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IMMEDIATE AND LONG-TERM RESULTS OF MICROPULSE DIODE LASER CYCLOPHOTOCOAGULATION IN PATIENTS WITH REFRACTORY GLAUCOMA

Boboev Saidavzal Abdurakhmanovich
Candidate of Medical Sciences, Head of the Ophthalmology Department, Samarkand State M

Boboev Siyovush Saidavzalzoda
Ph.D. Candidate, Department of Ophthalmology, Samarkand State Medical University

Z. M. Toshtemirova
6th year student of the Faculty of Medicine, Samarkand State Medical University

Abstract: This study investigates the efficacy and safety of micropulse transscleral cyclophotocoagulation (mCPC) in the treatment of refractory glaucoma, a severe form of glaucoma that resists conventional therapies. Refractory glaucoma patients often face complications such as persistent pain, elevated intraocular pressure (IOP), and visual impairment, despite maximum medical therapy. The study included 60 patients (aged 52–74) who underwent mCPC, following a dynamic observation period of 1 to 2 years. The primary aim was to reduce IOP and alleviate pain while minimizing postoperative complications. The laser treatment was applied in micropulse mode to avoid overheating and tissue damage. The results indicated a significant reduction in IOP and pain relief, with no severe complications. This procedure is a safe, minimally invasive alternative for patients who fail to achieve IOP control through conventional treatments.

Keywords: refractory glaucoma, micropulse transscleral cyclophotocoagulation, mCPC, intraocular pressure, laser treatment, glaucoma surgery, neovascular glaucoma, pain relief, ophthalmology, cyclophotocoagulation techniques.

Relevance of the Problem. Glaucoma is one of the most prevalent eye diseases, leading to visual impairment and blindness worldwide [5, 13]. One of its most severe forms is refractory glaucoma, for which traditional treatment methods are often ineffective. A widely utilized surgical technique for this type of glaucoma is contact transscleral diode laser cyclophotocoagulation (tCPC). However, this procedure is associated with a considerable number of complications, such as ciliary body (CB) atrophy, subatrophy of the eyeball, vitreous hemorrhage, hyphema, and retinal detachment, which restricts its use primarily to patients in the terminal stages of the disease [4, 6].

The limitations of conventional CPC have prompted the development of a novel approach—micropulse transscleral cyclophotocoagulation (mCPC). This method employs a specially designed probe to deliver a series of short pulses of laser energy, with a wavelength of 810 nm, to the ciliary body, alternating with off phases, which reduces the risk of overheating, excessive tissue destruction, and lowers the incidence of complications [11, 12, 14, 15].

Despite advancements in medication, laser, and surgical treatments for glaucoma, these do not always guarantee vision restoration. The number of cases of low vision and blindness continues to rise [5, 9, 18, 19]. Prolonged use of ocular hypotensive medications, such as beta-blockers and prostaglandins, frequently leads to damage to the conjunctival and corneal tissues, often resulting in dry eye syndrome [1]. One of the advantages of mCPC is its minimal invasiveness, absence of significant intraoperative and postoperative complications, and the possibility of repeat procedures in an outpatient setting [8, 15, 21].

The aim of this study is to examine both the immediate and long-term outcomes of the effectiveness of laser mCPC in patients with refractory glaucoma.

Materials and Methods. The clinical studies were conducted at the Department of Ophthalmology of the Multidisciplinary Clinic of Samarkand State Medical University and at the "A.A. Yusupov" Eye Center. The patients included in the study were under dynamic observation for 1 to 2 years prior to undergoing micropulse transscleral cyclophotocoagulation (mCPC) (1.3 ± 0.8 years). The age of the patients ranged from 52 to 74 years (65.41 ± 2.3), with 39 women (65%) and 21 men (35%).

Comorbid conditions observed among the patients included coronary heart disease, hypertension, and diabetes mellitus. Prior to and after mCPC treatment, all patients underwent standard comprehensive clinical and ophthalmological examinations. These included an anterior segment assessment using biomicroscopy, visual acuity testing with the standard Golovin-Sivtsev chart, peripheral visual field evaluation using a perimeter, intraocular pressure (IOP) measurement via the Maklakov tonometer or pneumotonometer, and fundus examination through direct and indirect ophthalmoscopy. The anterior segment was further examined using ultrasound biomicroscopy (UBM) with the Sonomed Esclon device (USA), repeatedly during the follow-up period, which spanned from one week to one year. Gonioscopy was performed using a Goldmann three-mirror lens.

To achieve IOP control and stabilize visual and functional parameters, mCPC in micropulse mode was performed on 60 patients with various stages of refractory glaucoma, all of whom had shown a lack of stabilization in the glaucoma process and IOP compensation with maximum hypotensive therapy. These patients also suffered from pain that was unrelieved by analgesics and exhibited intolerance to topical hypotensive medications. The primary cause of pain, reduced visual acuity, and visual field constriction was uncontrolled elevated IOP. It is important to note that reducing IOP to target levels was unattainable through medical treatments alone, often requiring ophthalmologists to adjust the regimen, frequency, and choice of medications. These challenges led to diminished quality of life and increased healthcare costs.

The follow-up period lasted for 6 months, with patients being monitored on days 1, 3, and 7, and subsequently at 1, 3, and 6 months post-treatment.

The objective of this study was to evaluate both the immediate and long-term outcomes of the effectiveness of laser micropulse transscleral cyclophotocoagulation (mCPC) in patients with refractory glaucoma.

The technique of performing MITSCPC involves treating the surgical field with Betadine solution three times in the operating room. Anesthesia is administered via three applications of 1% Alcaine solution on the episclera with intervals of 3–4 minutes, followed by a retrobulbar injection of 2% lidocaine solution, and the use of an eyelid retractor. Laser photocoagulation of the ciliary body with a microimpulse diode laser (“SubCyclo Supra – 810”) was performed 4 mm from the limbus in the projection of the pars plana. The energy level ranges from 1600 mW to 2000 mW, most commonly 2000 mW. The laser probe is moved along the upper and lower limbus following a 180° or 360° meridian, avoiding the 3 o'clock and 9 o'clock positions to prevent damage to the ciliary body's neurovascular structures [16]. The duration of one session varies from 100 seconds to 360 seconds. After the procedure, 1% Pred Forte solution was prescribed (1 drop twice daily), along with Diclofenac solution (1 drop three times daily) to control inflammation.

Patients tolerated the procedure painlessly and comfortably, with only a few reporting a burning sensation, foreign body feeling, or mild warmth in the area of the laser probe during the procedure.

Results and Discussion: The efficacy of MITSCPC was assessed using several criteria: improvements in the biomicroscopic picture of the anterior segment, intraocular pressure (IOP) status, elimination of pain, and reduction in the hypotensive treatment regimen. The most informative and objective clinical sign of IOP reduction after MITSCPC is the clearing of the corneal epithelium. Biomicroscopy of the anterior segment on the first day after the intervention showed a sharp reduction in corneal edema and a decrease in the degree of limbal vessel injection in 40 of the 60 eyes (66.6%). This was attributed to the effect of laser radiation on the ciliary body processes, which led to a reduction in aqueous humor production and increased drainage system surface area due to the opening of the anterior chamber angle. The thinning of the ciliary body resulted in increased uveoscleral outflow of aqueous humor.

In patients with refractory glaucoma, IOP dropped from 40.0–46.0 to 18.0–26.0 mm Hg immediately the next day after MITSCPC, representing a reduction of 18–20 mm Hg (47.6%). After 10 days, the IOP ranged from 18.0 to 22.0 mm Hg. A month later, the IOP slightly increased, fluctuating between 19.0 and 24.0 mm Hg. In the following two months, the indicators remained stable with a slight downward trend, reaching 18.0–22.0 mm Hg by the 6th month. After one year, we observed stabilization of IOP within the range of 7.0–23.0 mm Hg.

In analyzing visual function after the surgery, we noted stabilization of visual acuity and fields in 40% of patients (n=24). Visual acuity improved from 0.06±0.03 to 0.08±0.05, which was statistically significant ($p<0.05$). There was no significant decline in visual acuity during the observation period ($p>0.05$). In terms of visual field indicators, no negative trends were observed in patients over the year following surgery. Positive dynamics were noted in 16.7% (n=10) of patients. After 6 months of follow-up, 3 patients experienced a decline in visual acuity due to progressive cataract opacity. In 2 cases, visual acuity improved by one line on the Golovin-Sivtsev charts.

Almost all patients during the examination the day after the procedure mentioned experiencing pain an hour after the procedure, which subsided by morning, leading to high satisfaction with the procedure. Only one patient reported increased pain, which persisted for three days. This patient underwent a second session of the procedure. We believe that the reduction in eye pain is associated with a decrease in intraocular pressure (IOP), reduced swelling of the iris and ciliary body, and the subsiding of inflammatory processes, which, prior to the procedure, caused severe compression of nerve endings.

In the postoperative period, there was a decrease in the occurrence of reactive iridocyclitis, reactive ocular hypertension, and hyphema. Furthermore, none of the patients showed signs of ocular hypotony, macular edema, or subatrophy of the eyeball.

Ultrasound biomicroscopy revealed a statistically significant deepening of the anterior chamber, on average by 0.8±0.07 mm, with a consistent tendency toward the deblocking of the filtration zone. It is noteworthy that prior to the laser procedure, the ciliary body was hypertrophied, with an average thickness of 0.60±0.50 mm; after the procedure, there was a tendency toward atrophy, and the average thickness was 0.51±0.40 mm. The reduction and atrophy of the ciliary processes are related to the laser radiation's effect on the ciliary body tissue, which leads to decreased aqueous humor production and increased uveoscleral outflow.

In 15 eyes (25.0%), the disappearance of corneal edema allowed for a fundus examination. Expected expansion and deepening of the optic nerve head excavation were noted in all eyes, and in 7 eyes (21.9%), ophthalmic signs of the proliferative phase of diabetic retinopathy with preretinal and epiretinal neovascular membranes were observed.

Before the laser procedure, patients used an average of 2-3 anti-glaucoma medications daily to maintain IOP. The frequent instillation and high cost of these medications negatively impacted patients' quality of life. All anti-glaucoma drugs contain preservatives that adversely affect the ocular surface, leading to the development of dry eye syndrome, which further aggravates the condition for patients. A significant advantage of MITSCPC is that it allowed patients to discontinue local hypotensive drugs in 15% of cases (n=9) after treatment and reduce the use to only one medication in 75% of cases (n=45).

The number of hypotensive drugs used by patients with refractory glaucoma decreased by 52.4% by the end of the observation period, from 3.0 ± 0.5 to 1.0 ± 0.5 medications ($p<0.05$). In 15% of cases (n=9), we were able to normalize IOP without the use of hypotensive drops. In 75% of cases (n=45), patients continued the instillation of a single anti-glaucoma drug, most often 0.5% timolol solution. In 10% of cases (n=6), the use of a second anti-glaucoma medication (usually a prostaglandin once daily) did not maintain IOP compensation after 3-4 months. In cases where no effect was achieved, a repeat MITSCPC session was scheduled (with the exclusion of prostaglandin instillation 5 days before the procedure to prevent complications).

Given the low number of complications, it can be concluded with certainty that this technique should be performed on patients at earlier stages of glaucoma development, ensuring compensation for various levels of elevated IOP and improvement in visual functions. Stabilizing IOP allows such patients to preserve their visual acuity.

During the observation period from 3 to 6 months, the patients' condition was satisfactory, and the frequency of hypotensive medication instillations significantly decreased.

Based on the analysis of the results obtained, MITSCPC deserves consideration as a primary procedure for eyes with refractory glaucoma. Traditional laser effects on the ciliary body in microimpulse mode allow for effective and stable IOP reduction to normal levels in cases of both moderately elevated and highly elevated preoperative ocular hypertension.

Conclusion

1. This laser procedure primarily facilitates the elimination or significant reduction of pain, which in turn helps preserve eye function, enhances the quality of life for patients, and serves as a viable alternative to surgical methods in the treatment of refractory glaucoma.
2. Transscleral diode laser cyclophotocoagulation, when performed in micro-pulse mode, is considered highly effective, cost-efficient, and is associated with minimal complications. The procedure can also be conducted in outpatient settings, offering a practical solution for many patients.
3. The micro-pulse transscleral cyclophotocoagulation (MITSCPC) reduces the need for frequent instillations of anti-glaucoma medications, providing maximum hypotensive and neuroprotective effects while minimizing the toxic impact on the ocular surface, thereby preventing the development of dry eye syndrome.

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