Outcome of Micropulse Laser Transscleral Cyclophotocoagulation on Pediatric Versus Adult Glaucoma Patients

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Purpose: To study and compare the outcome of micropulse transscelral cyclophotocoagulation in pediatric glaucoma patients to that in adult glaucoma patients.

Methods: Consecutive pediatric and adult patients who received micropulse transscelral cyclophotocoagulation between July 2015 and December 2016 at University of California, San Francisco were retrospectively analyzed. All cases had at least 12 months of follow-up.

Results: Nine eyes from 9 pediatric patients and 27 eyes from 25 adult patients were included. The sample size in pediatric group is small because MP-TCP was not offered to pediatric patients after unsatisfactory results in initial cases. Preoperatively, the mean intraocular pressure (IOP) was 28.41 ± 8.32 mm Hg in adult patients and 34.28 ± 9.92 mm Hg in pediatric patients. Postoperatively, the mean IOP in adult patients significantly decreased at all follow-up points ($P < 0.001$). In pediatric patients, the mean IOP decreased to 20.44 ± 13.41 mm Hg at 1 month ($P = 0.021$), 23.56 ± 10.10 mm Hg at 3 months ($P = 0.093$), 23.00 ± 8.31 mm Hg ($P = 0.018$) at 6 months, and 27.20 ± 15.68 mm Hg ($P = 0.15$) at 12 months. No significant complications were noted in either group. The success rate in adults was 72.22% versus 22.22% in pediatric patients at 12 months ($P = 0.02$). Seven of 9 pediatric patients required reoperation during the 12 months of follow-up.

Conclusions: Micropulse transscelral cyclophotocoagulation is a safe procedure for pediatric as well as adult glaucoma patients. Its effect seems to be short lived in pediatric patients and the rate of reoperation was high.

Key Words: pediatric, transscleral, micropulse laser, minimally invasive

(*J Glaucoma* 2017;26:936–939)

Pediatric glaucoma is well known for its difficulty of management and the outcomes of current treatment options are limited.[1–3] Because of the relatively poor control achieved with medical management, the treatment of pediatric glaucoma is primarily surgical. The first-line surgical option is the angle surgery such as goniotomy and trabeculotomy, followed by tube-shunt implantation.[4] Cyclodestructive procedures such as transscleral cyclophotocoagulation (TSCPC) is an option when the first-line surgeries fail, but the severe postoperative complications including significant inflammation, retinal detachment, and choroidal detachment have led to its limited indication.[5]

The recently developed micropulse mode of laser emission can finely control the thermal elevation by separating a continuous-wave beam into repetitive short pulses.[6–8] This pulsatile nature allows the surrounding tissue to cool-off between the pulses, resulting in minimal collateral damage and prevention of necrosis.[9–11] Micropulse TSCPC (MP-TSCPC) is a new procedure that combines micropulse technique with traditional TSCPC. The transmitted energy of the laser is highly absorbed by pigmentary epithelium in ciliary bodies and trabecular meshwork.[12] This, combined with the micropulse laser's gentler mode of action, has led to the current view that MP-TSCPC targets ciliary and trabecular meshwork epithelial cells to reduce aqueous humor production with relative sparing of surrounding tissues and possibly enhance uveoscleral outflow through increased extracellular space.[13,14]

In past clinical studies, MP-TSCPC showed promising results for adult glaucoma patients; it offered satisfactory intraocular pressure (IOP) lowering and a decreased rate of complications compared with the traditional continuous-wave TSCPC.[15–17] Intuitively, we would extend MP-TSCPC treatment to pediatric glaucoma patients given its minimally invasive nature and safety profile. Currently, there has not been a study examining the effect of MP-TSCPC in pediatric cases of glaucoma.

Herein, we performed a retrospective study on the consecutive pediatric glaucoma patients who were treated with MP-TSCPC. To test the hypothesis that the effect of MP-TSCPC in pediatric cases would be comparable with that in adult cases, the clinical outcomes for consecutive adult glaucoma patients who received MP-TSCPC during the same time period were also examined and summarized. The relevant factors that may affect the outcome were further discussed.

MATERIALS AND METHODS

This was a retrospective observational study involving consecutive adult and pediatric glaucoma patients who underwent MP-TSCPC at the University of California, San Francisco (UCSF) glaucoma clinic between July 2015 and December 2016. This study was approved by the UCSF Committee on Human Research and upheld the tenets

Received for publication May 17, 2017; accepted July 21, 2017.
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Supported by Research to Prevent Blindness. National Eye Institute, EY00216
Shan Lin is a consultant for Allergan (global headquarters in Dublin, Ireland and US Administrative Headquarters in Parsippany, NJ), Aerie Pharmaceuticals (Irvine, CA and Bedminster, NJ), and ALeyeGN Technologies, LLC (Los Altos, CA).
Disclosure: The other authors have no conflict of interest to declare.
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DOI: 10.1097/IJG.0000000000000757

Declaration of Helsinki. All adult and pediatric patients who needed MP-TSCPC during this period were included in the study. Patients who did not have at least 12 months of follow-up were excluded.

The MicroPulse P3 treatment is part of the CYCLO G6 Glaucoma Laser System (IRIDEX Inc., Mountain View, CA) and was used in all subjects. The patients received either a retrobulbar block or general anesthesia. The G6 probe was placed at the limbus with the probe perpendicular to the surface of the globe. Laser settings were 2000 mW with a duty cycle of 31.33%. The laser was applied throughout 180 degrees for over 160 seconds. The same procedure was repeated for the other hemifield.

The following parameters were recorded for each patient: age, sex, glaucoma diagnosis, postoperative complications, preoperative and postoperative IOP, and number of glaucoma medications at 1, 3, 6, and 12 months of follow-up. Additional glaucoma surgeries were recorded for patients who failed to respond to MP-TSCPC treatment. As the IOP after an additional operation did not reflect the effect of MP-TSCPC alone, subjects who underwent reoperation were excluded from the statistical analysis of subsequent follow-up.

Standard of Success

Success was defined as: (1) 5 mm Hg $\leq$ IOP $\leq$ 21 mm Hg and reduced $\geq$20% from baseline at the 12 months of follow-up; (2) no use of oral carbonic anhydrase inhibitors, (3) no loss of light perception vision, and (4) no reoperation for glaucoma within the 12-month follow-up period.

Statistical Analysis

Preoperative and postoperative IOP and the number of glaucoma medications were compared with the Wilcoxon signed rank test. The success rates for pediatric and adult glaucoma patients were compared with the Fisher exact test. Statistical calculations were performed with the SPSS (IBM SPSS Statistics 22.0) with $P < 0.05$ denoting the statistical significance of differences.

RESULTS

A total of 36 eyes of 34 patients, comprised of 9 eyes of 9 pediatric patients and 27 eyes of 25 adult patients, were included in this study (Tables 1, 2). In the adult eyes, 5 (18.5%) had history of corneal transplant, 7 (25.9%) had history of tube-shunt implantation, 12 (44.4%) had history of cataract extraction, and 2 (7%) had history of filtering surgery. The prior surgical history for each pediatric patients is included in Table 2.

In the adult group, the mean pretreatment IOP was 28.41 ± 8.32 mm Hg (range, 18 to 50 mm Hg). The mean IOP at postoperative months (POMs) 1, 3, 6, and 12 were 14.44 ± 6.38 mm Hg (range, 5 to 32 mm Hg, $P < 0.0001$), 18.56 ± 7.66 mm Hg (range, 10 to 43 mm Hg, $P < 0.0001$), 18.62 ± 6.64 mm Hg (range, 12 to 36 mm Hg, $P < 0.0001$), and 18.98 ± 6.45 mm Hg (range, 13 to 32 mm Hg, $P < 0.0001$), respectively. Two patients at POM3 and another patient at POM6 underwent additional glaucoma surgery.

In pediatric cases, the mean pretreatment IOP was 34.28 ± 9.92 mm Hg (range, 24 to 54 mm Hg). At the 1, 3, 6, and 12 months of follow-up, the mean IOPs were 20.44 ± 13.41 mm Hg (range, 4 to 41 mm Hg, $P = 0.021$), 23.56 ± 10.10 mm Hg (range, 6 to 41 mm Hg, $P = 0.093$), 23.00 ± 8.31 mm Hg (range, 8 to 30 mm Hg, $P = 0.018$), and 27.20 ± 15.68 (range, 8 to 50 mm Hg, $P = 0.15$), respectively (Table 2 and Fig. 1). Seven of 9 pediatric patients required reoperation within the 12-month follow-up period.

TABLE 1. Demographic and Clinical Characteristics of Adult Glaucoma Patients

Patient Information	Value
Age (mean ± SD) (y)	60.6 ± 17.7
Sex [n (%)]	
Male	16 (64.0)
Female	9 (36.0)
No. preoperative glaucoma medications (mean ± SD)	3.00 ± 0.92
Diagnosis [n (%)]	
Primary open-angle glaucoma	12 (44.4)
Secondary glaucoma associated steroid	5 (18.5)
Secondary glaucoma after corneal transplant	2 (7.4)
Aphakic glaucoma	1 (3.7)
Neovascular glaucoma	4 (14.8)
Congential glaucoma	2 (7.4)
Secondary glaucoma associated trauma	1 (3.7)

At the 12-month follow-up period, success was achieved in 72.22% (26/36) of the adult patients but only in 22.22% (2/9) of the pediatric patients ($P = 0.02$). In adult cases, the number of medication was 3.00 ± 0.92 preoperatively, then significantly decreased to 2.52 ± 1.12 ($P = 0.013$) at 12 months. However, no significant change was found in the pediatric cases (1.89 ± 0.60 vs. 2.00 ± 1.00, $P = 0.564$).

At day 1 after the procedure, 65% patients had mild postoperative inflammation in terms of anterior chamber cells with slight conjunctival hyperemia. This resolved in 2 to 4 weeks time. No complications including shallow chamber, choroidal effusion, macular edema, and hyphema were noted in either group.

DISCUSSION

In this retrospective study, we reviewed and compared the clinical outcomes of MP-TSCPC in pediatric glaucoma patients with that of adult glaucoma patients. To our knowledge, this is the first study to investigate the effect of MP-TSCPC in pediatric glaucoma patients. At 12 months, the rate of success in the pediatric group was significantly lower than in the adult glaucoma patients. In Addition, the number of medications at the 12 months of follow-up was decreased significantly in adult patients but not in pediatric patients. Seven of 9 pediatric patients needed reoperation within 12 months of MP-TSCPC. The unsatisfactory results in initial cases led to decreased application of this procedure in pediatric patients during the study period.

The results of this study for the adult glaucoma patients correspond well with those of previous studies.[15–17] Tan et al[16] found MP-TSCPC comparable with conventional TSCPC with potentially lower rate of complication; Aquino et al[17] concluded that MP-TSCPC had similar efficacy to continuous-wave TSCPC with lower incidence of vision-threatening complications and more predictable effect on the IOP. The current study corroborates the conclusion that MP-TSCPC is a relatively safe and effective method of reducing IOP in adult glaucoma patients. No vision-threatening complications were noted, and mean IOP was decreased significantly by 33% at 12 months.

However, the outcomes in the pediatric group were not as promising as in the adult group. Although MP-TSCPC

TABLE 2. Demographic Characteristics and Clinical Outcomes of Pediatric Glaucoma Patients

Patient	Sex	Age (y)	Preoperative IOP (mm Hg)	Diagnosis	Prior Surgeries	IOP at POM1 (mm Hg)	IOP at POM3 (mm Hg)	IOP at POM6 (mm Hg)	IOP at POM12 (mm Hg)	Outcome
1	F	4	29	Sturge-Weber syndrome	None	31	29.5	20	20	Failure: GATT at POM3
2	F	1	25	Sturge-Weber syndrome	None	5	19	16	18.5	Success
3	M	1.3	24	Persistent hyperplastic primary vitreous	None	4	6	8	8	Success
4	F	1	42	Primary congenital glaucoma	None	37	6	9	10	Failure: AGV at POM1
5	M	4	38.5	Aphakic glaucoma	DSAEK Lensectomy	41	41	30	9	Failure: ECP plus at POM6
6	F	1.7	26	Aphakic glaucoma	Lesectomy	14	27	22	31.5	Failure: AGV at POM12
7	M	4	54	The Peter anomaly	AGV	17	25	27	50	Failure: TSCPC at POM12
8	M	17	31	Sturge-Weber syndrome	Molteno Lensectomy	22.5	23	28	16	Failure: AGV at POM6
9	M	14	39	Sturge-Weber syndrome	AGV	12.5	18	30	28	Failure: scheduled for AGV

AGV indicates Ahmed glaucoma valve; DSAEK, descemet's stripping automated endothelial keratoplasty; ECP, endoscopic cyclophotocoagulation; F, female; GATT, gonioscopy-assisted transluminal trabeculotomy; IOP, intraocular pressure; M, male; POM, postoperative month; TSCPC, transscleral cyclophotocoagulation.

FIGURE 1. Mean IOP before and after MP-TSCPC. The mean IOP for adult group is significantly decreased from the baseline at all points up to 12 months of follow-up. The mean IOP for pediatric group is significantly decreased from the baseline only at 1 and 6 months of follow-up. †IOP was statistically significant decreased from baseline in pediatric group ($P < 0.05$). *IOP was statistically significant decreased from baseline in adult group ($P < 0.05$). IOP indicates intraocular pressure; MP-TSCPC, micropulse transscleral cyclophotocoagulation; POM, postoperative month.

significantly decreased the mean IOP at postoperative months 1 and 6 in the pediatric group, the effect was short lived. By 12 months, the mean IOP did not differ significantly from the baseline. Moreover, 7 of 9 pediatric patients required reoperation to control IOP throughout the follow-up period.

There are several potential reasons for the low success rate in pediatric patients. First, the ciliary body of children may regenerate more rapidly than that of adults, which may account for the relatively quick rebound in IOP.[18–22] Second, the contact probe of MP-TSCPC is designed to be located precisely 3 mm from the limbus. The location of ciliary body in pediatric eyes may vary and the target location for MP-TSCPC could be different from that of adults.[23] Third, the patients in our case series reflect the nature of pediatric glaucoma, which is a mixture of diseases with different etiologies.[2] This diversity may have negatively influenced the success rate of MP-TSCPC.

In comparison with the MP-TSCPC, traditional cyclodestructive procedures such as TSCPC and endocyclophotocoagulation have been shown to yield success rate of 67% and 43%, respectively in pediatric glaucoma patients.[24–26] The result of our study suggests that for the simple reduction of IOP, MP-TSCPC may not be as effective as traditional TSCPC. Nonetheless, the vision-threatening complications associated with TSCPC can be prohibitive, especially in pediatric case. We did not notice any significant complications after MP-TSCPC in either pediatric or adult group in this study during 1-year of follow-up. Given its relatively low risk, MP-TSCPC could be applied in pediatric glaucoma with the provider being aware of its short-lived effect. It may serve adequately as bridge treatment while the patient waits for a more definite treatment.

There are several limitations to this study. First is the small size of the sample. Only 9 pediatric cases are reported in the case series. After the unsatisfactory results from initial cases, we thought that it was unethical to offer MP-TSCPC before attempting more definitive procedures with higher likelihood of long-term success. Second, we have not attempted repeat MP-TSPC application, whereas past literature has shown that the additional application of

MP-TSCPC can increase the rate of success in adult patients who did not respond to the first application.

In conclusion, MP-TSCPC is a safe procedure in pediatric and adult glaucoma patients, but the IOP reduction does not last long in pediatric patients. Given its safety profile, it could be considered as a bridge treatment in certain cases or used with caution in refractory pediatric glaucoma after established procedures have failed until further studies.

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