

New perspectives in the use of laser diode transscleral cyclophotocoagulation. A prospective single center observational cohort study

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Abstract

Purpose: The paper intends to present the results of using new methods of a new generation diode laser transscleral cyclophotocoagulation (TSCPC) in patients with different types of glaucoma. **Patients, Materials and Methods:** There have been treated 53 eyes from 59 patients with glaucoma refractory to medical, laser or surgical treatment. We have used the newest generation of 810 nm wavelength diode laser. There have been used two protocols of continuous-wave diode laser emitting radiation for cyclophotocoagulation. The first technique – the standard cyclophotocoagulation (high power and low exposure duration) – has been used for the eyes with limited visual function [visual acuity (VA) extremely low or eyes disorganized]. The second technique – slow coagulation, also named "slow burn" (lower power and greater exposure duration) – has been used for the eyes with apparently better visual prognosis ($VA \geq 20/400$). For evaluation, we followed both subjective parameters (eye pain decrease) and objective parameters [intraocular pressure (IOP) lowering and VA evolution]. Patients have been evaluated before laser intervention and postoperative at one, three and six months. **Results:** IOP has significantly decreased in both patient groups. In the eyes with better visual function ($VA \geq 1/20$), where we have used the "slow coagulation" technique, we found no decrease of VA. Eye pain has disappeared in almost all treated cases. **Conclusions:** The diode laser TSCPC is an efficient method of lowering IOP and decreasing eye pain. The "slow burn" technique has been shown its efficiency for extending the indications of cyclophotocoagulation also in glaucomatous eyes with better functional prognosis.

Keywords: diode laser transscleral cyclophotocoagulation, refractory glaucoma, "slow burn" technique.

Introduction

Since 1930, there has been a trend in reducing the intraocular pressure (IOP) in certain forms of glaucoma, by using the procedure of the destruction of the ciliary body epithelium that generates aqueous humor. Several procedures were used for cyclodestruction, such as penetrating cyclodiathermy [1], cyclocryotherapy [2], ultrasonic ablation of the ciliary body [3], and surgical ablation of the ciliary body [4]. Although at times successful, these procedures resulted in high rates of hypotony and other complications. Laser cyclophotocoagulation seemed to be a better method to selectively destroying the ciliary processes and during years the clinicians had switched off from xenon arc photocoagulator [5] to neodymium-doped yttrium aluminum garnet (Nd:YAG) 1064 nm lasers [6] reaching in the last 20 years the solid-state diode lasers 810 nm [7].

Our paper intends to present the results of using new methods of a new generation of diode laser transscleral cyclophotocoagulation (TSCPC) in patients with different types of glaucoma.

Patients, Materials and Methods

We present data from an observational study, which underwent in the Department of Ophthalmology of the "Metropolitan" Hospital of Bucharest, Romania, between January 2013–March 2015. The study was approved by the local Ethics Committee. We explained the patients the benefits and risks of TSCPC procedure. All patients signed the informed consent for the laser procedure. TSCPC was performed after retrobulbar anesthesia with 5 mL of 4% Lidocaine. The inclusion criteria comprised patients with refractory glaucoma (failed filtering surgery, uncontrolled IOP despite maximum medications, neovascular glaucoma, traumatic glaucoma, inflammatory glaucoma, silicone oil-induced glaucoma) with IOP over 35 mmHg and ocular pain. We excluded patients less than 18 years and patients who refused to sign the informed consent.

We have used the newest generation of 810 nm wavelength Iridex diode laser. There have been used two protocols of continuous-wave diode laser emitting radiation for cyclophotocoagulation.

The standard cyclophotocoagulation (high power and low exposure duration) has been used for the eyes with limited visual function [visual acuity (VA) extremely low or structurally affected eyes, such as opaque corneas], respectively the low coagulation (lower power and greater exposure duration) has been used for the eyes with apparently better visual prognosis ($VA \geq 20/400$).

The treatment consisted of multiple laser applications through a special probe (G-Probe™) patented by Iridex.

The laser radiation is absorbed by the melanin in the ciliary body and the ciliary processes. All consecutive applications are situated by one-half the width of the footplate. Routinely, three quadrants are treated by applying the laser probe (6–7 applications per quadrant) over 270° and usually omitting the temporal quadrant. If one needs to retreat, a safe rule is to begin the retreatment 45° from the initial treatment (the next 270° treatment will coat a half of the untreated quadrant, plus two and a half quadrants from the previous treatment).

The standard technique applied the following starting parameters: continuous mode with power 1750–2000 mW and exposure time 2000 ms [8], which are the equivalent of 3.5–4 J/application (eyes with darker pigmentation require less intensity to achieve corresponding results). The regulation of power is made in 250 mW steps: if there are excessive “pops” during the application (adjust downward) or not (adjust upward) (“pops” denote the status that the power is too high, which makes cellular water boil during utilization).

All patients had been treated with topical steroids and non-steroids for two to three weeks after the procedure and the glaucoma drugs had not been discontinued for the same period of time.

For evaluation, we followed both subjective parameters (eye pain decrease) and objective parameters (IOP measurements and best-corrected VA). All Snellen VA data were converted to logarithm of the minimum angle of resolution (*logMAR*) equivalents for the purpose of analysis. Patients have been evaluated before laser intervention and postoperative at one, three and six months.

Patient data were stored in a Microsoft® Office Excel 2010 database, respecting personal information security in order not to moral or financial harm the study members, patients or the hospital.

The normality of continuous variables distributions was checked by the Shapiro–Wilk test. Depending on Shapiro–Wilk test results, statistical analysis to evaluate changes from baseline was performed using the paired-samples *t*-test for the IOP and the Wilcoxon signed-rank test for the VA. Analysis was performed using the Statistical Package for the Social Sciences (SPSS) software (IBM® SPSS® Statistics, ver. 20).

Results

We included in our study 53 eyes from 59 patients according inclusion criteria. All patients completed all postoperative visits. Mean age at time of cyclophotocoagulation procedure was 64.28 ± 10.63 years. 56.6% of patients were males.

We divided the selected cohort into two groups – group 1, to which we performed the standard technique and group 2, to which we performed the “slow burn”

technique. In Figure 1, we present the study flow chart, according to *Consolidated Standards of Reporting Trials* (CONSORT) recommendations.

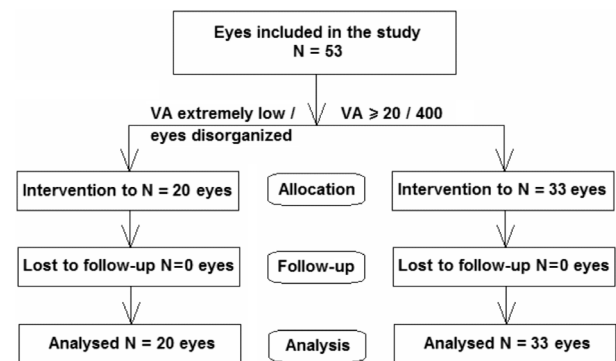


Figure 1 – Study flowchart, according to CONSORT recommendations. CONSORT: Consolidated Standards of Reporting Trials; N: No. of eyes; VA: Visual acuity.

In the group 1, we included 20 eyes. Preoperative IOP ranged from 39 to 65 mmHg, with a mean IOP of 49.7 ± 6.952 mmHg. VA, being very low, was not considered in the statistical analysis for those patients.

IOP evolution in the group 1 after standard TSCPC procedure is shown in Figure 2. The IOP was significantly reduced compared to preoperative values. The mean values of IOP were 17.55 ± 4.419 mmHg ($p < 0.0001$) at one month postoperatively, 19.75 ± 4.93 mmHg ($p < 0.0001$) at three months postoperatively and 19.7 ± 5.564 mmHg ($p < 0.0001$) at six months postoperatively. Fourteen eyes of 20 had IOP equal or less than 21 mmHg at the 6-month postoperative visit.

In the group 2, we included 33 eyes. Preoperative IOP ranged from 34 to 59 mmHg, with a mean IOP of 47.58 ± 6.25 mmHg. Preoperative VA ranged from 1.3 *logMAR* to 0.7 *logMAR*, with a mean VA of 1.164 ± 0.2089 *logMAR*.

IOP change according to follow-up evaluations is shown in Figure 3. Compared to pretreatment values, the IOP had fallen significant to mean values of 16.55 ± 3.692 mmHg ($p < 0.0001$) at one month postoperatively, 17.27 ± 3.685 mmHg ($p < 0.0001$) at three months postoperatively, respectively of 17.97 ± 4.081 mmHg ($p < 0.0001$) at six months postoperatively. At the 6-month postoperative evaluation, 29 eyes of 33 had IOP equal or less than 21 mmHg.

VA did not vary significantly in any of postoperative visits at one month ($p > 0.67$), three months ($p > 0.60$) and six months ($p > 0.05$). However, at the 6-month postoperative evaluation, VA was preserved or better in 31 eyes, with a mean VA of 1.13 ± 0.2158 *logMAR*.

The eye pain had disappeared in almost all treated cases. Two eyes of 20 in the group 1 and two eyes of 33 in the group 2 complained of ocular discomfort or pain at the 6-month postoperative visit. In these cases, the postoperative IOP decrease was not adequate, requiring reintervention.

Discussions

The main indication for TSCPC is the refractory glaucoma (failed filtering surgery, uncontrolled IOP despite maximum medication, neovascular glaucoma, traumatic glaucoma, inflammatory glaucoma, silicone oil-

induced glaucoma). The classical indication is referring to eyes with minimal visual potential. The benefits of TSCPC are: no incision and obviously low risk of infection, it can be performed immediately (in the operating room or in the office), no need to stop anticoagulants, rapid onset, repeatable, does not limit further surgical options [9]. The risks of TSCPC are: pain (intraoperative and in the first 48 hours), hyphema and/or fibrinous reaction in the anterior chamber, hypotony/phthisis bulbi, cataract and sympathetic ophthalmia. The most feared risk of TSCPC

is the possibility of decreasing VA due to: chronic post-operative inflammation, cataract, cystoid macular edema, neurotrophic cornea (corneal nerves damage) and infections associated with neurotrophic ulcers. This adverse effect had restricted for a long time the usage of TSCPC to patients with very low VA. All these aspects appeared to be more likely in eyes with preexisting poor vision [10]. The TSCPC influence on VA should be treated in comparison with the probable deterioration that would come in the absence of surgical procedure.

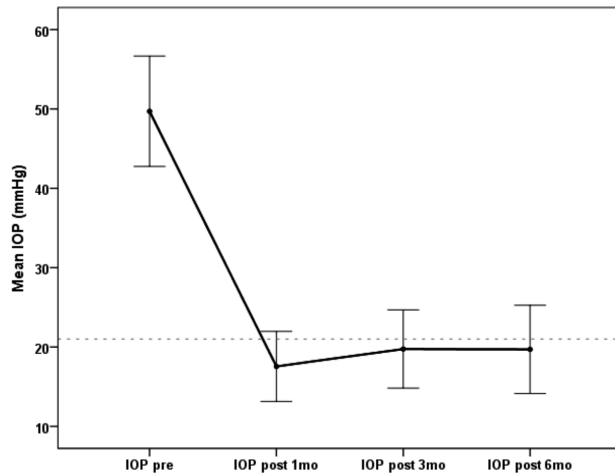


Figure 2 – Intraocular pressure (IOP) after TSCPC treatment, “standard technique” in the group 1 (error bars represent ± 1 standard deviation). The horizontal broken line represents the IOP of 21 mmHg. The decrease of IOP at all post-operative evaluations was statistically significant ($p < 0.0001$). TSCPC: Transscleral cyclophotocoagulation; mo: Month(s).

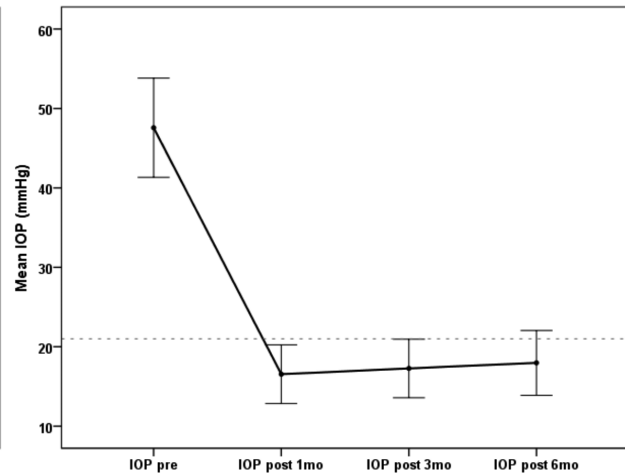


Figure 3 – Intraocular pressure (IOP) after TSCPC treatment, “slow coagulation technique” in the group 2 (error bars represent ± 1 standard deviation). The horizontal broken line represents the IOP of 21 mmHg. The decrease of IOP at all post-operative evaluations was statistically significant ($p < 0.0001$). TSCPC: Transscleral cyclophotocoagulation; mo: Month(s).

The slow coagulation technique has several advantages comparative with the standard TSCPC: it extends indications in patients with better vision, it reduces intraoperative discomfort, it reduces tissue disruption and it reduces the postoperative inflammatory response. There have been published studies about the nondestructive effect on VA of this method [11–13].

We should mention a study [14] that demonstrates that TSCPC is associated with an acute occlusive vasculopathy.

The effects of TSCPC on aqueous secretion are variate [15]. It is generally reported that an important mechanism of aqueous suppression after TSCPC is represented by the coagulative necrosis damage to the secretory ciliary epithelium successive to laser energy absorption by the pigmented ciliary epithelium [16]. Additional results are produced by ischemia; some vascular lesions occur after the propagation of laser energy from the ciliary epithelium to proximate vessels in the ciliary processes or from tissue destructions (“pops”). Tissue destruction may produce collateral disruption that combines the results of different vascular obstructions and variances in clinical efficacy may be partly demonstrated by inequalities in lesions, regeneration, and reperfusion of the ciliary process [15]. During the transition of 810 nm diode laser energy through the wall of the eye during TSCPC, only about 35% is displaced to the ciliary epithelium, the rest being absorbed or reflected [17]. This process calls for higher overall energy delivery and the extra laser absorption may produce other collateral damages in proximate structures,

such as blood vessels in the ciliary body or ciliary processes bringing potentially large ischemic lesions to ciliary epithelium. TSCPC represents both an inflow and outflow procedure [18]. The authors [18] suggested that TSCPC produces lesions to the ciliary body that renders it “leaky”, concurring an augmentation in non-conventional outflow, corresponding with the ocular hypotensive mechanism of prostaglandin analogue glaucoma medications. In addition, some authors [15] noted that aggressive forms of ciliary ablation can produce cyclodialysis clefts, and small ciliary clefts generate effects of more gentle forms of ciliary body treatment. Some authors avoided previous forms of cycloablation, due to the probability of phthisis or hypotony and it is widely accepted that such complications are produced by total ciliary epithelial ablation. This seems improbable in view of clinical studies made at endoscopic treatment after previous forms of cyclophotocoagulation (including TSCPC), concluding that frequent ciliary processes had been left completely untreated, and in view of histopathological studies of enucleated human eyes following TSCP demonstrating that the treatment had frequently completely missed the *pars plicata* [16, 19].

☞ Conclusions

The diode laser TSCPC is an efficient method of lowering IOP and decreasing eye pain. The “slow coagulation” technique has been shown its efficiency for extending the indications of cyclophotocoagulation also in glaucomatous eyes with better functional prognosis.

Conflict of interests

The authors declare that they have no conflict of interests.

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