

One-year clinical outcome after combined cataract surgery with excimer laser trabeculostomy versus cataract surgery alone in open-angle glaucoma: real life data in a community-based outpatient setting

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Research Article

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Abstract

Purpose: This study aims to evaluate and compare intraocular pressure change and number of topical antiglaucoma medications after combined cataract surgery with excimer laser trabeculostomy versus cataract surgery alone in patients with open-angle glaucoma.

Methods: Retrospective comparative chart evaluation of 42 patients with different types of open-angle glaucoma, undergoing either combined cataract surgery with excimer laser trabeculostomy (study group - 40 eyes) or cataract surgery alone (control group - 40 eyes). Study outcomes were median intraocular pressure change and mean number of antiglaucoma medications during 12 months follow-up after surgery.

Results: The median pre- and postoperative intraocular pressure in study group at 3, 6, and 12 months were 14 (12-17.75) mmHg, 11.5 (10-14) mmHg, 10.5 (9-13.75) mmHg, and 12.5 (11-14) mmHg, respectively. The median intraocular pressure reduction at 6- and 12 months follow-up resulted in -3 (-5 to 0.5) mmHg and -2 (-5 to 0.75) mmHg, respectively. The postoperative intraocular pressure was statistically significantly lower than the preoperative level in both groups at last follow-up ($p < 0.001$). The higher the preoperative intraocular pressure in the operated eye, the larger was the IOP-lowering effect at 12 months after combined surgery ($p < 0.001$). We found a statistically significant difference between the mean number of topical antiglaucoma medications before and after combined surgery ($p < 0.001$) with 80% of eyes medication-free, while the control group showed no reduction of preoperative medications.

Conclusion: This study shows a statistically significant reduction of intraocular pressure and topical antiglaucoma medications at 12 months after combined cataract surgery with excimer laser trabeculostomy.

KEY MESSAGE

What is known:

- Microinvasive glaucoma surgeries (MIGS) are a less invasive yet clinically effective alternative for the surgical management of open angle glaucoma.
- Excimer laser trabeculostomy combined with cataract surgery leads to statistically significant intraocular pressure (IOP) reduction.

What is new:

- Cataract surgery combined with excimer laser trabeculostomy diminishes significantly the intraocular pressure (IOP) and the number of antiglaucoma medications at 12 months.
- The IOP lowering effect of cataract surgery combined with excimer laser trabeculostomy is correlated positively with the preoperative IOP: the higher the preoperative IOP, the higher the IOP decrease.

INTRODUCTION

Microinvasive glaucoma surgery (MIGS) is a modern less invasive and more physiologic alternative procedure in the surgical treatment of open angle glaucoma (OAG) [1–5]. The use of new laser options was proposed decades ago and nowadays represents an interesting and promising approach in MIGS [6–15]. One of these options is a use of an excimer laser, and its first known experimental application in glaucoma filtering surgery was performed in 1987 by Berlin et al. to create full-thickness scleral fistulas ab interno using a transanterior chamber fiber-optic delivered 308 nm xenon chloride excimer laser [8, 9]. Later, an argon fluoride excimer laser (193 nm) with rectangular shape of the laser beam with a 10 mm length and 5 mm width at the focal point was also used in an experimental study to perform a trabeculectomy [7].

Excimer laser trabeculostomy (ELT) is a XeCl Excimer laser-based implant-free microinvasive glaucoma procedure with an emission wavelength of 308 nm, first performed clinically in 1996 [16–18]. Vogel and Lauritzen reported intraocular pressure (IOP) reduction by 11 mmHg in 4 cases over a follow-up time of 5 months and IOP rise by 2 mmHg in spite of medication in 2 cases in their first six ELT treated patients with OAG. Later they showed a mean IOP reduction of 7 mmHg in 81.5% of their 27 operated glaucoma patients [17]. Huang et al. reported several histopathologic changes of trabecular meshwork (TM) under light and electrical microscopy after ELT ab interno on ten rabbit eyes, such as local fractures on the TM and openings into Schlemm's canal, turgescient mitochondria, dilated like vacuoles and endoplasmic reticula in the early postoperative period. These TM changes supposed to reduce outflow resistance of aqueous humor and to control the IOP thereafter [19].

There are three different known laser systems for ELT: AIDA (ELT; AIDA, Glautech AG, Nurnberg, Germany), ExTra (MLase AG, Germering, Germany; ExTra ELT) and ExTra II (ELIOS™, Bausch+Lomb) [20, 21]. The ELT procedure has been approved for use in the European Union and Switzerland since 1998 [16]. Our review based on a PubMed, MEDLINE and EMBASE search for 'Excimer laser trabeculostomy', 'ELT', 'ELIOS' revealed more than 30 peer-reviewed articles, of which only a few studies showed a real-life data with ELIOS™ laser system [20–25]. Therefore, further research is warranted to expand the already existing data. According to the largest study, published to date by Deubel et al. IOP reduced from 25 mmHg to 17 mmHg, accounting for 32% in 428 patients at 12 months after combined phacoemulsification with ELT performed using the XeCl Excimer Laser AIDA [26].

The aim of this retrospective study is to evaluate and compare IOP change and topical IOP-lowering medication use after combined cataract surgery with ELT performed with ELIOS™ laser device versus cataract surgery alone in patients with open-angle glaucoma in a community-based outpatient setting.

MATERIAL AND METHODS

We performed a retrospective comparative chart review of 42 patients (80 eyes) with different types of mild to moderate OAG (56.2% primary open angle (POAG) and 43.8% pseudoexfoliation glaucoma

(PEXG)), who underwent combined cataract surgery with ELT (study group – 40 eyes) or cataract surgery alone (control group – 40 eyes) from March 2024 to January 2025 at Chiemsee Eye Clinic, Germany. The study adhered to the tenets of the Declaration of Helsinki, all patients consented to the use of their data for study purposes and informed consent was obtained from all the patients before surgery.

Indication for combined surgery was presence of early or moderate open angle glaucoma with borderline target or uncontrolled IOP under mono- or combined (one to three IOP-lowering medications) therapy. Those patients who underwent only cataract surgery and had borderline target or uncontrolled preoperative IOP under mono- or combined therapy received additional IOP lowering medications before surgery and were operated with controlled IOP that reached the target level of IOP in 80% of cases. 20% of cases still showed borderline target IOP. We used NICE thresholds for glaucoma disease definition, which is based on analysis of the optic disc using Optical coherence tomography (Optopol, Copernicus REVO OCT), automated visual field examination using the Medmont M700 Automated Perimeter (MAP, Australia), and IOP measurements (Goldmann applanation tonometry) [27]. Eye-specific target IOP was defined by NICE and European Glaucoma Society guidance [28, 29]. Patients with only one functional eye (monocular patients) or patients who underwent any previous ocular procedure such as selective laser trabeculoplasty or any other intraocular surgery, as well as patients with corneal endothelial cell density below 1500 cells/mm² or with macular changes (see below) were excluded from the study.

Main outcome measures were postoperative IOP levels and median IOP change in the operated eye. Secondary outcome was the mean number of topical IOP-lowering medications during follow-up. Preoperative IOP was taken at the time of surgery indication. Postoperatively, IOP was measured on the first postoperative day, 1st, 2nd week, and 1-, 3-, 6-, 9- and 12 months follow-up after surgery.

In addition to the slit lamp clinical examination, specular endothelial microscopy (Tomey, USA) and optical coherence tomography for the macula (OCT Macula, Optopol, Copernicus REVO OCT) were performed before surgery to meet the exclusion criteria and after surgery to exclude presence of possible postoperative complications such as corneal endothelial dysfunction and retinal macular changes.

Surgical procedure

Surgery was performed under topical anesthesia. After standard phacoemulsification the anterior chamber was filled with an ophthalmic cohesive viscoelastic device to widen the nasal angle. After rotating the head of the patient 30° away from the surgeon, and the surgical microscope oculars 30° towards the surgeon, an endoscope-guided photoablative 25°-angled laser probe (Excimer laser, ELIOS™, Bausch+Lomb) was introduced to the anterior chamber through the same temporal 2.2 mm clear corneal incision and approached the nasal angle under direct gonioscopic view (Swan Jacobs Goniolens, Volk, USA). Ten microscopic channels (200 µm) at a distance of 500 µm from one another were created over 180 degrees of the TM nasally with fiberoptic 308 nm xenone chloride excimer laser light energy (pulse frequency: 20 Hz, pulse duration: 60–120 ns, energy output: 1.3 mJ, total fiber length: 2 m) during

ab interno laser trabeculostomy. At the end of the surgery viscoelastic and small anterior chamber bleedings, due to the regular blood reflux from Schlemm's canal, were thoroughly rinsed out of the anterior chamber.

Postoperative medications included prednisolone acetate 1% eye drops 4 times daily in the first week with a tapering regimen during four weeks (weekly 4-3-2-1 taper schedule), 2 tablets of Diamox 250 mg to prevent IOP spikes in the early postoperative period and moisturizing eye drops. All the IOP-lowering drops, used before surgery, were discontinued on the surgery day in a study group. The decision to initiate them again was made during follow-up after combined surgery based on the target IOP.

Statistical Analysis:

All statistical analysis was conducted with IBM® SPSS® Statistics (Statistical Package for the Social Sciences). Absolute and relative frequencies were computed for dichotomous data, continuous data are presented as mean $\pm$ standard deviation and median respective inter-quartile range. Paired Wilcoxon test was used to compare pre- and post-operative IOP, and pre- and postoperative number of medications in both groups. Correlations between the IOP change from baseline to follow-up in the treated eye was analyzed using Spearman's rank correlation. Descriptive data was compared using Chi-Square and Mann-Whitney U tests.

RESULTS

The mean age of the patients in both groups was 74.6 ± 5.8 and 74.2 ± 6.8 years; 27 (64.3%) females and 15 (35.7%) males. There were no statistically significant differences between type and severity of glaucoma between the study and control groups. The demographic and clinical data of all patients in both groups is presented in Table 1.

The median pre- and postoperative IOP in the study group on the first postoperative day, 1st, 2nd week, and 1-, 3-, 6-, 9- and 12 months follow-ups were 14.0 (12.0-17.75) mmHg, 12.0 (10.0-15.0) mmHg, 15.0 (11.25-18.75) mmHg, 14.0 (12.0-17.0) mmHg, 14.0 (11.0-15.5) mmHg, 11.5 (10.0-14.0) mmHg, 10.5 (9.0-13.75) mmHg, 12.0 (10.0-14.0), and 12.5 (11.0-14.0), respectively. The median pre- and postoperative IOP in the control group on the first postoperative day, 1st, 2nd week, and 1-, 3-, 6-, 9- and 12 months follow-ups were 15.0 (13.25-18.0) mmHg, 18.0 (15.0-22.0) mmHg, 16.5 (13.0-19.75) mmHg, 15.0 (14.0-17.0) mmHg, 14.0 (12.0-16.0) mmHg, 14.0 (13.0-16.25) mmHg, 13.5 (12.25-15.0) mmHg, 14.0 (12.0-16.0), and 13.5 (12.0-16.0), respectively. The preoperative IOP was not significantly different between the study and control groups. The median postoperative IOP levels were statistically significantly lower than preoperative IOP levels at 12 months after surgery in both groups (-3.78 , $p < 0.001$ and -4.23 , $p < 0.001$ for study and control groups, respectively). The mean pre- and postoperative IOP levels in both groups are presented in Figure 1.

The median IOP change after combined surgery at 3-, 6-, 9- and 12 months follow-up was -3.5 (-5.75 to -0.25) mmHg, -3 (-5 to 0.5) mmHg, -3 (-5 to 0.25) mmHg, and -2 (-5 to 0.75) mmHg, respectively. The

median IOP change in the control group at 3-, 6-, 9- and 12 months follow-up was -1 (-2.25 to 1) mmHg, -1 (-3 to 0) mmHg, -1 (-2.75 to 0) mmHg, and -1 (-2.75 to -0.25) mmHg, respectively. The mean and percentage IOP changes in both groups at different follow-ups are presented in Table 2. Thus, IOP reduction in the study group was larger than in the control group at all follow-ups with the statistically significant difference at 3 months (2.46-, $p < 0.05$).

The higher the preoperative IOP level was in the operated eye, the larger was the IOP-lowering effect at 12 months after combined and cataract surgery (-0.85, $p < 0.001$ and -0.56, respectively) (Figure 2).

We found a statistically significant difference between the mean number of topical IOP-lowering medications before and at 12 months after combined surgery (1.45 ± 0.8 vs. 0.38 ± 0.9 ; -5.27, $p < 0.001$), but no significant difference was found between number of pre- and postoperative IOP-lowering medications in the control group (1.53 ± 0.5 vs. 1.5 ± 0.6) (Figure 3). 80% percent of patients after combined cataract surgery with ELT vs. 2.5% before surgery did not need IOP-lowering medications. In the study group, 32.5% of the patients required combined antiglaucomatous therapy preoperatively, but only 10% required it 12 months after surgery. In the control group, the percentage of the patients who required combined IOP-lowering therapy preoperatively and 1 year after surgery did not actually differ (Table 1).

Transient IOP elevation in the first week after surgery was noted in 5% of cases in the study group and in 15% of cases in the control group. Short-term microhyphema (0,5 and 1 mm) with no requirement of additional interventions was revealed also in 2 eyes (5%) in the study group, no hyphema was found in the control group.

DISCUSSION

According to the literature review ELT in combination with cataract surgery has been predicted to be a safe, clinically effective surgical procedure in treatment of OAG and ocular hypertension [29, 30]. The longest retrospective evaluation to date of the effectiveness of ELT in conjunction with phacoemulsification demonstrated long-term treatment success of phacoemulsification-ELT in 161 glaucoma eyes over an 8-year follow-up period. The mean IOP decreased significantly from 19.3 ± 4.8 mmHg at baseline to 15.4 ± 3.2 mmHg at 8 years and only 25.5% of the eyes required a subsequent surgery to lower IOP throughout the whole follow-up [25]. Another retrospective study reported long-term IOP lowering and decrease in the number of IOP-lowering medications in 74 eyes after phacoemulsification, combined with ELT over an 8-year follow-up period. IOP was reduced from 21.9 ± 6.44 mmHg to 14.04 ± 4.1 mm Hg at one year and 13.7 ± 2.8 mmHg at 8 years. The number of IOP-lowering medications changed from 1.58 ± 0.8 at baseline to 0.97 ± 0.95 at one year and 1.85 ± 0.7 at 8 years [24].

According to other studies with different ELT laser systems, average IOP reduction following ELT in combination with cataract surgery is reported to be -2.41 mmHg – -9.7 mmHg (13.6%-35.9%), and the reduction of IOP-lowering medications varies from - 0.6 to -1.4 (31.3%-82.4%) at 12 months follow-up after surgery [22–24, 29–39].

In our study mean IOP reduction was -3.3 ± 4.5 mmHg (21.9%) and -2.8 ± 4.2 mmHg (18.5%) at 6- and 12 months follow-up after combined surgery, respectively. Moreover, the larger IOP-lowering effect after combined surgery at different follow-ups in our study was associated with the higher preoperative IOP in the operated eye ($p < 0.001$). Eye-specific target IOP was determined according to stage of disease/visual field damage at diagnosis, the baseline IOP and disease progression rate. IOP level of 18 to 20 mmHg with a reduction of at least 20% from baseline IOP, 15 to 17 mmHg with a reduction of at least 30% from baseline IOP, and 10 to 12 mmHg was defined as a target IOP in early, in moderate and in advanced glaucoma, respectively [28].

Moreno-Valladares et al. reported a medication-free rate up to 81% in cataract surgery combined with ELT group at 12 months postoperatively [34]. In contrast to these data, Deubel et al. didn't find any significant difference between the prescribed preoperative and postoperative number of IOP-lowering medication [26]. The mean reduction of topical IOP-lowering medications was -1.13 ± 0.6 (77.9%) and -1.08 ± 0.7 (74.5%) in our study group at 6- and 12 months follow-up, respectively. Furthermore, target IOP was achieved in 80% of patients without IOP-lowering medications after combined surgery. The percentage of eyes requiring combined antiglaucomatous therapy was 69.2% less at 12 months after combined surgery in our study. However, there was no difference between the percentage of the patients who required combined IOP-lowering therapy preoperatively and 12 months after surgery in the control group. Therefore, cataract surgery in combination with ELT provides a real cost-effective solution to be used in the treatment of glaucoma patients in a community-based outpatient setting.

Among complications after combined cataract surgery with ELT the following was reported: transient IOP spikes in 8.8%-45.7%; hyphema in 5.9%-31.4%; corneal edema in 8.6% [17, 34]. In our study, transient IOP elevation in the first week after surgery was detected in 5% in the study and threefold more, in 15% of cases, in the control group. In one patient with POAG and epilepsy IOP rose to 35 mmHg and stay decompensated during 3 days after combined surgery, required indication of Diamox 250 mg, and the target pressure was achieved only after reducing the dose of lamotrigine, which had been increased just two weeks prior to surgery. Hyphema occurred in 5% of cases in the study group, which was clinically insignificant and did not require additional intervention. Our low rate of microhyphema was achieved with good pressurization of the eye with an IOP of about 25 mmHg through meticulous hydration of paracenteses at the end of surgery. We found no sight-threatening complications, such as corneal endothelial changes (endothelial failure with severe corneal edema and stromal scarring), retinal changes (persistent cystoid macular edema, development of subretinal fluid), choroidal effusions, Uveitis-Glaucoma-Hyphema Syndrome or endophthalmitis. Other authors described 3.4%-8.6% of their patients requiring additional filtering surgery during one-year follow-up [17, 34, 39]. In our study none of our patients needed additional filtering surgery or other glaucoma interventions during the whole follow-up.

The main strength of our study is that patients who underwent previous glaucoma procedures such as selective laser trabeculoplasty or other intraocular surgery were excluded from the study. Another

strength of our study is its comparative design in a community-based outpatient setting. The main limitations are its retrospective design and the short 1-year follow-up.

This research shows a statistically significant reduction of IOP and IOP-lowering medications at 3-, 6- and 12 months follow-up after ELT in combination with cataract surgery in glaucoma patients. Thus, this MIGS approach is a clinically safe and effective alternative surgical procedure that is associated with the reduction of topical IOP-lowering medication use at 12 months follow-up and therefore results in improved quality of life of patients with open angle glaucoma and may become the preferred surgical treatment option for those who do not wish to have glaucoma implants inserted.

Declarations

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Conflicts of interest/Competing interests: The authors have no conflicts of interest to declare that are relevant to the content of this article.

Availability of data and material: The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

Code availability (software application or custom code): Not applicable.

Ethics approval: This retrospective chart review study involving human participants adhered to the tenets of the Declaration of Helsinki. This study has not been granted ethics committee approval prior to commencing, because of the observational nature of the research.

Consent to participate/Consent to publish: All patients consented to the use of their data for study purposes and informed consent was obtained from all the patients before surgery.

Authors' contributions: **Conceptualization:** [Ines Lanzl]; **Project administration:** [Ines Lanzl]; **Methodology and Resources:** [Ines Lanzl, Fidan A. Aghayeva]; **Validation:** [Fidan A. Aghayeva]; **Data curation:** [Shen Li]; **Formal analysis:** [Abdelrahman Assaf]; **Investigation, Visualization:** [Fidan A. Aghayeva, Abdelrahman Assaf]; **Writing - original draft preparation:** [Fidan A. Aghayeva]; **Writing - review and editing:** [Ines Lanzl]; **Supervision:** [Ines Lanzl].

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Tables

Tables 1 and 2 are available in the supplementary files section.

Figures

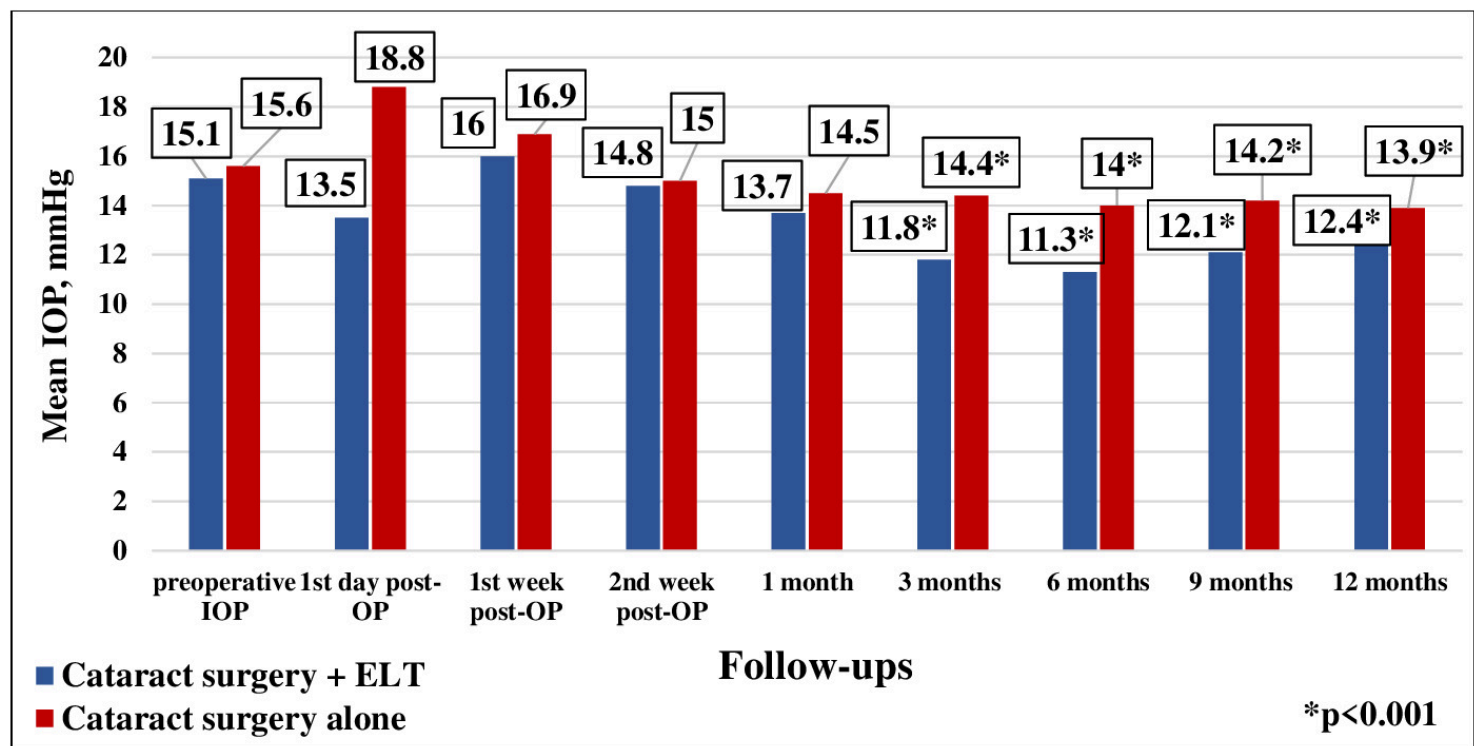


Figure 1

Mean IOP levels (mmHg) pre- and postoperatively in both groups. IOP = intraocular pressure. ELT = excimer laser trabeculostomy. *statistically significant difference between pre- and postoperative IOP levels, p<0.001.

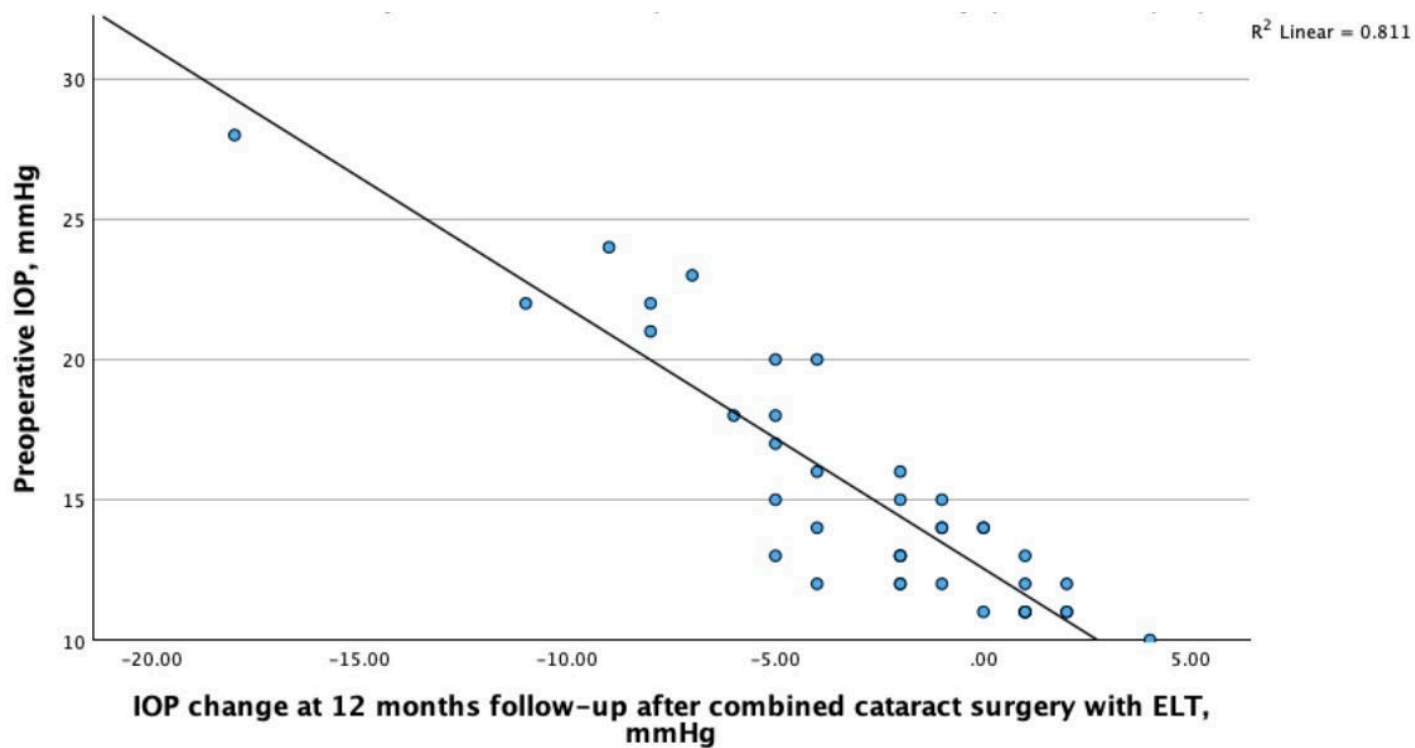


Figure 2

Correlation between preoperative IOP level in the operated eye and IOP change at 12 months follow-up after combined surgery ($p < 0.001$). IOP = intraocular pressure.

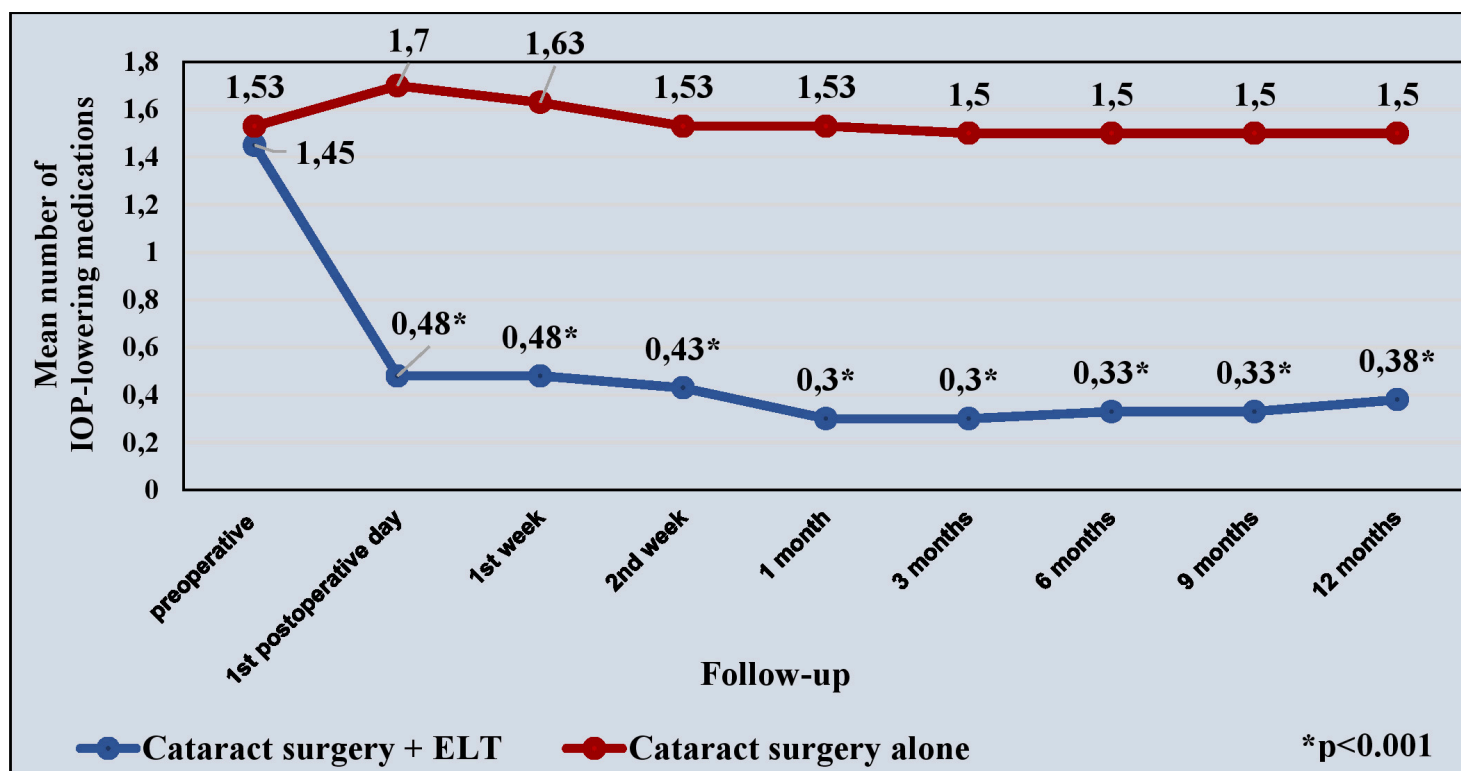


Figure 3

Mean number of IOP-lowering medications pre- and postoperatively in both groups. IOP = intraocular pressure; ELT = excimer laser trabeculostomy. *statistically significant difference between number of pre- and postoperative medications, $p < 0.001$.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table1.docx](#)
- [Table2.docx](#)