Transscleral vs Endoscopic Cyclophotocoagulation: Safety and Efficacy When Combined with Phacoemulsification

Abraham Nirappel
Massachusetts Eye and Ear Infirmary
Emma Klug
Massachusetts Eye and Ear Infirmary
Cameron Neeson
Massachusetts Eye and Ear Infirmary
Mari Chachanidze
Massachusetts Eye and Ear Infirmary
Nathan Hall
Massachusetts Eye and Ear Infirmary
Ta Chang
University of Miami
Lucy Shen
Massachusetts Eye and Ear Infirmary
David Sola-Del Valle (David_Sola-DelValle@meei.harvard.edu)
Massachusetts Eye and Ear Infirmary

Research Article

Keywords: Microinvasive glaucoma procedure, MicroPulse, endoscopic cyclophotocoagulation, survival-success rate

Posted Date: November 12th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-1041444/v1

Abstract

Precis: Phacoemulsification combined with MicroPulse transscleral cyclophotocoagulation appears to provide significantly greater long-term IOP reduction than phacoemulsification combined with endoscopic cyclophotocoagulation without compromising safety.

Purpose: To compare the effectiveness and safety of phacoemulsification combined with endoscopic cyclophotocoagulation (phaco/ECP), phacoemulsification combined with MicroPulse transscleral cyclophotocoagulation (phaco/MP-TSCPC), and phacoemulsification alone (phaco) in the treatment of coexisting cataract and glaucoma.

Methods: Retrospective cohort study of consecutive cases at Massachusetts Eye & Ear. The main outcome measures were the cumulative probabilities of failure between the phaco/ECP group, phaco/MP-TSCPC group, and the phaco alone group with failure defined as reaching NLP vision at any point postoperatively or the inability to maintain ≥20% IOP reduction from baseline with IOP between 5-18 mmHg. Additional outcome measures included changes in average IOP, number of glaucoma medications, and complication rates.

Results: 64 eyes from 64 patients (25 phaco/ ECP, 20 phaco/ MPTSCPC, 19 phaco alone) were included in this study. The groups did not differ in age (mean 71.04 ± 6.7 years) or length of follow-up time. Primary open-angle glaucoma was the most common type of glaucoma in the phaco alone (42%) and phaco/ECP (48%) groups while mixed-mechanism glaucoma was the most common type in the phaco/MP-TSCPC group (40%). The mean IOP reductions at 1 year were 3.07 ± 5.3 mmHg from a baseline of 15.78 ± 4.7 in the phaco/ECP group, 6.0 ± 4.3 mmHg from a baseline of 18.37 ± 4.6 in the phaco/MP-TSCPC group and 1.0 ± 1.6 from a baseline of 14.30 ± 4.2 mmHg in the phaco alone group. Surgical failure was less likely in eyes in the phaco/MP-TSCPC and phaco/ECP groups compared to phaco alone based on the Kaplan-Meier survival criteria, with failure defined as the inability to maintain an IOP reduction of 20% or more with IOP between 5-18 mm Hg long term. There were no differences in complications among the three groups.

Conclusions: Phaco/MP-TSCPC appears to provide for greater long-term IOP control than phaco alone and phaco/ECP. All three procedures had similar safety profiles.

Introduction

Laser cyclophotocoagulation has been proposed as a potentially safe and effective intraocular pressure (IOP)-lowering tool. During cyclophotocoagulation, the laser can be delivered through either a transscleral or an endoscopic approach to

the ciliary processes and decrease aqueous production.[1,2] In the endoscopic method, the surgeon directly visualizes and targets the ciliary processes using a video camera, while the transscleral method involves transmitting a beam of laser energy to the ciliary body through the overlying sclera. When combined with

phacoemulsification, laser cyclophotocoagulation can potentially decrease IOP without increasing the surgical risks. Theoretically, the endoscopic approach may allow for more precise targeting and thus limit collateral tissue damage when compared to the transscleral approach, although the longer operative time and greater intraocular manipulation may offset these potential advantages. Furthermore, whereas the transscleral approach can deliver laser circumferentially during one treatment session, the endoscopic approach can only treat up to 120-180 degrees of ciliary processes per session. Currently, there are no high-quality studies comparing the two approaches of cyclophotocoagulation with a phacoemulsification-only arm as a control, and the relative efficacy and safety of these two approaches remain unknown.

In this study, we compared the outcomes of combined phacoemulsification and MicroPulse transscleral cyclophotocoagulation (phaco/MP-TSCPC) and combined phacoemulsification and endoscopic cyclophotocoagulation (phaco/ECP) to phacoemulsification alone. Given the popularity of various microinvasive glaucoma surgery (MIGS) combined with cataract surgery in glaucoma patients, comparing the efficacy of these combined procedures is a topic of significant clinical interest.

Methods

Study Design

The study protocol was approved by the Institutional Review Board of Massachusetts Eye and Ear (MEE), and the data collection methods abided by the Declaration of Helsinki and the Health Portability and Accountability Act. We identified consecutive patients who had undergone either phaco/MP-TSCPC, phaco/ECP, or phaco alone at MEE from March 2011 to December 2019 using financial claims data. Patients were included for analysis if: 1) they had undergone clear-corneal phacoemulsification, 2) either no other combined procedure, ECP, or MP-TSCPC, 3) had a glaucoma diagnosis at the time of the index procedure, and 4) has a follow up of at least 6 weeks.

Patients were excluded if they were under the age of 18 years at the time of the procedure, received less than 300° of ECP, or if they had juvenile open-angle glaucoma (JOAG). If both eyes were treated with the same combination of procedures, only one eye per patient was randomly selected.

Demographic and ophthalmic data were collected from the preoperative visit. Preoperative IOP was calculated as an average of the IOP readings from the two visits immediately preceding treatment. Glaucoma severity was determined as mild, moderate or severe based on the glaucoma staging codes determined by the American Glaucoma Society, or as indeterminate if automated visual field data was not available.[3] Fixed-dose combination glaucoma medications were counted by the number of their constituent agents. Intraoperative data collected included laser power and duration of treatment. Mean deviation (MD) and pattern standard deviation (PSD) data from visual fields taken within six months prior to the procedure as well as the most recent visual fields performed were collected, when available.

Postoperative data on IOP, number of glaucoma medications, visual acuity, subsequent IOP-lowering procedures and the presence of complications were recorded. Complications are defined as postoperative findings of hypotony (defined as IOP less than 5 mmHg), cystoid macular edema (CME), and inflammation evidenced by the presence of any anterior chamber cells > 1 month after surgery. Surgical failure criteria are defined below.

Surgical Procedure

Phaco/MP-TSCPC

A peribulbar block was performed by anesthesia with 5 mL of 1% preservative-free lidocaine and 0.375% preservative-free bupivacaine, along with monitored anesthesia care. The patient's operative eye and ocular adnexa were then sterilized with 5% Betadine solution and draped in the usual sterile ophthalmic fashion. A sterile lid speculum was placed in the operative eye. Following standard phacoemulsification, two 90-second applications (one in the inferior quadrant and one in the superior quadrant) of MP-TSCPC were done with a power between 2000-2400 mW at a 31.3% duty cycle using the Generation 1 probe.[4] Power was titrated based on the need for IOP lowering at the discretion of the surgeon. The 3 and 9 o'clock meridians were avoided. The main wound and the paracentesis wounds were then hydrated and found to be free of any leaks. All patients received an intracameral injection of antibiotics. Unless patients had medical comorbidities (e.g., uncontrolled diabetes or hypertension) that prevented the use of systemic steroids, patients received 1 gram of IV methylprednisolone intraoperatively followed by a 6-day PO methylprednisolone taper (Medrol dose pack). IOP-lowering medications were given on postoperative day 1 at the discretion of the attending surgeon.

Phaco/ECP

A peribulbar block was performed by anesthesia with 5 mL of 1% preservative-free lidocaine and 0.375% preservative-free bupivacaine, along with monitored anesthesia care. The patient's operative eye and ocular adnexa were then sterilized with 5% Betadine solution and draped in the usual sterile ophthalmic fashion. A sterile lid speculum was placed in the operative eye. Following standard phacoemulsification, endocyclophotocoagulation was applied to the ciliary processes through the main wound with a power between 0.14 W and 0.40 W, which was titrated to ciliary body shrinkage.[29] An additional wound was created with a keratome to complete the treatment for a total of 300° to 360°. OVD material was removed with irrigation and aspiration. The corneal incisions were watertight at the end of the procedure. Triamcinolone was injected into the eye and patients were instructed to resume glaucoma eye drops on the evening following surgery at the surgeon's discretion.

Outcome Measures

The primary outcome measures included the average reduction in IOP and Kaplan-Meier survival. Failure was defined as reaching NLP vision at any point postoperatively or the inability to maintain ≥20% IOP reduction from baseline with IOP between 5-18 mmHg for two consecutive follow-up visits, with the latter

follow-up visit (IOP criteria) or the procedure date (additional IOP-lowering procedure) being the failure date. Patients were followed postoperatively until the failure date. Additional outcome measures included changes in the number of glaucoma medications, visual acuity, and the prevalence of postoperative complications.

Statistical Analysis

One-way ANOVA tests were conducted to determine if there were significant differences between the three groups in terms of average IOP reduction, medication burden reduction, or changes to visual acuity. Tukey's honest significant difference (Tukey HSD) post-hoc tests adjusted for multiple comparisons were conducted to make pairwise comparisons between each of the three groups. One-way ANOVA and Tukey HSD post-hoc tests were also used to detect if there were significant differences between the three groups in terms of preoperative IOP, number of glaucoma medications, or visual acuity. Chi-squared tests were also used to determine if the two groups differed significantly in terms of their preoperative characteristics or in the prevalence of postoperative complications.

Kaplan-Meier survival curves were constructed to compare the long-term cumulative probabilities of success between the groups that received either phaco alone, phaco/ECP or phaco/MP-TSCPC. Pairwise log-rank tests with adjustments for multiple comparisons were used to determine if the survival curves of the three groups differed significantly from one another. Cox proportional-hazard regression analyses were fit to determine the effects of age, sex, preoperative IOP, type of glaucoma, and preoperative medication burden on the hazard of failure. A life table was created to compare the cumulative probabilities of survival at various selected time points.

Results

Demographics

A total of 64 eyes from 64 patients were included in this study; 25 in the phaco/ECP group, 20 in the phaco/MPTSCPC group, and 19 in the phaco alone group (Figure 1). Total follow-up time ranged from 41 to 508 days. The mean follow-up time was 215.27 ± 34.36 days in the phaco/ECP group, 256.39 ± 42.33 days in the phaco/MP-TSCPC group, and 112.82 ± 7.87 in the phaco alone group (p = 0.021). The median follow up times were 201 (IQR: 35) in the phaco/ECP group, 243 (IQR: 46) in the phaco/MP-TSCPC group and 88 (IQR: 27) in the phaco alone group. Preoperatively, no significant differences were found among the 3 groups in gender (overall, 55.5% female, p=0.06), visual acuity (overall average ± standard deviation [SD], 0.59 ± 0.35, logarithm of the minimum angle of resolution, p=0.07), and age 71.0 ± 10.2 years (p=0.34). No patient reached NLP vision at any point in the study. Mean preoperative IOP was significantly higher in the phaco/MP-TSCPC group than in the phaco alone group (18.37 ± 4.6 mmHg vs 14.30 ± 4.2 mmHg, p=0.02). Primary open-angle glaucoma (POAG) was the most common type of glaucoma in the phaco alone (42%) and phaco/ECP (48%) groups while mixed-mechanism glaucoma was the most common type in the phaco/MP-TSCPC group (40%). Both the phaco/MP-TSCPC (63%,

p<.01) and the phaco/ECP (32%, p=0.03) groups had significantly lower proportions of severe glaucoma patients than the phaco alone groups (92%) (**Table 1**).

Effectiveness

A life table displaying the cumulative probability of survival in all three groups is displayed in **Table 2.**The cumulative probability of failure was significantly lower in the phaco/MP-TSCPC group compared to the phaco alone group (p<0.001, Figure 2) Holding preoperative characteristics constant (age, sex, baseline IOP, number of medications, and type of glaucoma), the phaco alone group was 3.40 times as likely to reach failure at any time point compared to phaco/MP-TSCPC group (p=0.005). Additionally, the cumulative probability of reaching failure at any time point was 1.98 times more likely following phaco/ECP compared to phaco/MP-TSCPC (p=0.038). However, once the differences in preoperative IOP were accounted for through the Cox PH model, this difference only approached significance (p=0.052). Patients who received phaco were 1.40 times more likely to reach failure as those who received phaco/ECP (p=0.044, **Table 3**). Preoperative IOP was found to be negatively correlated with the probability of failure in all Cox PH models (**Table 3**). Neither the age, sex, type of glaucoma, or number of preoperative medications of the patient was found to be correlated with the probability of failure in any of the Cox PH models (**Supplementary Table 1**).

The phaco/MP-TSCPC group achieved greater average IOP reduction than the phaco alone group at the month 3 (8.53 ± 6.8 vs 0.53 ± 1.65 mmHg, p<0.01), and month 6 (2.70 ± 5.0 vs 1.86 ± 1.2, p=0.02) visits. The phaco/MP-TSCPC group achieved greater average IOP reduction than the phaco/ECP group at month 1.5 (6.03 ± 6.8 vs 0.72 ± 2.25, p=0.02) and month 3 (8.53 ± 6.8 vs 0.53 ±1.65, p<0.01). At 1 year, the mean IOP reduction was 1.0 ± 1.6 mmHg in the phaco alone group, 6.0 ± 4.3 mm Hg in the phaco/MP-TSCPC group, and 3.07 ± 5.3 in the phaco/ECP group (p = 0.12). While the phaco/ECP group achieved greater average IOP reduction than the phaco alone group from week 1 onwards, this difference did not achieve statistical significance. **(Table 4)**. The phaco/MP-TSCPC group achieved a significantly higher mean medication reduction than the phaco alone group at the 6-month visit (1.3 ± 0.8 vs -0.09 ± 0.83, p=0.023, **Table 5**).

Changes in LogMAR visual acuity from baseline were not significantly different between the groups at any time point. (**Supplementary Table 2**). 61% (39) of the total patient population had visual field information available. There were no changes in visual field data postoperatively from the preoperative baseline for the patients who had visual field information available **(Supplementary Table 3**).

In terms of complications, 25% of the patients in the phaco/MPTSCPC group had anterior chamber inflammation at postoperative week 6, while 8% of patients in the phaco/ECP group and 0% of patients in the phaco alone group had inflammation at that time point (p=0.31). All instances of inflammation were resolved by the 6-month follow-up visit. There were no instances of endophthalmitis, hypotony or retinal detachment. There were no instances of any long-term postoperative complications within the 1-year follow-up period **(Table 6).**

Discussion

To the best of our knowledge, this is one of the first studies to examine the relative safety and effectiveness of MP-TSCPC and ECP as adjunct procedures combined with phacoemulsification. Prior studies have mostly demonstrated a limited IOP-lowering effect for phacoemulsification when performed alone. Arthur et al. demonstrated a mean IOP reduction of 2.5 mmHg from a baseline of 16.2 mmHg in a group of 37 patients with open-angle glaucoma.[5] Additionally, Poley et al. reported a mean IOP reduction of 2.7 mmHg at 1 year from a baseline of 17.8 mmHg in a group of 124 eyes. The authors noted that the magnitude of IOP reduction was highly correlated with the preoperative IOP.[6] The IOP reduction of the phaco alone group in the present study was less than that of prior studies at 1.0 mmHg at 1 year, which may be due to the comparatively lower preoperative IOP of 14.30 mmHg.

The use of combined ECP and phacoemulsification has been well established in the literature.[4,7–11] It has emerged as a preferred adjunct microinvasive procedure to phacoemulsification, primarily due to its convenience and low complication rate. Despite its popularity, some data on the long-term effectiveness of phaco/ECP as an IOP-lowering tool has been mixed. In a retrospective cohort study that consisted of 99 POAG patients, Perez et al. demonstrated that the surgical success rate after 1 year was significantly higher in the phaco/ECP group than in the phaco alone group (69.6% versus 40.0%, p=0.004).[12] Similarly, Francis et al. demonstrated mean IOP reductions of 2.7 mmHg and 0.9 mmHg in the phaco/ECP and phaco alone groups, respectively, at 3 years (p=0.003). Interestingly, the group that underwent cataract extraction alone showed regression to the preoperative IOP after 2-3 years of follow up while the group that received phaco/ECP seemed to maintain the IOP reduction throughout the entire course of the study.[13]

Other studies have raised into question the ability of phaco/ECP to consistently produce adequate IOP-reduction. In a retrospective study of over 300 eyes, Siegel et al. reported no significant difference in the IOP-lowering effect of phaco/ECP and phaco after 3 years of follow-up. Additionally, Lindfield et al. reported an average IOP reduction of 7.11 mmHg from a baseline of 21.54 mmHg at 18 months, with a mean medication reduction of 0 drops from a baseline of 1.98 drops.[9] While the IOP was significantly lowered at each follow-up visit, the authors noted that the reduction was not great enough for phaco/ECP to be considered an alternative for filtration surgery in high-risk eyes, rapidly progressive patients or when a low target pressure (<14 mmHg) is indicated. With an IOP reduction of 3.07 mmHg in the phaco/ECP group, the reduction at 1 year in the present study was amongst the lowest reported in the literature, despite treating at least 300° of the ciliary processes in all cases. The preoperative medicated IOP here was 15.78 mmHg in the phaco/ECP group, which was amongst the lowest reported in the literature. The comparatively low mean IOP reductions observed here are likely attributable to the low preoperative IOPs, as preoperative IOP has consistently been demonstrated to correlate with the magnitude of IOP reduction.

The results of the present study suggest that phaco/MP-TSCPC may allow for greater IOP reduction than phaco/ECP or phaco alone without increasing the risk of postoperative complications. The KM survival curves along with the results of the Cox Proportional Hazards model seem to indicate that phaco/MP-

TSCPC may be more effective than phaco/ECP in terms of long-term IOP reduction. While there was a significant difference in the unadjusted survival curves of the patients who received phaco/MP-TSCPC and phaco/ECP (p=0.038), this difference only approached significance when the differences in pretreatment characteristics were accounted for (p=0.052). As with other studies comparing phaco/ECP and phaco, phaco/ECP appeared to provide comparatively greater long-term IOP control than phaco alone. While both the phaco/MP-TSCPC and the phaco/ECP groups outperformed the phaco alone groups in terms of survival rates, combining MP-TSCPC rather than ECP with phacoemulsification seemed to provide for even greater long-term IOP reduction. When the differences in preoperative characteristics were adjusted for, phaco/MP-TSCPC was 3.4 times less likely to reach surgical failure at any time point compared to phaco alone (p=0.005). The long-term IOP-lowering effect in the phaco/ECP group seemed to be comparatively weaker, as performing phaco/ECP was only 1.4 times less likely than phaco alone to result in surgical failure at any time point (p=0.038). Notably, the majority of patients included in the phaco/MP-TSCPC group in the present study had severe glaucoma (63%). The use of phaco/MP-TSCPC in this group provided a mean IOP reduction of 6.0 mmHg at 1 year postoperatively, with a mean IOP of 12.37 mmHg at the 1-year visit. Prior studies have demonstrated that the maintenance of IOP within this range is effective in reducing the advancement of visual field defects, particularly in patients with severe glaucoma.[14] The sustained IOP reduction observed in this group indicates that phaco/MP-TSCPC may potentially be considered as an alternative to filtration surgery in patients with severe glaucoma.

In our cohort, post-operative complications were rare and were similar to those reported in the literature. Notably, all cases of postoperative inflammation resolved by the 6-month follow-up visit, and there were no new cases of CME in any group.

This study has several limitations. It is important to note that this study samples patients from a tertiary referral center and we cannot exclude biased referral patterns resulting in sampling bias. In addition, the study’s retrospective design, sample size and follow-up duration may also limit generalizability.

In conclusion, the results of the present study indicate that phaco/MP-TSCPC and phaco/ECP may be comparably safe and efficacious in reducing IOP when compared to phacoemulsification alone. Future studies on prospective randomized studies of combined MIGS procedures are needed to elucidate the optimal combination in different patient populations.

Declarations

Ethics approval and consent to participate”

Approval for this study was provided by the Partners Healthcare Institutional Review Board

Consent for publication:

n/a

Availability of data and materials”

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests”

The authors declare that they have no competing interests

Funding:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Authors’ contributions:

A.N. contributed to the conception, data acquisition, analysis, and drafting of this manuscript. E.K. and C.N. contributed to the data acquisition and drafting. M.C. contributed to the data acquisition. L.Q.S., T.C., and D.S. contributed to the conception and drafting of this work. All authors have approved of the submitted version of this work.

Acknowledgements

Ethics approval and consent to participate

The study protocol was approved by the Institutional Review Board of Massachusetts Eye and Ear (MEE), and the data collection methods abided by the Declaration of Helsinki and the Health Portability and Accountability

References

1. Dastiridou AI, Katsanos A, Denis P, et al. Cyclodestructive Procedures in Glaucoma: A Review of Current and Emerging Options. *Adv Ther*. 2018,35(12):2103-2127. doi:10.1007/s12325-018-0837-3
2. Anand N, Klug E, Nirappel A, Solá-Del Valle D. A Review of Cyclodestructive Procedures for the Treatment of Glaucoma. *Semin Ophthalmol*. 2020,35(5-6):261-275. doi:10.1080/08820538.2020.1810711
3. Fellman R., Mattox C., K.M. R, Vicchrilli S. Know the New Glaucoma Codes. *EyeNet Mag*. Published online 2011:65-66. http://www.aao.org/eyenet/article/know-new-glaucoma-staging-codes?october-2011
4. Dondelinger R. Phacoemulsification systems. *Biomed Instrum Technol*. 2013,47(6):499-503. doi:10.2345/0899-8205-47.6.499
5. Arthur SN, Cantor LB, Wudunn D, et al. Efficacy, safety, and survival rates of IOP-lowering effect of phacoemulsification alone or combined with canaloplasty in glaucoma patients. *J Glaucoma*.

2014,23(5):316-320. doi:10.1097/IJG.0b013e3182741ca9

6. Poley BJ, Lindstrom RL, Samuelson TW, Schulze R. Intraocular pressure reduction after phacoemulsification with intraocular lens implantation in glaucomatous and nonglaucomatous eyes. Evaluation of a causal relationship between the natural lens and open-angle glaucoma. *J Cataract Refract Surg*. 2009,35(11):1946-1955. doi:10.1016/j.jcrs.2009.05.061
7. Sun W, Yu CY, Tong JP. A review of combined phacoemulsification and endoscopic cyclophotocoagulation: Efficacy and safety. *Int J Ophthalmol*. 2018,11(8):1396-1402. doi:10.18240/ijo.2018.08.23
8. Siegel MJ, Boling WS, Faridi OS, et al. Combined endoscopic cyclophotocoagulation and phacoemulsification versus phacoemulsification alone in the treatment of mild to moderate glaucoma. *Clin Exp Ophthalmol*. 2015,43(6):531-539. doi:10.1111/ceo.12510
9. Lindfield D, Ritchie RW, Griffiths MFP. "Phaco-ECP": Combined endoscopic cyclophotocoagulation and cataract surgery to augment medical control of glaucoma. *BMJ Open*. 2012,2(3):1-6. doi:10.1136/bmjopen-2011-000578
10. Waldman CW, Desai M, Rahman EZ, Eliassi-rad B. Combined Endocyclophotocoagulation and Phacoemulsification in Patients with Glaucoma of African Descent. 2019,8(4).
11. Uram M. Combined Phacoemulsification, Endoscopic Ciliary Process Photocoagulation, and Intraocular Lens Implantation in Glaucoma Management. *Ophthalmic Surg*. 1995,26(4):346-352.
12. Pérez Bartolomé F, Rodrigues IA, Goyal S, et al. Phacoemulsification plus endoscopic cyclophotocoagulation versus phacoemulsification alone in primary open-angle glaucoma. *Eur J Ophthalmol*. 2018,28(2):168-174. doi:10.5301/ejo.5001034
13. Francis BA, Berke SJ, Dustin L, Noecker R. Endoscopic cyclophotocoagulation combined with phacoemulsification versus phacoemulsification alone in medically controlled glaucoma. *J Cataract Refract Surg*. 2014,40(8):1313-1321. doi:10.1016/j.jcrs.2014.06.021
14. The AGIS Investigators. The Advanced Glaucoma Intervention Study (AGIS): 7. The relationship between control of intraocular pressure and visual field deterioration. *Am J Ophthalmol*. 2000,130(4):429-440. doi:10.1016/S0002-9394(00)00538-9

Tables

Table 1: Baseline Characteristics

	Baseline Characteristics			p-value		
	phaco	phaco/MP-TSCPC	phaco/ECP	phaco vs phaco/ECP	phaco vs phaco/MP-TSCPC	phaco ECP vs phaco/MP-TSCPC
Number of eyes	19	20	25			
Mean Age (± SD)	66.75 ± 9.7	73.05 ± 14.9	72.68 ± 9.8	0.33	0.38	0.88
Age (Range)	52-83	38-91	49-93			
Sex (% Female)	63	55	48	0.32	0.60	0.64
IOP (mm Hg ± SD)	14.30 ± 4.2	18.37 ± 4.6	15.78 ± 4.7	0.45	0.02	0.11
Medications (±SD)	1.75 ± 1.30	3.37 ± 1.30	2.84 ± 1.30	0.13	<0.01*	0.20
Visual Acuity (±SD)	0.68 ± 0.54	0.84 ± 0.98	0.33 ± 0.23	0.20	0.80	0.57
Mean Follow-up Time (±SD) (days)	112.82 ± 7.87	256.39 ± 42.33	215.27 ± 34.36	0.01*	0.01*	0.67
Type of Glaucoma, N (%)						
Ocular hypertension	0 (0)	0 (0)	1 (4)	n/a	n/a	n/a
POAG	8 (42)	4 (16)	12 (48)	0.04	0.25	1
PXFG	2 (11)	0 (0)	2 (8)	0.82	n/a	n/a
Pigmentary	0 (0)	0 (0)	2 (8)	n/a	n/a	n/a
NTG	1 (8)	0 (0)	0 (0)	n/a	n/a	n/a
MMG	0 (0)	8 (40)	3 (12)	n/a	n/a	0.09
CACG	1 (8)	8 (40)	5 (20)	0.45	0.22	0.56
Severity of Glaucoma, N (%)						
Ocular hypertension	0 (0)	0 (0)	1 (4)	n/a	n/a	n/a
Mild	0 (0)	2 (11)	6 (24)	n/a	n/a	n/a

Moderate	1 (8)	5 (26)	10 (40)	0.32	0.45	0.53
Severe	11 (92)	12 (63)	8 (32)	<0.01*	0.03*	0.28

IOP=intraocular pressure, SD=standard deviation, mm Hg=millimeters of mercury, N=number of eyes, POAG=Primary Open-Angle Glaucoma, PXFG=Pseudoexfoliation Glaucoma, NTG=Normal Tension Glaucoma, MMG=Mixed-mechanism glaucoma, CAG = Chronic Angle-Closure Glaucoma, *indicates a significant difference

Table 2: Life table displaying the cumulative probabilities of survival in the phaco/ECP, phaco/MP-TSCPC, and phaco alone groups at 100 and 200 days postoperatively. Failure was defined as reaching NLP vision at any point postoperatively or the inability to maintain ≥20% IOP reduction from baseline with IOP between 5-18 mmHg for two consecutive follow-up visits

	Survival Probability	95% CI
Phaco/ECP		
100±15days	37.0%	(22.6%, 60.6%)
200±15 days	32.4%	(18.6%, 56.6%)
Phaco/MP-TSCPC		
100±15days	67.0%	(47.0%, 95.5%)
200±15 days	58.6%	(37.7%, 91.1%)
Phaco		
100±15days	18.8%	(5.4%, 65%)
200±15 days	0	N/A

CI=Confidence Interval, phaco=phacoemulsification, MP-TSCPC=MP-TSCPC=Micropulse Transscleral Cyclophotocoagulation (IRIDEX Corp., Mountainview, CA), ECP=endoscopic cyclophotocoagulation

Table 3: Output of the pairwise log-rank tests and Cox PH Model

Log Rank Test and Cox PH Model Outcomes	Hazard Ratio	p-value
phaco vs phaco/MP-TSCPC		
Log-Rank test		<0.001*
Procedure	3.40	0.005*
Preoperative IOP	1.09	0.011*
phaco vs phaco/ECP		
Log-Rank test		0.037*
Procedure	1.40	0.044*
Preoperative IOP	1.11	0.004*
phaco/ECP vs phaco/MP-TSCPC		
Log-Rank test		0.038*
Procedure	1.98	0.052
Preoperative IOP	1.12	0.002*

phaco=phacoemulsification, MP-TSCPC=MP-TSCPC=Micropulse Transscleral Cyclophotocoagulation (IRIDEX Corp., Mountainview, CA), ECP=endoscopic cyclophotocoagulation, PH=Proportional Hazards, *indicates a significant difference Holding all else constant, the probability of achieving failure at any time point postoperatively with phaco alone was 3.40 times more likely than with phaco/MP-TSCPC (p=0.005). Higher baseline IOP was found to be a statistically significant predictor of survival in comparing phaco/MP-TSCPC and phaco alone, with a one unit increase in baseline IOP reducing the hazard of clinical failure at any point in time by 9% (p=0.022)

Table 4: Comparison of average IOP reductions between the phaco/ECP, phaco/MP-TSCPC, and phaco alone groups.

Mean IOP reduction (mm Hg ± SD)				p-value		
	phaco	phaco/MP-TSCPC	phaco/ECP	phaco vs phaco/ECP	phaco vs phaco/MP-TSCPC	phaco/ECP vs phaco/MP-TSCPC
Day 1	-5.13 ± 9.2	0.53 ± 4.5	-3.13 ± 4.3	0.69	0.16	0.39
n	*19*	*20*	*25*			
Week 1	0.04 ± 2.23	2.13 ± 7.3	4.68 ± 5.6	0.18	0.13	0.41
n	*17*	*20*	*24*			
Week 6	0.72 ± 2.25	6.03 ± 6.8	2.83 ± 9.3	0.33	<0.01*	0.02*
n	*19*	18	*19*			
Month 3	0.53 ± 1.65	8.53 ±6.8	2.81 ± 4.0	0.24	<0.01*	<0.01*
n	*16*	*18*	*21*			
Month 6	1.86 ± 1.2	6.80 ± 4.4	2.70 ± 5.0	0.38	0.02*	0.08
n	*18*	*18*	*25*			
Year 1	1.0 ± 1.6	6.0 ± 4.3	3.07 ± 5.3	0.24	0.10	0.10
n	*17*	*19*	*23*			

IOP=Intraocular pressure, mm Hg=millimeters of Mercury, phaco=phacoemulsification, MP-TSCPC=MP-TSCPC=Micropulse Transscleral Cyclophotocoagulation (IRIDEX Corp., Mountainview, CA), ECP=endoscopic cyclophotocoagulation, (SD)=standard deviation, a negative IOP reduction indicates an increase in IOP postoperatively, *n*= number of patients at each follow-up visit, *indicates a significant difference

Table 5: Comparison of average medication reductions between the phaco/ECP, phaco/MP-TSCPC, and phaco alone groups.

Mean Med reduction (mm Hg ± SD)				p-value		
	phaco	phaco/MP-TSCPC	phaco/ECP	phaco vs phaco/ECP	phaco vs phaco/MP-TSCPC	phaco/ECP vs phaco/MP-TSCPC
Day 1	0.27 ± .50	1 ± 0.87	0.36 ± 0.48	0.96	0.11	0.07
Week 1	0.58 ± 1.09	0.68 ± 0.70	0.79 ± 0.48	0.79	0.95	0.92
Week 6	0.13 ± 0.8	0.65 ± 0.53	0.82 ± 1.03	0.38	0.60	0.90
Month 3	-0.25 ± 1.5	0.47 ± 0.58	0.92 ± 0.47	0.22	0.54	0.72
Month 6	-0.09 ± 0.83	1.3 ± 0.8	1 ± 0.75	0.08	*0.03	0.82
Year 1	-0.2 ± 1.2	0.25 ± 1.1	0.62 ± 0.76	0.12	0.92	0.38

phaco=phacoemulsification, MP-TSCPC=MP-TSCPC=Micropulse Transscleral Cyclophotocoagulation (IRIDEX Corp., Mountainview, CA), ECP=endoscopic cyclophotocoagulation, (SD)=standard deviation, *indicates a significant difference

Table 6: Comparison of complication rates between the phaco alone, phaco/MP-TSCPC and phaco/ECP groups

Complication Rates, N (%)	phaco	phaco/MP-TSCPC	phaco/ECP	p-value (one-way ANOVA)
Week 6				
Inflammation	0 (0)	5 (25)	2 (8)	0.31
CME	0 (0)	0 (0)	0 (0)	n/a
Posterior Synechiae	0 (0)	0 (0)	0 (0)	n/a
Anterior Synechiae	0 (0)	0 (0)	0 (0)	n/a
Endophthalmitis	0 (0)	0 (0)	0 (0)	n/a
Hypotony	0 (0)	0 (0)	0 (0)	n/a
Retinal Detachment				
Month 3				
Inflammation	0 (0)	2 (10)	0 (0)	.11
CME	0 (0)	0 (0)	0 (0)	n/a
Posterior Synechiae	0 (0)	0 (0)	0 (0)	n/a
Anterior Synechiae	0 (0)	0 (0)	0 (0)	n/a
Endophthalmitis	0 (0)	0 (0)	0 (0)	n/a
Hypotony	0 (0)	0 (0)	0 (0)	n/a
Retinal Detachment				
Month 6				
Inflammation	0 (0)	0 (0)	0 (0)	n/a
CME	0 (0)	0 (0)	0 (0)	n/a
Posterior Synechiae	0 (0)	0 (0)	0 (0)	n/a
Anterior Synechiae	0 (0)	0 (0)	0 (0)	n/a
Endophthalmitis	0 (0)	0 (0)	0 (0)	n/a
Hypotony	0 (0)	0 (0)	0 (0)	n/a
Retinal Detachment	0 (0)	0 (0)	0 (0)	n/a
Year 1				
Inflammation	0 (0)	0 (0)	0 (0)	n/a
CME	0 (0)	0 (0)	0 (0)	n/a
Posterior Synechiae	0 (0)	0 (0)	0 (0)	n/a

Anterior Synechiae	0 (0)	0 (0)	0 (0)	n/a
Endophthalmitis	0 (0)	0 (0)	0 (0)	n/a
Hypotony	0 (0)	0 (0)	0 (0)	n/a
Retinal Detachment	0 (0)	0 (0)	0 (0)	n/a

N=number of eyes, phaco=phacoemulsification, MP-TSCPC=MP-TSCPC=Micropulse Transscleral Cyclophotocoagulation (IRIDEX Corp., Mountainview, CA), ECP=endoscopic cyclophotocoagulation, CME=Cystoid Macular Edema

Figures

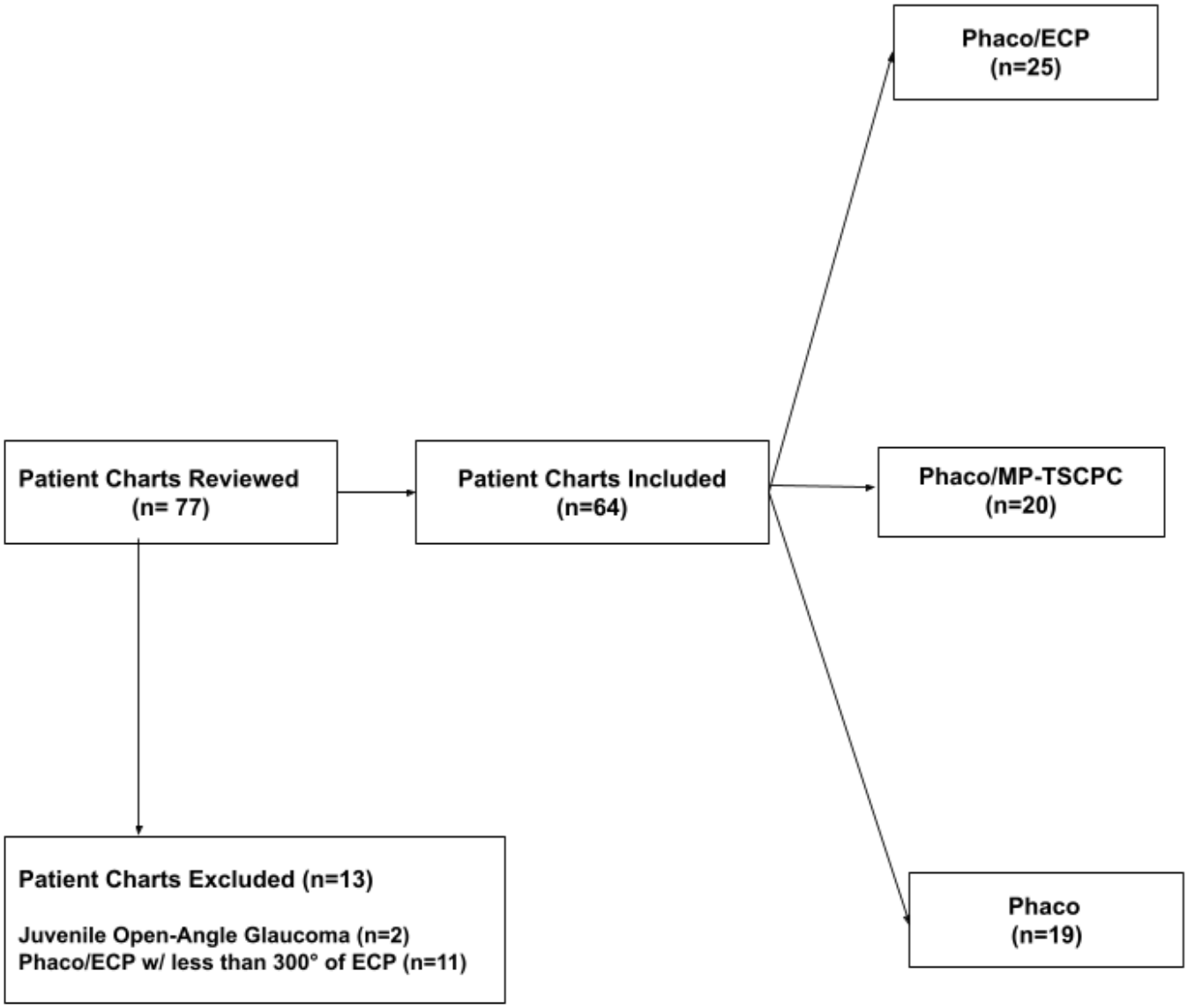

Figure 1

Flowchart depicting exclusion criteria and sample sizes for each arm.

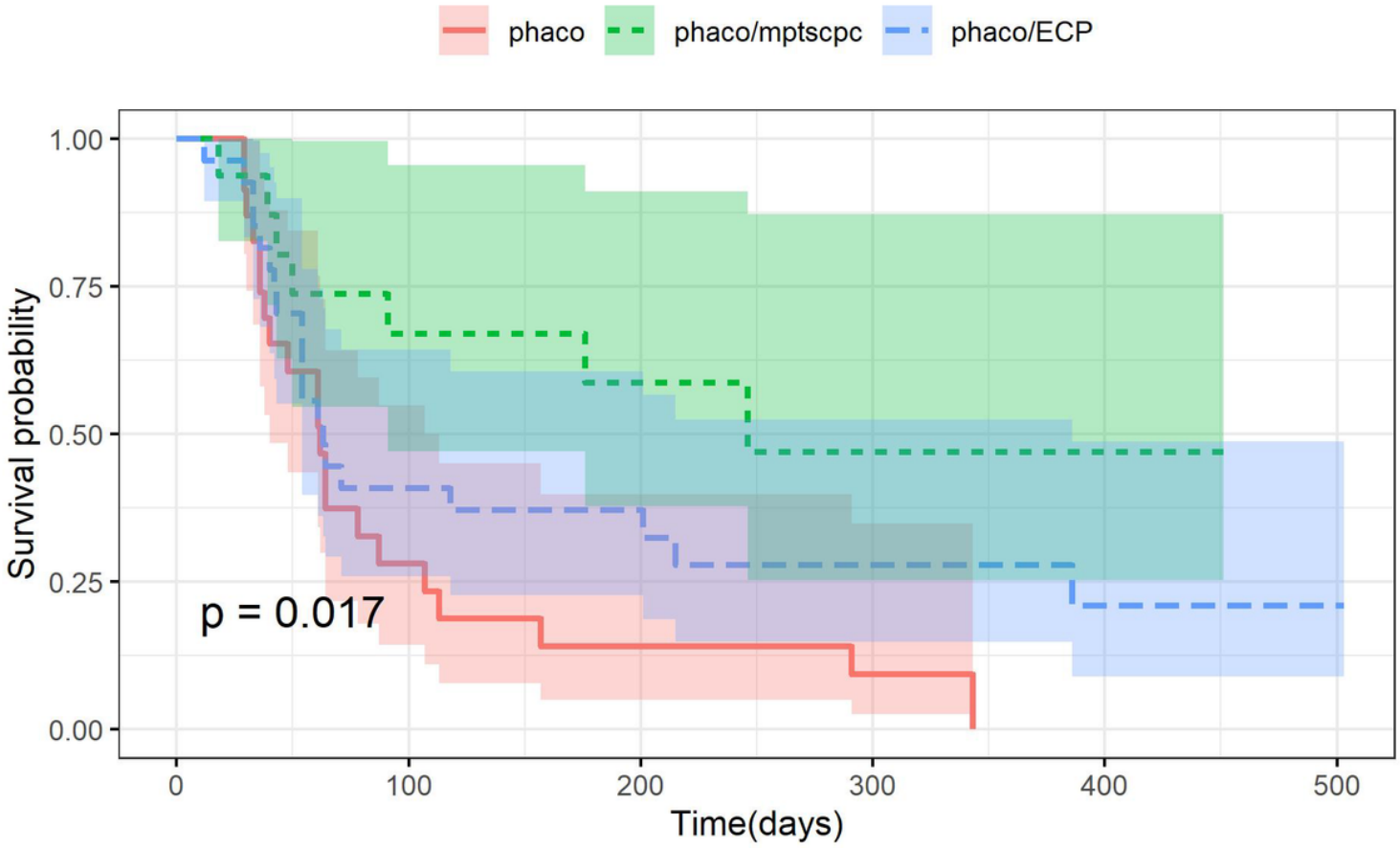

Figure 2

Kaplan-Meier curve comparing the cumulative probabilities of failure following phaco/ECP alone, phaco/MP-TSCPC, and phaco alone.

Supplementary Files

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

- SupplementaryTable110.12113.pdf
- SupplementaryTable210.1213.pdf
- SupplementaryTable310.127.pdf