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BRIEF REPORT

Treatment outcomes of micropulse transscleral cyclophotocoagulation in advanced glaucoma

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Abstract Glaucoma is the leading cause of irreversible blindness worldwide. The goal of this study was to describe our experience with the novel micropulse transscleral cyclophotocoagulation (MP-TSCPC; IRIDEX IQ810 Laser Systems, CA) in patients with advanced glaucoma. Patients with advanced glaucoma who underwent MP-TSCPC were included in our study. Laser settings were 2000 mW of 810 nm infrared diode laser set on micropulse delivery mode. The laser was delivered over 360° for 100–240 s. The duty cycle was 31.3 %, which translated to 0.5 ms of "on time" and 1.1 ms of "off time." Surgical success was defined as an intraocular pressure (IOP) of 6–21 mmHg or a reduction of IOP by 20 % at the last follow-up visit. Failure was defined as an inability to meet the criteria for success or a need for incisional glaucoma surgery. Nineteen patients underwent MP-TSCPC with mean follow-up of 60.3 days. Mean IOP dropped from 37.9 mmHg preoperatively to 22.7 mmHg at last follow-up, representing a 40.1 % decrease. The success rate for initial treatment was 73.7 % ($n = 14$). Three patients underwent a second treatment, increasing the overall success rate to 89.5 % ($n = 17$). Four patients gained one line of vision, and four patients lost one line of vision. The novel MP-TSCPC laser had a high rate of surgical success after a short follow-up period in patients with advanced glaucoma. Further long-term evaluation and comparison to the traditional transscleral cyclophotocoagulation are warranted.

Keywords Transscleral cyclophotocoagulation · Glaucoma · Micropulse diode laser · MP3 laser surgery

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Introduction

Glaucoma is the leading cause of irreversible blindness in the world [1, 2]. Glaucoma therapies are designed to either increase the outflow or decrease the production of aqueous humor in order to reduce intraocular pressure (IOP) and preserve visual function. Traditional transscleral cyclophotocoagulation (TSCPC) is a cyclodestructive procedure that uses continuous diode laser to target the ciliary body in order to reduce the production of aqueous humor. Traditional TSCPC may be associated with serious complications including uveitis, vision loss, chronic hypotony, and rarely phthisis bulbi and sympathetic ophthalmia [3–7]. Due to the risks of serious complications, TSCPC is typically reserved for the treatment of refractory glaucoma or palliation of painful eyes with a very poor prognosis [8]. There has been debate over whether there is a direct correlation between the amount of laser energy used and the rate of complications. Some studies have shown that higher energy leads to higher complication rates, while others have demonstrated that the risk of complications is more affected by the underlying type of glaucoma [7, 9, 10]. Concerns regarding postoperative complications must be balanced with concerns for overall efficacy, as studies have shown that mean IOP reduction is strongly correlated with the number of delivered laser burns [11].

Diode laser cyclophotocoagulation emits light near the infrared spectrum at 810 nm, which is strongly absorbed by melanin. The TSCPC is designed to target the melanin in the pigmented ciliary body epithelium, thereby decreasing the rate of aqueous production. Traditionally, this has been performed using a continuous delivery of laser energy. While this

technique was found to be safer than cryodestruction, the continuous mode has been shown to cause significant collateral tissue damage to adjacent non-pigmented structures including the ciliary stroma and ciliary muscle [12]. The non-selective targeting feature of cyclodestruction is thought to contribute to higher rates of postoperative complications, including prolonged inflammation and hypotony, as compared with other glaucoma procedures.

More recently, a micropulse delivery mode of diode laser (Micropulse TSCPC, MP-TSCPC, IRIDEX IQ810 Laser Systems, Mountain View, CA; Fig. 1) has been used to treat glaucoma by ablating the ciliary processes and reduce aqueous humor production with more selective targeting and less collateral damage [13]. The micropulse delivery mode includes "on" and "off" cycles, allowing energy to build up in the targeted pigmented tissues, eventually reaching the coagulative threshold. The adjacent non-pigmented structures have time to "cool off" during the "off" cycle, thus never reaching the coagulative threshold, which minimizes collateral tissue damage [13].

Only a few studies have described the outcomes of this novel treatment for glaucoma. They showed micropulse transscleral cyclophotocoagulation (MP-TSCPC) to have comparable efficacy with fewer side effects when compared with traditional continuous wave mode diode laser delivery [13, 14]. This more favorable side effect profile has the potential to make MP-TSCPC an earlier therapeutic option instead of reserving it for end-stage refractory eyes.

Methods

Patients with advanced glaucoma from the Glaucoma Service at Wills Eye Hospital who underwent MP-TSCPC from July 2014 through February 2015 were included in this retrospective study. Intra-operatively, the patients received a retrobulbar block of a 1:1 mixture of carbacaine and marcaine at the beginning of the case. The IQ810 Iridex Laser settings were programmed as follows: power—2000 mW, micropulse "ON" time—0.5 ms, micropulse "OFF" time—1.1 ms, and duty cycle (proportion of each cycle during which the laser is on)—31.33 %.

The laser probe was then applied in a continuous sliding or "painting" motion from 9:30 to 2:30 and from 3:30 to 8:30. The 3 and 9 o'clock positions were bypassed to avoid damage to ciliary neurovascular structures, as is standard technique with traditional continuous wave TSCPC. The laser was delivered over 360° for 100–240 s at the physician discretion (e.g., adjusting treatment duration based on iris color).

The following baseline parameters were recorded for each patient: age, gender, race/ethnicity, glaucoma diagnosis, preoperative IOP, number of glaucoma medications prior to surgery, and preoperative best corrected visual acuity (BCVA).

Data was then collected from each patient's subsequent postoperative visits, including BCVA, IOP, number of glaucoma medications, pain level, and presence of complications. Surgical success was defined as an IOP of 6–21 mmHg or a reduction of IOP by 20 %. Failure was defined as an inability to meet the aforementioned criteria for success or a need for incisional glaucoma surgery.

Results

A total of 19 patients underwent the MP-TSCPC treatment and were included in our study. The mean age was 71.2 years, and the patients were predominantly female ($n = 11$, 58 %). The demographic and clinical characteristics of the study patients are shown in Table 1. The mean follow-up was 60.3 days. Seven patients underwent anterior chamber paracentesis following application of the laser under sterile technique using a 30-g needle for short-term IOP control.

Mean IOP dropped from 37.9 mmHg preoperatively to 22.7 mmHg at last follow-up, representing a 40.1 % decrease. Mean number of glaucoma medications decreased from 2.6 preoperatively to 1.9 postoperatively. There was a 73.7 % ($n = 14$) success rate for initial treatments. Three patients (15.8 %) underwent a second treatment, increasing the overall success rate to 89.5 % ($n = 17$).

There was a 10.5 % ($n = 2$) failure rate. One patient, diagnosed with primary open-angle glaucoma, failed due to

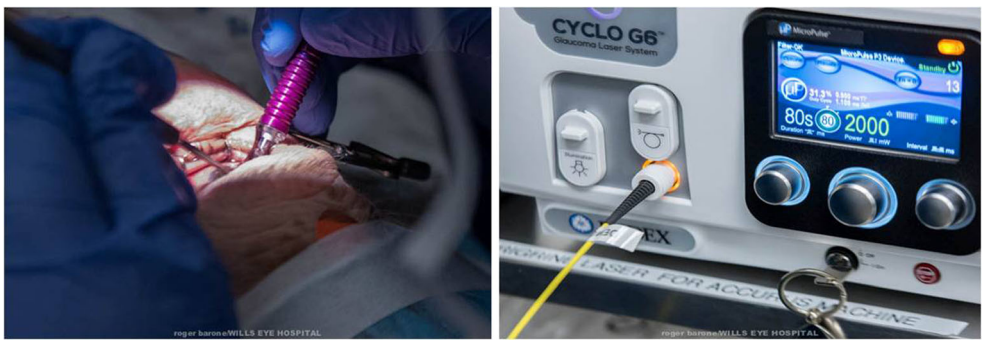

Fig. 1 *Right panel*: micropulse transscleral cyclophotocoagulation performed using the MP3 probe. *Left panel*: the IQ810 Iridex Laser machine is shown with the settings used (2000 mW power and 31.3 % duty cycle). Courtesy: Roger Baron, Wills Eye Hospital

Table 1 Demographic and clinical characteristics of the patients included in the study

Variable	Data ($N = 19$)
Age (years) (SD)	71.2 (±12.5)
Gender: *n* (%)	
Male	8 (42 %)
Female	11 (58 %)
Race: *n* (%)	
Caucasian	11 (57.9 %)
African-American	5 (26.3 %)
Hispanic	2 (10.5 %)
Asian	1 (5.3 %)
Diagnosis	
Primary open-angle glaucoma	5 (26.3 %)
Secondary open-angle glaucoma	6 (31.6 %)
Primary angle-closure glaucoma	5 (26.3 %)
Neovascular glaucoma	3 (15.8 %)
Intraocular pressure (mean)	
Baseline (mmHg)	37.9
Last visit (mmHg)	22.7
Reduction (%)	40.1 %

elevated IOP, which required incisional glaucoma surgery. Another patient with pseudoexfoliation glaucoma, failed due to clinically significant hypotony. No patient reported pain greater then "mild," and all subjective reports of pain had resolved by postoperative week 1. No patient lost light perception vision. Four patients gained one line of vision, and four patients lost one line of vision. Visual acuity of the remaining patients remained unchanged. The only complication was corneal edema, which occurred in one patient (5.3 %).

Discussion

Traditionally, TSCPC is reserved for end-stage glaucoma due to the high rate of serious complications. Micropulse delivery allows energy to build up to the coagulative threshold in targeted pigmented tissues during the "on" cycles. It also allows adjacent non-pigmented tissue to cool during the "off" cycle. This minimizes collateral tissue damage, resulting in fewer complications without sacrificing efficacy [6, 7].

Our preliminary experience with MP-TSCPC demonstrated comparable efficacy to traditional TSCPC with a 40.1 % reduction in IOP at last follow-up. This rate is comparable to other published reports on MP-TSCPC [14]. There was one case (5 %) of hypotony and one case (5 %) that required glaucoma surgery. Patients tolerate the procedure very well, and no one had subjective pain beyond the first week postoperatively. There were no cases of prolonged inflammation or phthisis bulbi. The results of this study suggest an improved safety profile in comparison with the traditional TSCPC. This improved safety profile makes subsequent treatments a more reasonable option for patients. This series is limited by both its retrospective nature and by its small sample size. Moreover, the paracentesis performed in some patients could have been a confounding factor. Prospective evaluation of the MP-TSCPC is warranted and is currently underway.

Compliance with ethical standards

Funding Iridex Corporation provided the laser platform used in this study.

Ethical approval All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. For this type of study (retrospective chart review), formal consent is not required.

Conflict of interest Drs. Moster, Kuchar, and Waisbourd received research support from Iridex. Dr. Moster is a consultant for Alcon, Allergan, Solx, and Merck; was an expert testimony case witness in 2013; has grants from Aerie, Aeon, New World Medical, Alcon, Glaukos, and Bausch and Lomb; and receives payment for lectures from Alcon, Allergan, Ista, Merck, Bausch and Lomb, New World Medical, TBI, and Solx. Courtney Reamer has no conflicts of interest to declare.

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