Real life experience following combined excimer laser trabeculostomy and phacoemulsification in eyes with ocular hypertension or mild glaucoma and cataract

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Abstract

PURPOSE: To assess the efficacy and safety of combined phacoemulsification and excimer laser trabeculostomy (ELT) in eyes with cataract and mild controlled glaucoma or ocular hypertension.

METHODS: Single-centre analysis of eyes that underwent phacoemulsification and ELT between 2017 and 2021. Change in intraocular pressure (IOP), glaucoma medication requirements, corrected distance visual acuity (CDVA), complications and re-interventions were evaluated. Success was defined as a reduction $\geq 20\%$ from preoperative IOP, an IOP $\leq 14$ mmHg or a reduction in glaucoma medication requirements with an IOP equal or lower than the preoperative IOP.

RESULTS: Mean follow-up was 658 $\pm$ 64 days. Mean preoperative IOP was 17.76 $\pm$ 4.88 mmHg, it decreased to 15.35 $\pm$ 3.10 mmHg at 1 year (n=37) ($p = 0.006$) and to 14.00 $\pm$ 3.78 at 3 years (n=8) ($p = 0.074$). Mean number of glaucoma medication requirements decreased from 2.02 $\pm$ 1.0 preoperatively to 1.02 $\pm$ 0.96 at 1 year (n=37) ($p < 0.001$) and to 1.63 $\pm$ 0.92 at 3 years (n=8) ($p = 0.197$). Complete success was achieved in 17.7% of eyes and qualified success in 54.8%. Two eyes of 2 patients had early postoperative hyphema. Two eyes of 1 patient underwent filtering surgery 2 months after the procedure, and 2 eyes of 1 patient underwent laser trabeculoplasty 3.8 years after the procedure due to uncontrolled IOP.

CONCLUSIONS: Combined phacoemulsification and ELT is effective and safe in eyes with mild glaucoma or ocular hypertension and cataract. It significantly reduced IOP and glaucoma medication requirements 1 year after surgery.

Introduction

Cataract and glaucoma are the two most common causes of preventable blindness worldwide [1]. Despite technologic improvements, these conditions still represent a major public health problem.

Treatment of cataract is surgical whereas therapy for glaucoma may be medical, laser or surgical depending on the severity of the disease and other factors like lack of response to topical drugs or bad tolerance or compliance to medical treatment. The aim of glaucoma treatment is to halt optic nerve damage and prevent visual field loss by lowering intraocular pressure (IOP). When affected by both conditions, cataract and glaucoma, the surgical approach is widely debated, with several authors advocating to undertake procedures in a specific order and many others favour in performing both simultaneously [2–5].

Microinvasive glaucoma surgeries (MIGS) have emerged as an alternative to traditional glaucoma surgeries [6]. These procedures are less invasive and have a good safety profile allowing the surgeon to treat mild to moderate disease earlier and therefore improving glaucoma control and patient compliance.

Excimer laser trabeculostomy (ELT) is a MIGS procedure that aims to increase the physiologic outflow of the aqueous humour by creating selective permanent perforations at the trabecular meshwork and Schlemm’s canal providing a direct communication between the anterior chamber and the episcleral aqueous humour collector channels [7].

The main purpose of this study was to assess the efficacy and safety of combined phacoemulsification and ELT for the treatment of patients with medically controlled mild glaucoma or ocular hypertension and coexisting cataract.

Patients And Methods

Study design

We performed a single center, retrospective review of all patients undergoing combined ELT and phacoemulsification from January 2017 to October 2021. The study followed the tenets of the Declaration of Helsinki. Every participant signed an IRB-approved informed consent before the surgery was performed. Sixty-two eyes of 44 patients were included. All the surgeries were performed by 3 experienced surgeons (EA, LP, SF).

Eligibility criteria for treatment was medically controlled mild glaucoma or ocular hypertension and presence of a visually significant cataract.

Before surgery, all patients had a complete ophthalmologic examination. The evaluation included manifest refraction, slit-lamp biomicroscopy, Goldmann applanation tonometry, binocular indirect ophthalmoscopy through a dilated pupil, corneal topography, (Orbscan II; Bausch & Lomb, Rochester, NY, USA), pachymetry (ultrasound pachymetry; Corvis ST; OCULUS, Wetzlar, Germany), optic nerve and macular optical coherence tomography (OCT) (CIRRUS HD-OCT 5000; Carl Zeiss Meditec, Jena, Germany) and visual field assessment (Humphrey Field analyzer 3; Carl Zeiss Meditec, Jena, Germany). Optic biometry was performed to every patient before surgery (IOL master 700; Carl Zeiss Meditec, Jena, Germany).

Data collection was performed through individual chart review and registered into a standardized study spread sheet by one investigator (R.P). Collected variables were the following: age, gender, eye, preoperative and postoperative (3-months, 1-year and at final visit in cases with $\geq 1$ year of follow-up) corrected distance visual acuity (CDVA), manifest refraction, type of glaucoma, cup to disc ratio, IOP, glaucoma medication requirements
Surgical procedure

After sub-Tenon anesthesia and patient preparation, a standard phacoemulsification through a clear corneal 2.4-mm incision and posterior chamber intraocular lens implantation was performed. Acetylcholine was injected, to achieve a better visualization of the trabecular meshwork. The laser treatment (ExTra Laser System, MLase AG, Germany) was performed under viscoelastic stabilization in the anterior chamber. With direct gonioscopic visualization, the ELT probe was advanced bevel up, through the anterior chamber and placed in direct contact with the trabecular meshwork. A foot pedal system was used to apply the laser energy. Ten microchannels were created over 90 degrees, 500 μm apart at the inferior-nasal or at the inferior-temporal quadrant.

After the procedure, patients were instructed to either stop all or continue some of their glaucoma medications as per surgeon preference. Typically, patients used a combination of antibiotic and steroid drops 3 or 4 times a day while awake and tapered over 2–4 weeks.

Statistical analysis and outcome parameters

Outcome variables were tested for normality with Shapiro-Wilk and Kolmogorov Smirnov tests. Descriptive analyses were performed for all variables. Comparison of continuous variables was made with Paired t-test or Wilcoxon signed-rank test according to data distribution. Repeated measurement analysis of variance (ANOVA) was performed to compare the mean IOP at different follow-up time points with baseline. Comparison of categorical variables was made with chi-square test. Kaplan-Meier survival analysis was performed and a univariate and multivariate binary logistic regression was performed to selected variables. A p value < 0.05 was considered statistically significant. Analyses were made with IBM SPSS Statistics version 25 (IBM Corp).

Outcome parameters:

Complete success was defined as a reduction ≥20% from baseline IOP or an IOP ≤14 mmHg without glaucoma medication.

Qualified success was defined as a reduction ≥20% from baseline IOP, or an IOP ≤14 mmHg with the same or less glaucoma medication requirements, or a reduction in glaucoma medication requirements with an IOP equal or lower than the preoperative IOP.

Failure was defined as an IOP reduction <20% from baseline, no reduction in glaucoma medication requirements, or the need of other surgical or laser procedure to control IOP.

Results

Sixty-two eyes of 44 patients were included. Mean follow-up was 658 ± 64 days. Thirty-seven eyes (59.7%) accomplished the 1-year follow-up, 22 eyes (35.5%) reached the 2-year mark and 8 eyes (12.9%) had 3 years of follow-up at the time of evaluation. Preoperative characteristics can be seen in Table 1.
Table 1
Preoperative characteristics (n = 62)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>70.53 ± 9.99</td>
</tr>
<tr>
<td>Right eye</td>
<td>42.00%</td>
</tr>
<tr>
<td>CDVA (decimal scale)</td>
<td>0.59 ± 0.34</td>
</tr>
<tr>
<td>IOP (mmHg)</td>
<td>17.76 ± 4.88</td>
</tr>
<tr>
<td>Medication</td>
<td>2.02 ± 0.99</td>
</tr>
<tr>
<td>Type of glaucoma</td>
<td>72.58%</td>
</tr>
<tr>
<td>- POAG</td>
<td>8.10%</td>
</tr>
<tr>
<td>- CACG</td>
<td>3.20%</td>
</tr>
<tr>
<td>- NTG</td>
<td>12.90%</td>
</tr>
<tr>
<td>- PEX</td>
<td>3.20%</td>
</tr>
<tr>
<td>- OHT</td>
<td>0.61 ± 0.23</td>
</tr>
<tr>
<td>C/D ratio</td>
<td></td>
</tr>
<tr>
<td>RNFL (avg µ)</td>
<td>73.30 ± 32.35</td>
</tr>
<tr>
<td>VF MD (dB)</td>
<td>-4.81 ± 4.95</td>
</tr>
<tr>
<td>VF VFI (%)</td>
<td>90.1 ± 14.4</td>
</tr>
</tbody>
</table>

SD = standard deviation; CDVA = corrected distance visual acuity; IOP = intraocular pressure; POAG = primary open angle glaucoma; CACG = chronic angle closure glaucoma; NTG = normal tension glaucoma; PEX = pseudoexfoliative glaucoma; OHT = ocular hypertension; RNFL = retinal nerve fiber layer; avg = average; VF = visual field; MD = mean defect; dB = decibels; VFI = visual field index.

CDVA improved from 0.59 ± 0.34 (decimal scale) to 0.81 ± 0.27 (decimal scale) at the 1-year mark (p < 0.01). Similarly, a statistically significant improvement in CDVA was found in the eyes that accomplished 2 and 3-years of follow-up (22 and 8 eyes respectively). (p values: < 0.01 and 0.05 respectively) Fig. 1. Sixty percent (22 eyes) gained 1 or more lines of CDVA and 40% (15 eyes) had no change in CDVA at 1-year.

Mean IOP for the different time periods is shown in Fig. 2A. Eight eyes (12.9%) had a hypertensive spike 24 hours after surgery (≥10 mmHg above the preoperative IOP), however all eyes were controlled with an IOP equal or lower than the preoperative IOP 1 week after the procedure. Mean IOP reduction was almost 14% after the first year (n = 37) and 21% in the eyes that were followed for 3-years (n = 8). IOP values showed a statistically significant reduction at the 1-year follow-up (p < 0.01). However, to further assess the efficacy of the procedure, we separated the eyes into 2 groups as follows; group 1: eyes that had a preoperative IOP < 21.0 mmHg and group 2: eyes that had a preoperative IOP > 21.0 mmHg. We found that in group 1 (44 eyes), mean IOP reduction was 1.0% (0.34 mmHg) and in group 2 (18 eyes) mean reduction was 18.3% (4.39 mmHg). Difference between groups was statistically significant (p = 0.012). Figure 2B.

A statistically significant reduction in IOP-lowering medication was found after the first postoperative time period and lasted until 1-year of follow up (p < 0.01). After the 1-year time-point, the number of IOP-lowering medication increased but remained lower than the preoperative number of medications used (p = 0.19). Figure 3.

Binary logistic regression did not show a significant relation between diagnoses (Primary Open Angle Glaucoma, Chronic Angle Closure Glaucoma, Normal Tension Glaucoma, Pseudoexfoliative Glaucoma, and Ocular Hypertension), age, sex, treatment area, and the outcome of the procedure. Kaplan-Meier survival analysis for qualified success of the entire cohort can be seen in Fig. 4A. Mean survival time was 996.15 ± 73.14 days. After the mean survival follow-up time, qualified success rate was 55.0%. In Fig. 4B Kaplan-Meier survival analysis for group 1 and group 2, mean survival time was 1017.37 ± 80.36 days for group 1 and 943.61 ± 168.31 days for group 2.

The most common intraoperative complication was minor bleeding in the anterior chamber, which occurred in 38 eyes (61.3%) and only 3 (4.8%) showed significant hyphema at the postoperative period. Four eyes (6.5%) of 2 patients needed further interventions to control IOP – 2 eyes of one patient required filtering surgery (2 months after the procedure), and 2 eyes of another patient underwent LASER trabeculoplasty after 3.8 years. No cases of ocular hypotony or visual loss and no severe complications occurred during the entire follow-up.

**Discussion**

Since the introduction of MIGS, a wide variety of procedures have gained increasing interest, especially when there is coexisting cataract, and a combined procedure can be considered [7]. The aim of many angle-based MIGS procedures is to bypass the juxtacanalicular trabecular meshwork.
and the inner wall of Schlemm’s canal by inserting stents. In contrast, ELT stands as the only laser-based MIGS procedure that creates channels to restore the natural drainage pathway of the aqueous humor from the anterior chamber to Schlemm’s canal.

Despite the fact that MIGS procedures are minimally invasive, there is evidence to support the reduction in IOP and in glaucoma medication requirements with these interventions, however they do not reduce IOP as effectively as bleb forming procedures such as trabeculectomy (which remains to be the gold standard for glaucoma surgical treatment) and non-penetrating deep sclerectomy or as glaucoma drainage implants (either valvulated or non-valvulated) [6]. These techniques are usually indicated and performed in more advanced cases (moderate and severe glaucoma), in contrast, MIGS procedures are considered as a good alternative in cases of mild glaucoma or ocular hypertension. The effect of ELT as well as the effect of other angle-based MIGS procedures varies in function of the preoperative IOP and the episcleral venous pressure, which limits the hypotensive efficacy of the procedures [8]. Therefore, ELT appears to be more effective in eyes with higher baseline IOP than in eyes with better controlled pressure.

The aim of this study was to analyze the long-term efficacy of ELT concerning its IOP-lowering effect and reduction of glaucoma medication requirements in eyes with mild controlled glaucoma or ocular hypertension. This study reflects a real-life experience because no medication wash-out was performed previous to the procedure.

In our series, the IOP was significantly reduced by 14% during the first-year of follow-up. This reduction remained stable until the 3-year follow-up. This was higher than the 11.5% reported by Töteberg et.al (study with a similar cohort, eyes with preoperative IOP of 16.5 ± 2.9 mmHg) and similar to the reports of Pache et.al (16.8%), Moreno Valladares et.al (22.0%) and Jozic et.al (24.0%) [8–11]. However, it was lower than the 29% reduction reported by Deubel et.al, the 29% reported by Babighian et.al, and 35% reported by Berlin et.al [12–15]. (All studies had a preoperative IOP higher than the one in our study population) (Table 2). In fact, when we separated our cohort according to baseline preoperative IOP, we found that in group 1 (baseline IOP < 21 mmHg), mean IOP reduction was 1.0% and in group 2 (baseline IOP > 21 mmHg) the mean reduction was 18.3%, in line with the reports of Moreno-Valladares et. al and Jozic et. al. [8–10].

In this cohort, a statistically significant reduction in glaucoma medication requirements was found after the first postoperative time period, and this lasted until 1-year follow-up. Afterwards, IOP-lowering medication requirements increased but remained lower than the preoperative number of medication used. Most studies show a similar decrease in medication requirements at 1-year; however, few studies present longer follow-up times. Data of the long-term follow-up studies published by Babighian et al. and Deubel et.al showed a similar trend [12–14]. Moreover, the longest follow-up study conducted by Berlin et. al, showed an increase in medication at the final follow-up compared to the preoperative requirements [15].

In our series, after a mean follow-up of 658 days, 93.5% of eyes did not need another IOP-lowering procedure to be controlled. The Kaplan-Meier analysis showed that ELT could achieve satisfactory results (qualified success rate of 54.8%) with a mean survival time of 996 days. Complete success at our series was 18%, in line with the reports of Töteberg et.al but lower than other published studies (Table 2) [16, 17]. This may be due to our strict definition of success. We decided to use this definition because mean preoperative IOP in our patients was well-controlled and was considerably lower than the mean preoperative IOP from other studies, making the use of the most common definition of success (IOP ≤ 21 mmHg or reduction of ≥ 20% from baseline IOP) not suitable for our particular group of eyes. In our patients, the qualified success was 54.8% which is similar to the reports of Töteberg et.al, Deubel et.al and Moreno-Valladares et. al. [8, 12, 17], but lower than the reports of Babighian et.al and Töteberg et.al. [14, 16]. If we considered the definition of success as an IOP ≤ 21 mmHg or a reduction of ≥ 20% from baseline IOP, we would have a qualified success of 88.7% which is in line with the report of Babighian et. al.

This study is not free of limitations. Sample size and loss to follow-up limited the statistical power of the results. As we collected data from a single centre facility and because missing data was handled with available data method, some selection bias could be present (if missing pattern was not completely random, however, missing data was less than 5%). Data was analysed for changes in each intervened eye over time, and although paired analyses were used, unmeasured confounding could exist. We believe that further prospective studies including a bigger sample size and randomized blind interventions should be performed to allow adjustment for other confounders and draw causal conclusions.

In summary, our results provide real-life experience data regarding phacoemulsification and ELT in eyes with well controlled mild glaucoma or ocular hypertension. This study may help surgeons decide which patients are the best candidates to perform this MIGS procedure. Our study showed that combined phacoemulsification and ELT is effective and confirms that with higher preoperative IOP levels, the reduction in IOP is higher. ELT is a reasonably safe procedure that allows to treat mild disease earlier and therefore improve patient compliance for a limited time.
<table>
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<th>Author (journal)</th>
<th>Year</th>
<th>N</th>
<th>Follow-up (months)</th>
<th>Preoperative IOP</th>
<th>Decrease in IOP (mmHg)</th>
<th>Decrease in IOP (%)</th>
<th>Decrease in medication</th>
<th>Success definition</th>
<th>Complete success (%)</th>
<th>Qualified success (%)</th>
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<tr>
<td>Babighian et al. [14] (Ophthalmologica)</td>
<td>2006</td>
<td>21</td>
<td>24</td>
<td>24.80 ± 2.00</td>
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<td>52.4</td>
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<td>16.80</td>
<td>Not reported</td>
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<td>Moreno-Valladares et al.[8] (Arch Soc Esp Ophthalm)</td>
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<td>12</td>
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<td>22.00</td>
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<td>Complete success (%)</td>
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<td>Current study</td>
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<td>17.76 ± 4.88</td>
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<td>21.00</td>
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<td>18.0</td>
<td>55.0</td>
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</table>

IOP: intraocular pressure.

Statements And Declarations

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Competing interests: The authors have no relevant financial or non-financial interests to disclose.

Author contributions: Study concept and design (RP, EA); data collection (RP); analysis and interpretation of data (RP, EA); writing the manuscript (RP, NM-C); critical revision of the manuscript (EA, LP, SF, NM-C); supervision (EA, LP).

Ethics approval: This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Instituto de Micocirugía Ocular, Barcelona.

Consent to participate: Informed consent was obtained from all individual participants included in the study.

References


Figures

**Figure 1**

Legend not included with this version.
Figure 2
Legend not included with this version.

Figure 3
Legend not included with this version.

Figure 4
Legend not included with this version.