with the energy bursts sequentially building up to a photocoagulative state in the pigmented epithelium. At the same time, during "off-cycles," surrounding tissue is allowed to cool and remains below the photocoagulative threshold, thereby, theoretically preventing damage to surrounding tissue.[9]

Previous studies, though few in number with limited follow-up, have demonstrated that MP-TSCPC is an effective and safe alternative to traditional TSCPC at lowering IOP, with possible decreased rates of complications.[9–11] Given the recent interest in this technique and the increasing use of MP-TSCPC to treat eyes with glaucoma, the authors felt it was paramount to publish on our initial results with this procedure. The authors report their experience and data on the largest cohort of patients having undergone MP-TSCPC to date.

METHODS

A retrospective chart review was performed for all patients who underwent a MP-TSCPC at Glaucoma Associates of Texas. All patients were included in this study. Given the nascent nature of this procedure, the authors did not exclude any eyes and wanted to report any and all information obtained regarding the postoperative outcomes and complications with all available follow-up. The eyes in this study reflect the initial learning curve for all surgeons involved. The study followed the tenants of the

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From the *Glaucoma Associates of Texas, Dallas, TX; and †Miller School of Medicine, Bascom Palmer Eye Institute, University of Miami, Miami, FL.
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Reprints: Matthew E. Emanuel, MD, Glaucoma Associates of Texas, 10740 N. Central Expy, Suite 300, Dallas, TX 75231 (e-mail: matthew.emanuel@gmail.com).

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Declaration of Helsinki and was approved by the affiliated hospital's institutional review board.

The surgery was performed in adults with various types of glaucomas and varying past ocular histories. Most patients received a peribulbar block, though patients at high risk of hemorrhage were treated with brief intravenous sedation. Laser settings were determined by the treating physician without strict parameters. Because of the nascent nature of this procedure combined with lack of standardization in treatment techniques, some physicians opted for a fast-sweeping motion of about 10 seconds back-and-forth over 180 degrees, and others used a slow-sweeping motion of about 1 minute over the same distance.

RESULTS

A total of 84 eyes were treated with MP-TSCPC in this study. The mean age of treated patients was 74 years (range, 13 to 98 y). In total, 48 patients (57%) were female and most patients were white (n = 49, 58%) (see Table 1 for complete demographics). Primary open-angle glaucoma was predominant diagnosis (n = 49, 58%) (see Table 2 for distribution of glaucoma diagnoses). All patients (n = 84, 100%) were on medical glaucoma therapy and most patients had undergone prior incisional glaucoma surgery (n = 66, 79%) (Table 3). Mean follow-up time was 4.3 months (SD, 3.0 mo), with the following breakdown: 74 (88%) patients at 1 month; 61 (73%) patients at 3 months; 39 (46%) patients at 6 months; and 10 (12%) patients at 12 months.

For all eyes, mean IOP was redeuced from 27.7 mm Hg (SD, 10.3 mm Hg) preoperatively to 16.3 mm Hg (SD, 9.5 mm Hg) at 1 month postoperatively, a 41.2% reduction. Postoperative mean IOP further lowered to 14.6 mm Hg (SD, 8.8 mm Hg), 13.0 mm Hg (SD, 6.9 mm Hg), and 11.1 mm Hg (SD, 4.4 mm Hg) at months 3, 6, and 12, respectively. Similarly, the mean number of antiglaucoma medications was reduced from 3.3 (SD, 1.0) preoperatively to 1.9 (SD, 1.3), 2.0 (SD, 1.4), 2.0 (SD, 1.4), and 2.3 (SD, 1.5) at months 1, 3, 6, and 12, respectively.

Vision changes after MP-TSCPC were common (Tables 4, 5). At week 1, 42.7% (n = 32) of eyes lost 1 line of vision or more and 33.3% (n = 25) lost 2 lines of vision or more; 16% (n = 12) were noted to have improved vision of at least 1 line. These numbers stayed essentially stable at 1 month, with 44.6% (n = 33) of eyes losing 1 line or more and 35.1% (n = 26) losing 2 lines or more. At month 3, 41% (n = 25) of eyes lost 1 line or more and 26.2% (n = 16) lost 2 lines or more. Three patients lost light-perception vision, all of which had light-perception vision preoperatively.

TABLE 1. Demographic Information

No. eyes (no. patients)	84
Mean age (SD) (y)	74 (16)
Median (range) (y)	78 (13-98)
Female sex [n (%)]	48 (57)
Race [n (%)]	
African American	24 (29)
Asian	4 (5)
Hispanic	6 (7)
White	49 (58)
Multiracial/unspecified	1 (1)

TABLE 2. Distribution of Glaucoma Types

Glaucoma Diagnosis	n (%)
Primary open angle	49 (58)
Chronic angle closure	6 (7)
Pseudoexfoliation	8 (10)
Pigment dispersion	1 (1)
Uveitic/inflammatory	2 (2)
Mixed mechanism	2 (2)
Unspecified	1 (1)
Traumatic	2 (2)
Neovascular	5 (6)
Other secondary glaucoma	6 (7)
Aphakic glaucoma	2 (2)

Of the 84 patients treated with MP-TSCPC, 5 (6%) required further laser or surgical intervention for adequate IOP control; 2 patients underwent implantation of a glaucoma drainage implant and 3 underwent TSCPC.

The most common complications were IOP related, namely persistent hypotony (IOP $\leq$ 5 mm Hg at 2 consecutive appointments) or an IOP spike (increase in IOP of $>$ 25% from baseline within 1 month of laser). There were 5 cases of persistent hypotony during the study period. Four additional patients had a single IOP reading $\leq$5, but IOP normalized thereafter. Of note, 2 additional patients had IOP readings $\leq$5 but had inadequate follow-up data to confirm persistent hypotony. One patient with persistent hypotony had undergone prior CPC. Three patients were found to have an IOP spike as defined above. Hyphema (n = 3) and choroidals (n = 1) were also noted, though both of these complications had resolved before 3-month follow-up in all patients. No patients experienced phthisis bulbi or sympathetic ophthalmia.

Postoperative inflammation was common following MP-TSCPC. At 1 week 86% (63/73 eyes) had some degree of anterior chamber cell and/or flare, improving to 46% (28/61 eyes) at 3-month follow-up. In total, 74% (45/61 eyes) were on topical steroids at postoperative month 3.

Laser settings were determined by the treating physician. Mean power setting was 1939 mW with a range of 1600 to 2000 mW. The most common power settings were

TABLE 3. Prior History of Ocular Procedures

	n (%)
Prior glaucoma surgery	57 (68)
Prior trabeculectomy	10 (12)
Prior drainage implant	37 (44)
Prior trabectome	6 (7)
Prior GATT	8 (10)
Prior CPC	7 (8)
Prior ECP	1 (1)
Prior LPI	9 (11)
Prior ALT/SLT	27 (32)
Prior cataract surgery	64 (76)
Prior strabismus surgery	2 (2)
Prior retina	9 (11)
Prior vitrectomy	10 (12)

ALT indicates argon laser trabeculosplasty; CPC, cyclophotocoagulation; ECP, endoscopic cyclophotocoagulation; GATT, gonioscopy-assisted transluminal trabeculotomy; LPI, laser peripheral iridotomy; SLT, selective laser trabeculoplasty.

TABLE 4. Vision Changes After MP-TSCPC: Postoperative Month 1

	Frequency	%	Cumulative (%)
Lost to LP, NLP	2	2.7	2.7
−10.00	2	2.7	5.4
−6.00	3	4.1	9.5
−5.00	1	1.4	10.8
−4.00	2	2.7	13.5
−3.00	6	8.1	21.6
−2.00	10	13.5	35.1
−1.00	7	9.5	44.6
0.00	29	39.2	83.8
1.00	4	5.4	89.2
2.00	6	8.1	97.3
4.00	2	2.7	100.0
Total	74	100.0	

Values < 0 = number of lines of Snellen vision lost.
Values > 0 = number of lines of Snellen vision gained.
LP indicates light perception; MP-TSCPC, micropulse transscleral cyclophotocoagulation; NLP, no light perception.

2000 mW (n = 49, 58.3%) and 1900 mW (n = 19, 22.6%). Mean treatment time was 319 seconds, typically divided between the hemispheres (range, 180 to 360 s), with most patients being treated for 360 seconds (n = 42, 50%), 300 seconds (n = 14, 16.7%), or 240 seconds (n = 12, 14.3%). Most patients received a 360-degree treatment (n = 68, 81%; range, 180 to 360 degrees) while avoiding the 3 and 9 o'clock positions. There was no standard technique for the sweeping motion during application (fast vs. slow).

CONCLUSIONS

Eyes with limited visual potential or at high risk for complications of incisional glaucoma surgery can often be treated with ciliary body ablation. Traditionally, TSCPC has been used in eyes with advanced or uncontrolled glaucoma with either limited visual potential or high risk for more invasive procedures. Recently, MP-TSCPC has been used to treat these eyes with reports of safe and effective outcomes.[9–11]

Our initial results confirm that MP-TSCPC is relatively safe and effective. The mean decrease in IOP at 6 and 12 months was 15.5 and 18.0 mm Hg, respectively ($P < 0.001$). The mean decrease in glaucoma medications at 6 and 12 months was 1.4 and 1.0, respectively ($P < 0.001$ at 6 mo and $P = 0.085$ at 12 mo). Importantly, there were no cases of serious complications such as phthisis or sympathetic ophthalmia. At 3 and 6 months, there were 8 and 3 eyes with persistent hypotony, respectively.

TABLE 5. Vision Changes After MP-TSCPC: Postoperative Month 3

	Frequency	%	Cumulative (%)
Lost to LP, NLP	3	4.9	4.9
−5.00	2	3.3	8.2
−3.00	5	8.2	16.4
−2.00	6	9.8	26.2
−1.00	9	14.8	41.0
0.00	32	52.5	93.4
1.00	1	1.6	95.1
2.00	1	1.6	96.7
3.00	1	1.6	98.4
4.00	1	1.6	100.0
Total	61	100.0	

Values < 0 = number of lines of Snellen vision lost.
Values > 0 = number of lines of Snellen vision gained.
LP indicates light perception; MP-TSCPC, micropulse transscleral cyclophotocoagulation; NLP, no light perception.

A significant number of patients did experience vision changes after MP-TSCPC. In total, 41% of patients experienced some degree of vision loss following laser treatment. Although some patients had a potential cause for decreased vision (eg, hyphema, persistent inflammation, hypotony), other patients had no identifiable cause. Further follow-up is necessary to see if visual acuity ultimately returns to baseline or if this is a permanent change, particularly in patients without a known etiology.

Studies comparing MP-TSCPC and traditional TSCPC are limited. Aquino et al[11] randomized 48 patients to receive either MP-TSCPC or TSCPC, with a primary outcome of IOP between 6 and 21 mm Hg and a 30% reduction, with or without medications. At 12 months, 75% of MP-TSCPC and 29% of TSCPC were successfully achieved the primary outcome. At 18 months, success of MP-TSCPS decreased to 52%, whereas success of TSCPC stayed stable at 30%. Furthermore, more complications were noted in the TSCPC group with higher rates of prolonged inflammation and 1 case of phthisis bulbi in the TSCPC group.

The outcomes of our study are promising, with good evidence of the IOP-lowering effects of MP-TSCPC and decreased need for ocular antihypertensive medications postlaser at 6 months. As the largest cohort of MP-TSCPS patients evaluated to date, the IOP-lowering effects described in this study appear to be similar to prior reports. Longer follow-up will be essential to determine the long-term efficacy of MP-TSCPC. The vision loss and persistent inflammation, even though relatively mild in many patients, is still of concern.

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