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Endocyclophotodestruction in Glaucoma Patients Undergoing Combined Surgery of Pars Plana Vitrectomy and Phacoemulsification

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Background: The purpose of this trial was to assess the effect of a novel intraoperative endocyclophotodestruction method on intraocular pressure in patients undergoing combined procedure of phacovitrectomy to determine the efficacy of this combined surgical approach.

Material/Methods: The study sample included 87 subjects divided into 2 groups: Group I consisted of 52 patients who underwent intraoperative endocyclophotodestruction performed during phacovitrectomy. Group II consisted of 35 controls. The follow-up duration was 12 months. The preoperative (baseline) intraocular pressure (IOP) was determined and later assessed postoperatively at the following time points: on 1 day and at 1, 2, 3, 6, and 12 months. Other evaluated parameters were the number of topical antiglaucoma medications, and the cyclophotodestruction circumference-to-outflow resistance ratio (R).

Results: The mean postoperative reduction of intraocular pressure was by 4.26 mmHg at 6 months and by 4.91 mmHg at 12 months. The number of topical antiglaucoma medications was reduced postoperatively from the mean preoperative value of 1.66 to 0.69 at 6 months and 1.04 at 12 months.

Conclusions: The results show a significant reduction of intraocular pressure in patients undergoing the combined triple-procedure surgery and postoperative decrease in the number of topical medications. The best outcomes in terms of IOP decrease and reduced number of medications were achieved in patients with low outflow coefficient. Endocyclophotodestruction is an alternative IOP-reducing technique to be used in patients with glaucoma who require phacovitrectomy. It is recommended for patients with low outflow coefficient in whom posterior pole abnormalities constitute the main indications for surgery.

MeSH Keywords: **Glaucoma • Laser Coagulation • Ophthalmologic Surgical Procedures • Vitrectomy**

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Background

The term 'glaucoma' refers to a group of conditions sharing a common feature of progressive optic nerve neuropathy. It is also characterized by specific lesions in optic disc morphology and conforming visual field defects. Elevated intraocular pressure (IOP) is the main risk for neuropathy development. Elevated IOP was until recently defines as a value exceeding 21 mmHg, which was an upper limit of the statistical reference range. It turned out, however, that neuropathy may progress in eyes with IOP below 21 mmHg (normal tension glaucoma) and, conversely, it does not occur in a significant proportion of eyes with IOP over 21 mmHg. Thus, intraocular pressure may be relatively elevated in eyes of genetically predisposed patients and patients with other risk factors of neuropathy, especially ischemic conditions. The damage to the optic nerve causes irreversible visual field defects and may in extreme cases lead to complete vision loss. The unsatisfactory efficacy of medical treatment and glaucoma surgery, experienced relatively often in glaucoma care, constituted the basis for the development of novel procedures to improve patient quality of life.

Microinvasive glaucoma surgery (MIGS) is a surgical subspecialty that has developed dynamically in recent years. The conventional (AquaSys, iStent, Cypass, trabectom) and unconventional (Ex-press) methods of restoring the outflow of aqueous humor from the anterior chamber have been developed. The former includes using a microstent for creating a fistula within the trabecular meshwork, which drains the aqueous humor directly to the scleral venous sinus. Another way to achieve a similar effect involves the use of trabectome for removing the trabecular meshwork and the internal wall of Schlemm's canal. The unconventional outflow restoration involves creating a fistula that drains the aqueous humor into the subconjunctival space. Endoscopic diode laser photocoagulation of ciliary processes (endocyclophotocoagulation, ECP) is one of the newer methods for reducing the intraocular pressure. No report has been published so far on the use of an argon laser for ciliary process destruction during the pars plana vitrectomy, and we believe we are the first to attempt it.

The purpose of the present study was to assess the safety and efficacy of endocyclophotodestruction in glaucoma patients undergoing phacovitrectomy. We attempted to determine the effects of the additional procedure on intraocular pressure and the number of antiglaucoma medications used postoperatively by these patients.

Material and Methods

The study was conducted between 2009 and 2011 in the Military Institute of Medicine in Warsaw, and included 87 patients. Group I consisted of 52 subjects (44 females and

Figure 1. IOP levels during observation time. (A) Ciliary processes; (B) ciliary processes – laser pointer; (C) ciliary processes – laser impact.

8 males) 46 to 85 years old (the mean age was 72 years) in whom endocyclophotodestruction was performed as an additional procedure. Group II consisted of 35 controls (29 females and 6 males) ages 54–86 years (the mean age was 73 years).

The inclusion criteria were: at least 18 years of age, confirmed diagnosis of glaucoma, and scheduled for combined vitrectomy and phacoemulsification procedure. The following posterior pole abnormalities constituted the indications for surgery: diabetic retinopathy, AMD, vitreous hemorrhage, epiretinal membrane, and

Table 1. No. of medications and average IOP in both groups during observation period.

	0	1 week	1 month	2 months	3 months	6 months	12 months
Mean no. of medications (incl. CPD)	1.66	0.04	0.19	0.42	0.61	0.69	1.04
Mean no. of medications (w/o CPD)	1.59	1.59	1.59	1.59	1.59	1.61	1.61
Mean IOP (incl. CPD)	19.56	16.77	17.23	16.38	16.08	15.3	14.65
Mean IOP (w/o CPD)	19.11			20.21			19.82

macular hole (grade I–IV). All patients showed adequate verbal responses and were informed about potential performance of an additional procedure during their combined surgery. They were educated concerning the potential risks, complications, and benefits and gave their informed consent for the performance of an additional antiglaucoma procedure during the scheduled surgery.

The aqueous humor outflow coefficient for the treated eye was determined preoperatively and was calculated based on outflow resistance determined using a Schötz tonometer.

The first stage of the combined procedure involved lensectomy using phacoemulsification, followed by implantation of an artificial, foldable PC-IOL. Then, pars plana vitrectomy (25G) was performed. First, the vitreous, the internal limiting membrane (ILM), or the epiretinal membrane and the ILM were removed. Next, during scleral buckling, the ciliary processes were coagulated with an argon laser using the wide angle viewing system (IBOS) under direct vision (Figure 1A–C). The laser power was set within the range of 0.18 to 0.24 W and the value was dependent on its absorption by the ciliary processes. They turned visibly pale during the procedure. The circumference and the extent of photocoagulation depended on the aqueous humor outflow resistance. This relationship was inversely proportional. The lower the outflow coefficient, the larger is the circumference of endocyclophotodestruction. During the final stage of the surgery, SF₆ gas was injected into the vitreous chamber. The mean duration of the surgery was 50 min.

The following topical medications were used during the postoperative period: non-steroid anti-inflammatory drugs (NSAIDs), steroid anti-inflammatory drugs, antibiotics, and mydriatics, all administered to the conjunctival sac of the treated eye.

The postoperative follow-up was 12 months for both study groups, with the follow-up visits scheduled at the following time points: 1 week and 1, 2, 3, 6, and 12 months postoperatively. Applanation tonometry was performed at each pre- and postoperative visit in order to determine the intraocular pressure. At each visit the measurement was taken by the same clinician, in the same conditions and using the same tonometer.

The decreased production of the aqueous humor and, in turn, the decrease in the IOP was anticipated as a result of ciliary

process destruction. The Internal Review Board approved the experimental performance of a novel technique for cyclophotodestruction, which had not been used until then.

Results

The preoperative IOP in group I ranged between 13 and 39 mmHg (mean value of 19.56 mmHg). At 6 months postoperatively, the IOP range was 10–20 mmHg (mean value of 15.30 mmHg) and at 12 months postoperatively the IOP range was 10–19 mmHg (mean value of 14.65 mmHg) (Table 1). The outflow resistance (1/R) was 0.03–0.76 (mean value of 0.15), the extent of photocoagulation was 100–220 degrees (mean value of 53 degrees).

The number of topical antiglaucoma medications (i.e., active substances) used by the patients preoperatively was: 1 in 26 subjects, 2 in 20 subjects, 3 in 4 subjects, and 4 in 2 subjects (mean number of 1.66 medications). At 6 months postoperatively, 30 subjects did not use any antiglaucoma medication, 8 used only 1, and 14 used 2 medications (mean number of 0.69 medications).

Table 2 and Figures 2, 3 shows the IOP in 1st group during observation period.

The intraocular pressure in the treated eye decreased on average by 4.91 mmHg and the number of antiglaucoma medications used by the patients dropped on average by 0.62.

The preoperative intraocular pressure in group II ranged between 12 and 30 mmHg (mean value of 19.11 mmHg). At 6 months postoperatively, it fell to within the range of 13 to 29 mmHg (mean value of 20.21 mmHg), to settle at the level of 11 to 28 mmHg (mean value of 19.82) at 12 months. The mean outflow resistance was 0.19. The number of topical medications used by the patients in the control group did not change as compared to the preoperative values (mean number of 1.59).

Patients in both groups used: latanoprost, betaxolol, bimatoprost, brimonidine, dorzolamide, timolol, dorzolamide + timolol, bimatoprost + timolol, and brimonidine+timolol.

Table 2. IOP in 1st group during observation period.

Intraocular pressure	Observation time								
	Preoperatively	1 day	1 month	2 months	3 months	4 months	5 months	6 months	12 months
	(0)	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
No. of subjects	52	52	52	52	52	52	52	52	52
Minimum	13.00	10.00	12.00	11.00	12.00	12.00	11.00	10.00	10.00
Maximum	39.00	21.00	23.00	23.00	22.00	20.00	19.00	19.00	19.00
Median	18.00	16.50	16.50	16.00	15.50	16.00	15.00	15.00	15.00
Arithmetic mean	19.42	16.77	16.58	16.38	15.79	16.31	15.23	15.35	15.19
Standard deviation	5.38	2.72	2.94	3.06	2.41	2.42	1.70	2.08	2.02
Asymmetry coefficient	2.10	-0.60	0.44	0.12	0.48	0.07	0.35	-0.13	-0.42
ANOVA test									
Statistical analysis	Wilcoxon test Z, 0, I								
	Wilcoxon test Z, 0, III								
	Wilcoxon test Z, 0, V								
	Wilcoxon test Z, 0, VII

Figure 2. IOP in 1st group during observation period.

No complications of endocyclophotodestruction were observed throughout the study.

Discussion

We believe this is the first published study to assess the efficacy and safety of cyclophotocoagulation as an additional procedure performed during combined phacoemulsification and vitrectomy surgery in patients with concomitant glaucoma. Our results can only be compared to the results of diode laser endoscopic cyclophotocoagulation (ECP).

Figure 3. IOP in 1st group during observation period.

Murthy et al. studied ECP in eyes with refractory glaucoma. The follow-up period ranged between 3 and 21 months (mean duration of 12.27 months). The intraocular pressure (IOP) decreased from 32.58 ± 9.16 mmHg to 13.96 ± 7.71 mmHg ($p=0.001$, t-test). The mean number of topical antiglaucoma medications used by the patients dropped from 2.51 ± 0.97 to 1.09 ± 1.16 ($p=0.001$, Wilcoxon test). The efficacy was 82.2% [1].

Lima et al. evaluated the efficacy and safety of combined phacoemulsification and ECP procedures as first-line treatment in patients with cataract concomitant with glaucoma. The mean follow-up duration was 35.15 ± 8.14 months. The preoperative IOP

(23.07±5.52 mmHg) was significantly higher as compared to the value on the 1st postoperative day (13.14±6.09 mmHg), at 1 month postoperatively (11.03±2.59 mmHg), at 6 months postoperatively (12.33±3.01 mmHg), at 12 months postoperatively (12.19±2.19 mmHg), at 24 months postoperatively (12.14±2.89 mmHg), and during the last follow-up visit (12.29±2.44 mmHg) ($p=0.001$). The number of medications used by the patients decreased from the preoperative 1.44±0.97 to 0.37±0.74 ($p=0.001$). Partial response was achieved in 334 eyes (90.76%) and complete response was achieved in 205 eyes (55.7%). The following postoperative complications were observed: IOP spikes [14.4% (53/368)], anterior chamber fibrin [7.06% (26/368)], cystoid macular edema [4.34% (16/368)], ocular hypotony [2.17% (8/368)], and iris bombe [1.08% (4/368)] [2].

Virenda et al. compared the effect of extracapsular cataract extraction (ECCE) and phacoemulsification (phaco) with posterior chamber intraocular lens (PCIOL) implantation on intraocular pressure (IOP). The mean IOP decrease in the ECCE group was 2.70 mmHg (19.74%) vs. 2.74 mmHg (20.57%) in the phaco group as compared to baseline values. A significant IOP drop was observed in both groups at 2 months postoperatively. Intraocular pressure values stabilized after month 4 and remained significantly lower as compared to baseline [3].

The presented results show a significant reduction of intraocular pressure in patients undergoing the combined triple-procedure surgery, as well as a postoperative decrease in the number of topical medications used by these patients. The described method is definitely recommended in patients with proliferative diabetic retinopathy. In this condition, the material occluding the trabecular meshwork is continuously supplied into the vitreous chamber and anterior chamber of the eye and obstructs the outflow pathways (iron from dysmorphic RBCs, "shadow cells", and proteins leaking from the abnormal blood vessels

within the iridocorneal angle). The combined surgery is particularly recommended in such cases, as it does not interfere with the filtration angle, thus eliminating the risk of intra- and postoperative bleeding there. Such complication may even cause the undesirable IOP elevation. The endocyclophotocoagulation may also be repeated if necessary, without need to perform another vitrectomy. Using scleral trocars with an infusion system and surgical light (dual-mode cannula), as well as a biomicroscope viewing system, offer the possibility to complete the ciliary process photocoagulation. Obviously, a clear cornea is the primary prerequisite for this surgical approach. This method is also effective in relatively narrow pupils, as scleral buckling at ciliary process projection enables translocating the latter into the optical axis and coagulating them under direct vision without the need to use iris retractors. Standard administration of SF6 gas into the vitreous chamber during the combined procedure prevents IOP spikes during the early postoperative period and allows time for the fibrosis to take place during the gas absorption phase. As a result, the production of the aqueous humor decreases, which ultimately leads to IOP reduction. Endocyclophotodestruction offers an alternative approach to IOP reduction in glaucoma patients. It shows the highest efficacy in glaucoma patients with low outflow coefficient (and high outflow resistance and a large circumference of the destroyed ciliary processes), whose main indication for surgery is the pathology involving the posterior pole.

Conclusions

Argon laser endocyclophotodestruction performed during vitrectomy is an easy procedure that does not cause additional injury to the treated eye. Scleral buckling helps visualize the ciliary processes, which enables targeting the laser beam precisely onto the target area, while other ocular structures remain intact.

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