COMBINED CATARACT AND GLAUCOMA SURGERY: THE EFFECT OF PUPIL ENLARGEMENT ON SURGICAL OUTCOMES (AN AMERICAN OPHTHALMOLOGICAL SOCIETY THESIS)

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ABSTRACT

Purpose: To determine whether pupil enlargement during phacotrabeculectomy affects postoperative visual acuity and intraocular pressure (IOP) compared to combined surgery without pupil enlargement.

Methods: A retrospective study of 74 patients who underwent combined phacotrabeculectomy with (37 eyes) or without (37 eyes) pupil enlargement was performed. Postoperative outcome measures included best-corrected visual acuity (BCVA), IOP, number of medications, and complications up to 6 months. Wilcoxon-Mann-Whitney test was used to compare outcomes between groups.

Results: Demographic characteristics of the two groups were similar except for diagnosis; chronic angle-closure glaucoma and pseudoexfoliation syndrome were more common in the pupil enlargement group. Preoperatively, the pupil enlargement group had a mean IOP of 21.2 ± 6.6 mm Hg compared to 21.1 ± 6.4 mm Hg for the control group (P=.978, Wilcoxon-Mann-Whitney test). Mean preoperative logMAR equivalent (BCVA) was 0.68 ± 0.67 and 0.63 ± 0.59, respectively (P=.727, Wilcoxon-Mann-Whitney test). At 6 months, mean IOP was 15.5 ± 5.6 mm Hg in the study group and 13.3 ± 4.5 mm Hg in the control group (P=.039, Wilcoxon-Mann-Whitney test). Mean postoperative vision at 6 months was better in the control group (0.36 ± 0.48) vs pupil enlargement group (0.51 ± 0.66) but not statistically different (P=.324 Wilcoxon-Mann-Whitney test). The groups did not differ in number of postoperative glaucoma medications. Complications were rare in both groups.

Conclusion: The results of this study suggest that the outcomes of combined phacoemulsification and trabeculectomy are not adversely impacted by pupil enlargement, although IOP control may be relatively impaired.

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INTRODUCTION

The surgical management and postoperative care of glaucoma patients who develop visually significant cataracts is complex compared to cataract surgery alone in eyes without glaucoma. Concomitant cataract and glaucoma is a common finding, especially among the elderly population.[1-3] Although there is still some controversy as to whether phacoemulsification combined with trabeculectomy is the best surgical approach in such cases, it is frequently practiced in patients with both a visually significant cataract and glaucoma.[4-11] Often a combined approach is used not only to improve vision but also to regulate the intraocular pressure (IOP) in the postoperative period, especially when multiple glaucoma medications are needed preoperatively to keep the IOP at a reasonable level. Some reports suggest that combined phacotrabeculectomy is as safe and effective in controlling IOP as trabeculectomy alone.[5-7] However, a combined approach has been found to be associated with more postoperative complications compared to phacoemulsification alone.[8,12-14]

Phacoemulsification performed in patients with glaucoma is frequently challenging because of a number of factors, including a small pupil that is resistant to pharmacologic dilation or even viscoelastic mechanical dilation. It has been reported that 42.5% of patients with glaucoma undergoing cataract surgery require pupil dilation such as sphincterotomy.[15] Reasons for this may be use of miotic therapy, posterior synechiae after uveitis or laser iridotomy, or iris atrophy and fibrosis with pseudoexfoliation.[16] Small pupils encountered during phacoemulsification are associated with a number of serious intraoperative complications, such as posterior capsule rupture, vitreous loss, iris injury, and corneal injury.[17,18] Therefore, adequate dilation in these patients prior to starting phacoemulsification is a reasonable objective. A number of techniques have been recommended to enlarge the pupil in order to allow easier cataract removal.[19-26] These include iris pupillary mini-sphincterotomies or pupilloplasty,[27] mechanical pupil stretching bimanually with instruments or a device like a Beehler dilator,[28-30] pupillary rings,[31,32] and flexible iris hooks.[21,33-36] However, excessive iris manipulation increases the level of postoperative inflammatory reaction[19] that may jeopardize the success of the combined procedure. Manipulation and injury of the uveal tissue during these maneuvers may lead to capillary vasodilation, increased vessel permeability, and attraction of inflammatory cells.[37] Postoperative inflammation has been identified as an important factor for trabeculectomy failure, especially in the early postoperative period. There is an added concern that there may be corneal edema, macular edema, and trabeculectomy failure (Yuen D, et al. IOVS 2007;48:ARVO E-abstract 5462). Shingleton and colleagues[38] found that the use of pupil stretching during phacoemulsification was not associated with a significant difference in IOP, best-corrected visual acuity (BCVA), inflammation, or other complications postoperatively and can be used safely in patients with small, poorly dilated pupils. It is unclear, however, whether pupil stretching has a negative influence on surgical outcomes of glaucoma patients undergoing phacotrabeculectomy.

In this study, our aim was to determine whether pupil enlargement during combined phacotrabeculectomy affects postoperative BCVA and IOP compared with the outcomes of patients who underwent combined surgery but without pupil manipulation. Our hypothesis is that intraoperative iris manipulation may cause increased ocular inflammation, which may affect the surgical outcomes of phacotrabeculectomy; patients who undergo phacotrabeculectomy with pupil stretch may have higher postoperative IOP, especially in the early postoperative period.

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MATERIALS AND METHODS

This study was approved by the Institutional Review Board of Wills Eye Institute (IRB 10051E) and followed the tenets of the Declaration of Helsinki. A retrospective analysis of data from 221 patients who underwent combined phacotrabeculectomy with or without pupil enlargement was performed. Procedures were performed by six surgeons at Wills Eye Institute between 2005 and 2010. Effort was made to contact referring physicians and obtain follow-up information. We excluded patients with insufficient data to guarantee 6 months of follow-up and patients that had concomitant surgeries. Seventy-four patients were included in the study: 37 who underwent combined surgery with concomitant use of pupil enlargement (the study population) and 37 with adequate pharmacologic dilation who did not need pupil manipulation (the control group). Patients were chosen based on age and IOP to be matched controls for data analysis. Iris enlargement was defined as any procedure where the pupils were mechanically stretched with iris hooks; Malyugin ring (MicroSurgical Technology, Redmond, Washington); a bimanual maneuver with Kuglen hook (Katena Products Inc, Denville, New Jersey), Sinskey hook (Katena Products Inc), collar button, or Lester hook (Katena Products Inc); or by multiple sphincterotomies.

Baseline IOP, visual acuity, number of hypotensive medications, demographics, ocular characteristics, diagnosis, and history of ocular surgery, laser, and tamsulosin use were noted Details of the surgery were also recorded, including type of iris enlargement technique used, one-site vs two-site approach, type of conjunctival flap (limbus- vs fornix-based), intraoperative complications, and use of antimetabolites, trypan blue, and intracameral triamcinolone and acetylcholine. Postoperative outcome measures included visual acuity, IOP, number of medications, and complications at 1 week, 1 month, and 6 months.

STATISTICAL ANALYSIS

Analyses were performed using SAS 9.2 (SAS Institute Inc, Cary, North Carolina). To summarize the data, frequency counts with percentages were tabulated for categorical variables, and means with standard deviations were calculated for continuous variables. The associations between group and various patient characteristics, intraoperative and postoperative variables, and outcomes were also tested. Fisher exact tests were used for testing group independence for each categorical variable, such as diagnosis. For continuous variables, such as age, the normal approximation to the Wilcoxon-Mann-Whitney test was used for comparison of central tendency between groups.

Wilcoxon-Mann-Whitney test was used to determine if any association exists between having pupil enlargement and visual acuity, IOP, and medication use. Visual acuity and IOP were analyzed on a continuous scale using linear mixed modeling. A generalized estimating equations (GEE) Poisson model was employed to test the effect of group on number of medications taken. In all multivariable models, the following predictors were considered: group, age, sex, diagnosis, history of iridotomy, and site. Additionally, the preoperative VA and preoperative IOP levels were included in the VA and IOP models, respectively. Group was included in all models regardless of significance, whereas the other variables were assessed using a backwards elimination algorithm and retained if their *P* value was <.1. The significance level for all tests was set at $\alpha = .1$.

RESULTS

GROUP CHARACTERISTICS

The characteristics of the pupil enlargement group and control group were comparable in most variables. There were no significant differences between the groups in terms of age, gender, eye, tamsulosin use, previous laser trabeculoplasty, and previous use of brimonidine and pilocarpine.

Differences between the groups that do achieve statistical significance include differences in diagnosis (*P*=.022, Fisher's exact test) and history of laser peripheral iridotomy (*P* =.0166, Fisher's exact test). Eighty-one percent of the control group and 51% of the pupil stretch group were diagnosed with primary open-angle glaucoma (POAG). Chronic angle-closure glaucoma (CACG) and pseudoexfoliative glaucoma are more common in the pupil stretch group than the control group, although POAG is the predominant diagnosis in both groups. These characteristics are summarized in Table 1 by group.

OPERATIVE TECHNIQUES

Procedures were performed by six surgeons. The divide and conquer phacoemulsification technique was used in all cases. The groups differed in site (*P*=.001, Fisher's exact test) and use of trypan blue (*P*=.005, Fisher's exact test), which was used exclusively in the pupil stretch group in 22% of the cases. Over half of the procedures performed in the pupil stretch group (54%) involved two sites, compared to only 16% of the control group. The groups were similar in regard to use of intracameral acetylcholine and use and duration of intraoperative mitomycin C, 0.4 mg/mL. Findings are summarized in Table 2.

POSTOPERATIVE MANAGEMENT

All patients received topical prednisolone acetate in the postoperative period. The average steroid use in the postoperative period was 6.97 weeks in the pupil stretch group and 7.05 in the control group (*P*=.58, Wilcoxon-Mann-Whitney test). One patient in the group with no pupil stretch and one patient in the group with pupil stretch used steroid drops for more than 12 weeks postoperatively. Both patients had anterior uveitis preoperatively. There were no significant differences between the groups in terms of total laser suture lysis or releasable sutures removed (*P*>.20 for all, Fisher's exact test). Findings are summarized in Table 3.

TABLE 1. DEMOGRAPHIC AND PREOPERATIVE OCULAR CHARACTERISTICS OF GLAUCOMA PATIENTS WHO UNDERWENT COMBINED CATARACT AND GLAUCOMA SURGERY WITH AND WITHOUT PUPIL STRETCH

VARIABLE	CONTROL GROUP (n = 37)		PUPIL STRETCH GROUP (n = 37)		*P*
Age, mean ± SD	77.2 ± 9.7		77.1 ± 11.5		.808*
Age, n (%)					
<70	8	(22)	7	(19)	
70-79	11	(30)	10	(27)	
80+	18	(49)	20	(54)	
Gender, n (%)					.808†
Female	23	(62)	25	(68)	
Male	14	(38)	12	(32)	
Ethnicity, n (%)					.407†
Caucasian	23	(62)	19	(51)	
African American	10	(27)	8	(22)	
Asian	1	(3)	2	(5)	
Other	3	(8)	8	(22)	
Glaucoma diagnosis, n (%)					.022†
Chronic angle-closure	3	(8)	6	(16)	
Mixed mechanism	0	(0)	2	(5)	
Normal tension	1	(3)	1	(3)	
Open-angle	30	(81)	19	(51)	
Pseudoexfoliation	2	(5)	7	(19)	
Uveitic	1	(3)	2	(5)	
Tamsulosin use, n (%)					1.000†
No	36	(97)	35	(95)	
Yes	1	(3)	2	(5)	
Previous laser therapy, n (%)					.457†
Argon or Selective Laser Trabeculoplasty, n (%)					
No	27	(73)	23	(62)	
Yes	10	(27)	14	(38)	
Laser peripheral iridotomy, n (%)					.0166†
Yes	9	(24)	20	(54)	
No	28	(76)	17	(46)	
Previous glaucoma surgery, n (%)					1.000†
No	36	(97)	35	(95)	
Yes	1	(3)	2	(5)	
Use of pilocarpine					1.000†
Yes	5	(14)	6	(16)	
No	32	(86)	31	(84)	
Use of brimonidine					.102†
Yes	23	(62)	15	(41)	
No	14	(38)	22	(59)	
Eye, n (%)					.486†
Right	16	(43)	20	(54)	
Left	21	(57)	17	(46)	

SD, standard deviation.
*Wilcoxon-Mann-Whitney test.
†Fisher's exact test.

TABLE 2. INTRAOPERATIVE CHARACTERISTICS OF GLAUCOMA PATIENTS WHO UNDERWENT COMBINED CATARACT AND GLAUCOMA SURGERY WITH AND WITHOUT PUPIL STRETCH

VARIABLE	CONTROL GROUP (n = 37)		PUPIL STRETCH GROUP (n = 37)		P
Type of stretch, n (%)					
Kuglen hook		…	9	(24)	
Collar button		…	3	(8)	
Lester hook		…	1	(3)	
Malyugin ring		…	6	(16)	
Sinskey hook		…	1	(3)	
Iris hook		…	14	(38)	
Sphincterotomy		…	3	(8)	
Surgeon, n (%)					.075†
A	3	(8)	4	(11)	
B	10	(27)	9	(24)	
C	20	(54)	11	(30)	
D	4	(11)	8	(22)	
E	0	(0)	2	(5)	
F	0	(0)	3	(8)	
Conjunctival flap, n (%)					.564†
Fornix-based	31	(84)	28	(76)	
Limbal-based	6	(16)	9	(24)	
Site, n (%)					.001†
One site	31	(84)	17	(46)	
Two sites	6	(16)	20	(54)	
Trypan blue, n (%)					.005†
No	37	(100)	29	(78)	
Yes	0	(0)	8	(22)	
Intracameral acetylcholine use, n (%)					.417†
No	30	(81)	26	(70)	
Yes	7	(19)	11	(30)	
Triamcinolone, n (%)					.493†
No	37	(100)	35	(95)	
Yes	0	(0)	2	(5)	

TABLE 2 CONTINUED.

VARIABLE	CONTROL GROUP (n = 37)		PUPIL STRETCH GROUP (n = 37)		P
MMC use, n (%)					1.000†
No	3	(8)	3	(8)	
Yes	34	(92)	34	(92)	
Mean length MMC use, mean ± SD (weeks)	1.66 ± 0.64		1.59 ± 0.78		.784*
Intraoperative complications, n (%)					1.000†
None	35	(95)	36	(97)	
Posterior capsule rupture	2	(5)	1	(3)	

MMC, mitomycin C; SD, standard deviation.
*Wilcoxon-Mann-Whitney test.
†Fisher's exact test.

TABLE 3. SUMMARY OF POSTOPERATIVE CARE OF GLAUCOMA PATIENTS WHO UNDERWENT COMBINED CATARACT AND GLAUCOMA SURGERY WITH AND WITHOUT PUPIL STRETCH

VARIABLE	CONTROL GROUP (n = 37)		PUPIL STRETCH GROUP (n = 37)		P
Length of postoperative steroid use, mean ± SD (weeks)	7.05 ± 0.2		6.97 ± 0.2		.584*
Releasable sutures removed, n (%)					.004†
No	14	(38)	27	(73)	
Yes	23	(62)	10	(27)	
Laser suture lysis, n (%)					.397†
No	31	(84)	27	(73)	
Yes	6	(16)	10	(27)	

SD, Standard deviation.
*Wilcoxon-Mann-Whitney test.
†Fisher's exact test.

VISUAL ACUITY

Mean preoperative VA was 0.68 for the pupil stretch group compared to 0.63 for the control group. This difference was not statistically significant (*P*=.727, Wilcoxon-Mann-Whitney test). Figure 1 shows preoperative VA levels by group.

Mean logMAR equivalent VA tends to decrease between the three postoperative time points (1 week, 1 month, and 6 months). As seen in Table 4, the only two exceptions of this downward trend are a slight increase between the 1-week and 1-month measures for the pupil stretch group and between the 1-month and 6-month measures in those with CACG.

In the multivariable analysis of VA levels over time, we see that the preoperative VA level is a significant predictor of the change in VA levels in the first 6 months. A 0.1-point increase in preoperative logMAR equivalent translates, in mean, to a 0.06-point higher postoperative VA level. This difference is not significantly dependent on time. Group assignment, that is, whether or not pupil stretch was used, was not found to be significantly associated with VA at any of the three time points considered. The full results of this analysis can be found in Table 5.

INTRAOCULAR PRESSURE

Mean preoperative IOP was 21.2 mm Hg for the pupil stretch group compared to 21.1 mm Hg for the control group, a nonsignificant difference (*P*=.978, Wilcoxon-Mann-Whitney). Figure 2 shows preoperative IOP levels by group. Intraocular pressure appears to decrease over time for all subgroups. Increases in IOP occur within patients less than 70 years old, with a CACG/mixed mechanism glaucoma diagnosis, or with preoperative IOP of less than 20 mm Hg between the preoperative IOP level and 1-week reading. Moreover, an increase is seen in mean IOP between 1 month and 6 months for those with two-site procedures; however, this increase in mean IOP from 14.3 to 14.4 mm Hg is very small. Table 6 includes a more detailed summary of IOP levels over time.

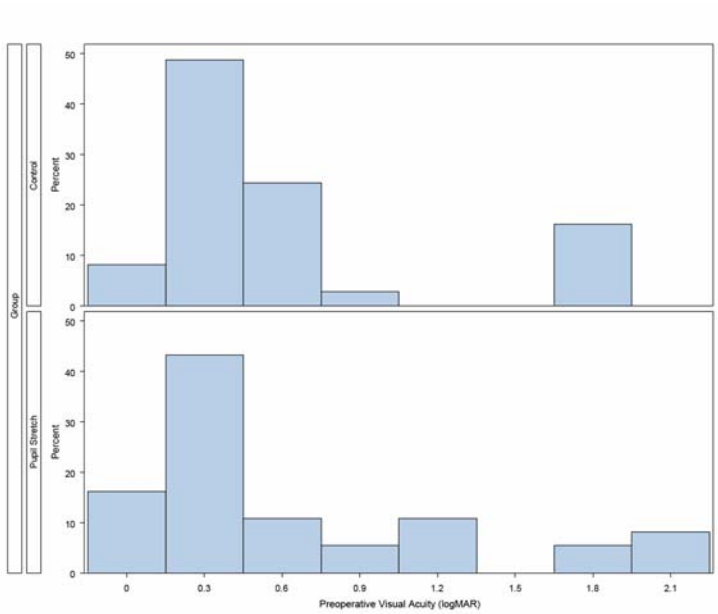

FIGURE 1.

Histogram of preoperative visual acuity levels of glaucoma patients who underwent combined cataract and glaucoma surgery with (top) and without (bottom) pupil stretch.

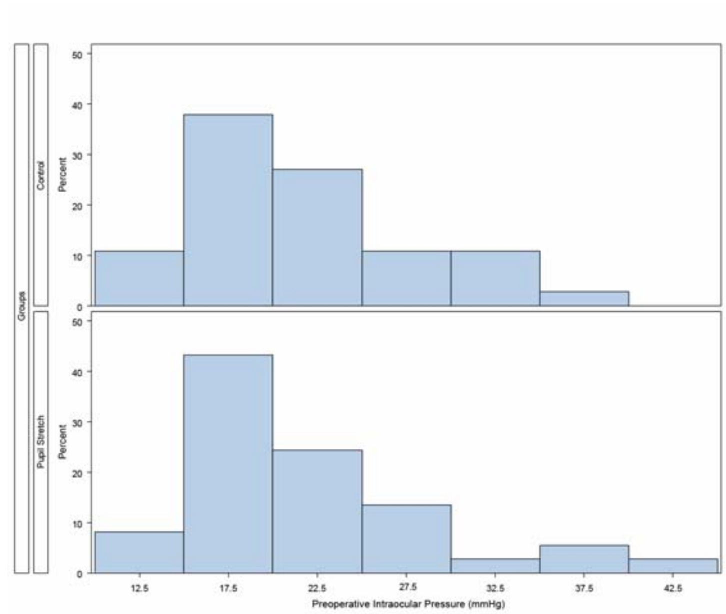

FIGURE 2.

Histogram of preoperative intraocular pressure levels of glaucoma patients who underwent combined cataract and glaucoma surgery with (top) and without (bottom) pupil stretch.

In the multivariable model for IOP, group, history of iridotomy, age, and preoperative IOP values were found to be significantly associated with IOP levels in the first 6 months after surgery. Group is significant at each time point; however, the largest difference between groups is found at week 1, when the pupil stretch group has IOP on average 3.7 mm Hg higher than the group without pupil stretch. This difference decreases modestly at the 1-month and 6-month measurements but remains significant, with the pupil stretch group on average 2.8 and 2.4 mm Hg higher than the control group at each measurement, respectively.

Additionally, preoperative IOP value is significantly associated with IOP levels, with a 1 mm Hg increase in preoperative IOP being associated with a 0.2 mm Hg increase in IOP level after surgery. Moreover, patients with a history of iridotomy had IOP on average 2.3 mm Hg lower than patients that did not. At the 1-week time point, patients under 70 years old had IOP 4.5 mm Hg higher than those in their 70s, whereas patients over 80 years old had IOP 2.3 mm Hg lower than the 70- to 79-year-olds. This effect decreases at the 1-month and 6-month time points and loses statistical significance. A summary of these results is included in Table 7.

NUMBER OF MEDICATIONS TAKEN

Before the procedure, the mean number of medications taken was 2.76 for a patient in the control group and 2.92 for a patient in the pupil stretch group (P=.498, Wilcoxon-Mann-Whitney test). As seen in Table 8, patients are taking, on average, two to three medications before the procedure, but after surgery this mean number of medications drops to less than one in all subgroups considered. In most subgroups we observed a trend of the overall mean number of medications taken increasing with time after the initial postprocedure drop.

The final multivariable model included group, gender, and number of surgical sites. The number of medications taken is not significant at either the first or second time points, namely, 1 week and 1 month; however, at 6 months, the average number of medications taken by a patient who had pupil stretch is 1.75 times greater than the average number of medications taken by a patient in the control group (P=.090, GEE Poisson model). We find gender to be associated with medication use, with the average number of medications being 1.98 times higher in women than men (P=.047, GEE Poisson model). Site appears to be consistently associated with medication use across all time points, with the mean number of medications for a patient with two-site surgery being 0.52 times that of a single-site patient. These results are summarized in Table 9.

COMPLICATIONS

Intraoperative complications were rare and did not differ between groups (*P*=1.000, Fisher's exact test). There were two cases of posterior capsular rupture in the control group and one in the pupil stretch group. One patient in the pupil stretch group had a scleral flap tear.

Postoperative complications are given in Table 10. Overall, 8 eyes (22%) in the pupil stretch group and 11 eyes (30%) in the control group experienced postoperative complications (*P*=.595, Fisher's exact test). These included wound leak, cystoid macular edema (CME), choroidal effusion, hyphema, shallow anterior chamber, persistent corneal edema, and persistent anterior chamber inflammation, defined as the presence of cells in the anterior chamber after 1 month. There were three cases of CME in the control group (8%), but two patients had pre-existing epiretinal membranes and another had diabetic retinopathy. The two patients, one from each group, with persistent corneal edema had Fuchs' corneal dystrophy diagnosed prior to surgery. Overall, the rate of postoperative difficulties was quite similar in the two subgroups. Concern about hyphema, persistent uveitis, or CME with pupillary enlargement was not actualized in the postoperative course of patients in this study.

TABLE 4. BEST-CORRECTED VISUAL ACUITY (BCVA) LOGMAR EQUIVALENT OF GLAUCOMA PATIENTS WHO UNDERWENT COMBINED CATARACT AND GLAUCOMA SURGERY AT BASELINE, 1 WEEK, 1 MONTH, AND 6 MONTHS POSTOPERATIVELY

VARIABLE	PREOP	1 WEEK	1 MONTH	6 MONTHS
	Mean ± SD, *P value**			
Group	*.727*	*.509*	*.373*	*.324*
Control	0.63 ± 0.59	0.67 ± 0.69	0.46 ± 0.58	0.36 ± 0.48
Pupil stretch	0.68 ± 0.67	0.53 ± 0.59	0.55 ± 0.69	0.51 ± 0.66
Age	*.233*	*.468*	*.292*	*.225*
<70	0.85 ± 0.75	0.79 ± 0.75	0.65 ± 0.72	0.56 ± 0.70
70-79	0.47 ± 0.50	0.43 ± 0.45	0.41 ± 0.61	0.32 ± 0.45
80+	0.69 ± 0.63	0.62 ± 0.68	0.50 ± 0.61	0.46 ± 0.58
Gender	*.115*	*.133*	*.243*	*.076*
Female	0.73 ± 0.66	0.66 ± 0.64	0.56 ± 0.66	0.51 ± 0.60
Male	0.52 ± 0.55	0.49 ± 0.65	0.41 ± 0.59	0.31 ± 0.50
Site	*.754*	*.458*	*.433*	*.189*
Single	0.66 ± 0.64	0.56 ± 0.64	0.47 ± 0.62	0.38 ± 0.54
Two	0.65 ± 0.62	0.68 ± 0.66	0.57 ± 0.67	0.54 ± 0.64
Diagnosis	*.347*	*.597*	*.318*	*.735*
POAG/NTG	0.61 ± 0.56	0.56 ± 0.60	0.48 ± 0.59	0.38 ± 0.46
CACG/Mixed	0.65 ± 0.81	0.71 ± 0.76	0.47 ± 0.73	0.61 ± 0.88
Other	0.87 ± 0.75	0.70 ± 0.78	0.64 ± 0.74	0.53 ± 0.67
Iridotomy	*.612*	*.852*	*.720*	*.873*
Yes	0.65 ± 0.65	0.57 ± 0.60	0.50 ± 0.62	0.45 ± 0.57
No	0.66 ± 0.62	0.62 ± 0.68	0.51 ± 0.65	0.43 ± 0.58
Preop BCVA	*<.001*	*<.001*	*.001*	*<.001*
<0.3	0.14 ± 0.07	0.17 ± 0.12	0.15 ± 0.11	0.08 ± 0.08
0.3-0.6	0.38 ± 0.09	0.55 ± 0.55	0.39 ± 0.44	0.34 ± 0.41
0.6+	1.41 ± 0.58	0.99 ± 0.77	0.91 ± 0.84	0.81 ± 0.74

CACG, chronic angle-closure glaucoma; IOP, intraocular pressure; Mixed, mixed mechanism glaucoma; NTG, normal-tension glaucoma; POAG, primary open-angle glaucoma; preop, preoperative; SD, standard deviation.
**P* values are from Wilcoxon-Mann-Whitney tests for 2-level covariates and Kruskal-Wallis tests for 3-level covariates.

SUCCESS RATES

Success was defined as an IOP reduction of at least 20% from baseline IOP, with or without medications. Success rates were similar between the two groups. The success rates were 89% in the pupil stretch group and 92% in the control group at 6 months (*P*=1.00, Fisher's exact test).

TABLE 5. ADJUSTED GROUP COMPARISONS (PUPIL STRETCH VS CONTROL GROUP) OF BEST-CORRECTED VISUAL ACUITY (BCVA) LOGMAR EQUIVALENT AT 1 WEEK, 1 MONTH, AND 6 MONTHS POSTOPERATIVELY AFTER COMBINED CATARACT AND GLAUCOMA SURGERY

	MEAN DIFFERENCE	(95% CI)	P*
Group			
Pupil stretch vs control at 1 week	-0.13	(-0.36, 0.11)	.287
Pupil stretch vs control at 1 month	0.06	(-0.17, 0.30)	.588
Pupil stretch vs control at 6 months	0.11	(-0.13, 0.34)	.358
Pre BCVA			
0.1-point increase	0.06	(0.04, 0.07)	<.001

CI, confidence interval; Pre BCVA, preoperative best-corrected visual acuity LogMAR equivalent.
*Linear mixed model.

TABLE 6. MEAN INTRAOCULAR PRESSURE (MM HG) OF GLAUCOMA PATIENTS WHO UNDERWENT CATARACT AND GLAUCOMA SURGERY AT BASELINE, 1 WEEK, 1 MONTH, AND 6 MONTHS POSTOPERATIVELY

VARIABLE	PREOP	1 WEEK	1 MONTH	6 MONTHS
	Mean ± SD, *P value**			
Group	*.978*	*.210*	*.076*	*.030*
Control	21.1 ± 6.4	16.4 ± 6.0	14.3 ± 4.6	13.3 ± 4.5
Pupil stretch	21.2 ± 6.6	19.7 ± 9.1	16.8 ± 6.4	15.5 ± 5.6
Age	*.148*	*.009*	*.694*	*.540*
<70	22.7 ± 9.2	23.7 ± 9.8	16.2 ± 5.5	15.3 ± 5.8
70-79	22.3 ± 5.5	18.3 ± 6.9	14.9 ± 5.1	13.0 ± 3.6
80+	19.9 ± 5.5	15.6 ± 6.2	15.6 ± 6.2	14.9 ± 5.6
Gender	*.883*	*.518*	*.954*	*.242*
Female	20.9 ± 6.2	18.2 ± 9.1	15.3 ± 5.4	15.0 ± 5.3
Male	21.7 ± 7.0	17.7 ± 5.1	15.9 ± 6.3	13.4 ± 4.9
Site	*.625*	*.968*	*.296*	*.946*
Single	21.7 ± 7.1	17.9 ± 7.9	16.2 ± 5.9	14.5 ± 5.1
Two	20.0 ± 5.1	18.2 ± 8.0	14.3 ± 5.2	14.4 ± 5.4
Diagnosis	*.905*	*.295*	*.034*	*.372*
POAG/NTG	21.1 ± 6.1	17.3 ± 6.8	14.3 ± 5.2	13.9 ± 4.2
CACG/Mixed	20.9 ± 8.8	22.5 ± 10.8	17.5 ± 4.3	18.0 ± 8.2
Other	21.6 ± 5.9	17.2 ± 8.3	18.8 ± 7.2	13.3 ± 4.3
Iridotomy	*.387*	*.808*	*.456*	*.427*
Yes	20.1 ± 5.7	17.8 ± 7.2	14.7 ± 4.8	15.0 ± 4.9
No	21.8 ± 6.9	18.2 ± 8.3	16.1 ± 6.2	14.1 ± 5.3
Pre IOP	*<.001*	*.732*	*.514*	*.173*
<20	16.4 ± 2.4	17.4 ± 7.1	14.8 ± 4.7	13.7 ± 4.0
20+	25.9 ± 5.7	18.6 ± 8.6	16.2 ± 6.5	15.2 ± 6.1

CACG, chronic angle-closure glaucoma; IOP, intraocular pressure; Mixed, mixed mechanism glaucoma; NTG, normal-tension glaucoma; POAG, primary open-angle glaucoma; preop, preoperative; SD, standard deviation.
*P values are from Wilcoxon-Mann-Whitney tests for 2-level covariates and Kruskal-Wallis tests for 3-level covariates.

TABLE 7. ADJUSTED GROUP COMPARISONS (PUPIL STRETCH VS CONTROL GROUP) OF INTRAOCULAR PRESSURE AT 1 WEEK, 1 MONTH, AND 6 MONTHS POSTOPERATIVELY AFTER COMBINED CATARACT AND GLAUCOMA SURGERY

VARIABLE	MEAN DIFFERENCE	(95% CI)	P*
Group			
Pupil stretch vs control at 1 week	3.7	(0.9, 6.6)	.010
Pupil stretch vs control at 1 month	2.8	(-0.1, 5.6)	.055
Pupil stretch vs control at 6 months	2.4	(-0.4, 5.2)	.094
Iridotomy			
Yes vs no	- 2.3	(0.0, - 4.6)	.054
Pre IOP			
1-point increase	0.2	(0.0, 0.3)	.019
Age			
<70 vs 70-79 at 1 week	4.5	(0.5, 8.4)	.028
80+ vs 70-79 at 1 week	-2.3	(-5.5, 0.9)	.157
<70 vs 70-79 at 1 month	0.3	(-3.6, 4.3)	.864
80+ vs 70-79 at 1 month	1.3	(-1.9, 4.5)	.428
<70 vs 70-79 at 6 month	1.3	(-2.7, 5.2)	.531
80+ vs 70-79 at 6 month	2.3	(-0.9, 5.5)	.151

CI, confidence interval; Pre IOP, preoperative intraocular pressure.
*Linear mixed model.

TABLE 8. SUMMARY OF NUMBER OF MEDICATIONS TAKEN BY GLAUCOMA PATIENTS WHO UNDERWENT CATARACT AND GLAUCOMA SURGERY AT BASELINE, 1 WEEK, 1 MONTH, AND 6 MONTHS POSTOPERATIVELY

VARIABLE	PREOP	1 WEEK	1 MONTH	6 MONTHS
	(mean ± SD, *P value**)			
Group	*.498*	*1.000*	*.779*	*.160*
Control	2.76 ± 0.95	0.57 ± 0.90	0.51 ± 0.77	0.62 ± 1.04
Pupil stretch	2.92 ± 1.28	0.62 ± 1.09	0.62 ± 1.19	0.89 ± 1.15
Age	*0.048*	*0.801*	*0.605*	*0.760*
<70	2.33 ± 1.18	0.40 ± 0.74	0.33 ± 0.62	0.87 ± 1.25
70-79	3.29 ± 1.19	0.67 ± 1.11	0.81 ± 1.29	0.86 ± 1.15
80+	2.79 ± 0.99	0.63 ± 1.02	0.53 ± 0.92	0.66 ± 1.02
Gender	*0.582*	*0.018*	*0.389*	*0.234*
Female	2.90 ± 1.13	0.79 ± 1.11	0.67 ± 1.12	0.58 ± 1.13
Male	2.73 ± 1.12	0.23 ± 0.59	0.38 ± 0.70	0.85 ± 1.03
Site	*0.573*	*0.194*	*0.262*	*0.165*
Single	2.90 ± 0.97	0.69 ± 1.01	0.60 ± 0.92	0.88 ± 1.12
Two	2.73 ± 1.37	0.42 ± 0.95	0.50 ± 1.14	0.54 ± 1.03
Diagnosis	*0.029*	*0.619*	*0.470*	*0.772*
POAG/NTG	3.04 ± 1.09	0.69 ± 1.09	0.69 ± 1.12	0.82 ± 1.20
CACG/mixed	2.64 ± 1.03	0.45 ± 0.82	0.27 ± 0.65	0.45 ± 0.69
Other	2.17 ± 1.11	0.33 ± 0.65	0.33 ± 0.49	0.75 ± 0.97
Iridotomy	*0.344*	*0.968*	*0.769*	*0.621*
Yes	3.00 ± 1.13	0.66 ± 1.17	0.76 ± 1.33	0.76 ± 1.24
No	2.73 ± 1.12	0.56 ± 0.87	0.44 ± 0.69	0.76 ± 1.00

POAG, primary open-angle glaucoma; NTG, normal-tension glaucoma; CACG, chronic angle-closure glaucoma; mixed, mixed mechanism glaucoma; preop, preoperative; SD, standard deviation.
*P values are from Wilcoxon-Mann-Whitney tests for 2-level covariates and Kruskal-Wallis tests for 3-level covariates.

TABLE 9. ADJUSTED GROUP COMPARISONS (PUPIL STRETCH VS CONTROL GROUP) OF MEDICATION USE AT 1 WEEK, 1 MONTH, AND 6 MONTHS POSTOPERATIVELY AFTER COMBINED CATARACT AND GLAUCOMA SURGERY

VARIABLE	MEAN RATIO	(95% CI)	P*
Group			
Pupil stretch vs control at 1 week	1.33	(0.63, 2.82)	.448
Pupil stretch vs control at 1 month	1.48	(0.68, 3.19)	.322
Pupil stretch vs control at 6 months	1.75	(0.92, 3.34)	.090
Sex			
Female vs male	1.98	(1.01, 3.87)	.047
Site			
Two vs single	0.52	(0.27, 1.02)	.058

CI, confidence interval.
*Generalized estimating equations Poisson model.

TABLE 10. POSTOPERATIVE COMPLICATIONS OF GLAUCOMA PATIENTS WHO UNDERWENT COMBINED CATARACT AND GLAUCOMA SURGERY WITH AND WITHOUT PUPIL STRETCH

	GROUP		
	CONTROL* n = 37	PUPIL STRETCH n = 37	P VALUE†
Postoperative complications, n (%)			0.595
None	26 (70)	29 (78)	
Bleb leak	0 (0)	3 (8)	
Cystoid macular edema	3 (8)	0 (0)	
Choroidal effusion	2 (5)	0 (0)	
Shallow anterior chamber	1 (3)	0 (0)	
Hyphema	1 (3)	1 (3)	
Persistent AC inflammation	4 (11)	3 (8)	
Persistent corneal edema	1 (3)	1 (3)	

AC, anterior chamber.
*One patient in the control group had two complications.
†Fisher's exact test.

DISCUSSION

In an effort to minimize intraoperative complications, pupillary enlargement is frequently utilized during combined phacoemulsification and trabeculectomy surgery.[22,39] With iris manipulation there is the potential to incite a more pronounced inflammatory response which may have undesirable consequences that could negatively impact visual recovery and IOP control. Postoperative inflammation has been correlated with the development of CME and a drop in vision.[40-43] With uncomplicated phacoemulsification cases there is a clinically significant CME rate of 1% to 2%,[44] whereas with complicated surgery such as with vitreous loss, the prevalence rate of CME rises to 10% to 20%.[45,46] It has been suggested that pupillary manipulation may lead to a higher rate of CME (Yuen D, et al. IOVS 2007;48:ARVO E-abstract 5462). Aggressive pupillary enlargement may yield an atonic large pupil with glare and impaired vision.[47-50] With increased surgical time and intraocular manipulation with pupil enlargement techniques, there may be more likelihood of endothelial cell loss and subsequent corneal edema.[51] There has also been concern raised that with increasing inflammation, conjunctival or uveitic, the chance of trabeculectomy success may be jeopardized.[52-54] Although

Shingleton and coworkers[38] did not detect any difference in vision, IOP control, or inflammation after phacoemulsification in eyes undergoing pupillary stretching, there may be a different response in glaucomatous eyes. Roth and coworkers[53] demonstrated that without topical steroids suppressing inflammation, the trabeculectomy failure rate was higher compared to eyes receiving postoperative topical steroids. When eyes with uveitis underwent phacotrabeculectomy, as reported by Park and colleagues,[54] IOP control was not achieved as successfully as in the control group without prior uveitis. They attributed the higher failure rate to inflammation that promoted subconjunctival fibrosis.

The present retrospective study was performed to examine patients who underwent pupillary expansion during combined cataract and glaucoma surgery and compared them with those who did not have pupillary manipulation. Preoperative IOP, visual acuity, and number of medications in both groups were similar. The postoperative vision at the 6-month follow-up period was similar for the two groups. The mean postoperative IOP measurement favored the control group that did not require pupillary enlargement, particularly in the first week. This may be due to the intraoperative iris manipulation and subsequent inflammation in the immediate postoperative period. At 6 months of follow-up, the mean IOP in the control group vs the pupil enlargement group was 13.3 mm Hg vs 15.1 mm Hg, respectively. This difference was statistically significant. Factors other than group assignment may have accounted for higher postoperative IOP in the pupil stretch group. For example, significantly more patients in the pupil stretch group had a diagnosis of CACG or pseudoexfoliative glaucoma when compared to controls. This is important since we found, in the subgroup analysis, that patients with a diagnosis of CACG had higher postoperative IOP at all time points when compared with patients with POAG. We also found that patients with pseudoexfoliative glaucoma had higher IOP at 1 month postoperatively when compared with patients with POAG. However, these results should be interpreted with caution because of the small number of patients with CACG or pseudoexfoliative glaucoma included in our study (n= 9, both groups). Moreover, other studies have shown results that are conflicting with our findings.

Landa and colleagues[55] found similar IOP reduction after phacotrabeculectomy in patients with pseudoexfoliative glaucoma and POAG. In addition, a greater IOP reduction among patients with CACG compared with patients with POAG has been reported.[56,57] The multivariable model for IOP showed that higher preoperative IOP and younger age were also associated with higher postoperative IOP. Tanito and colleagues[58] studied factors associated with reduced IOP after combined cataract and glaucoma surgery. Their results that lower postoperative IOP was associated with older age are consistent with our findings. They also found that lower preoperative IOP is better correlated with IOP control. However, another study found that the reduction in postoperative IOP was greater in eyes with higher mean preoperative IOP and pseudoexfoliation undergoing combined cataract and trabeculectomy.[11] History of laser peripheral iridotomy was associated with lower IOPs in the postoperative period. This is in agreement with the literature that shows that a history of laser peripheral iridotomy prior to trabeculectomy is not associated with surgical failure.[59,60] At 6 months, the average number of medications taken by a patient who had pupil manipulation was 1.75 times greater than the average number of medications taken by a patient in the control group (P=.090).

Intraoperative (Table 2) and postoperative (Table 10) complications were compiled. There did not appear to be any difference in intraoperative difficulties such as capsular rupture and vitreous loss, although there was more use of trypan blue in the eyes that required pupillary enlargement than in the control group (22% vs 0%). The apparent lack of any discernible difference in intraoperative complications between the two groups would point to the benefit of pupillary enlargement in helping to avoid serious intraoperative difficulties such as capsular rupture and vitreous loss. During the postoperative period there was no difference between the subgroups in serious postoperative problems such as CME or the need for a return to the operating room for problems such as unregulated IOP or intraocular lens repositioning. Furthermore, there was no difference between the groups in corneal edema or postoperative persistent uveitis. These findings are in agreement with those in other studies.[38]

The study would support the practice of adequate pupillary dilation by one of several available techniques to minimize intraoperative complications, since the postoperative course seems to be similar in both groups in terms of ultimate visual improvement. However, the glaucoma management appears to favor the control group with no pupil manipulation with a lower mean IOP and less glaucoma medication at the last 6-month follow-up. The additional operative time and iris manipulation may predispose these eyes to more uveitis and stimulation for subconjunctival fibrosis and ultimately higher IOP.

There are limitations of the present study that need to be acknowledged: This is a retrospective study with no randomization or masked observers; multiple surgeons with different operative techniques (different methods of pupil enlargement that could incite different amounts of ocular inflammation, one- or two-site approach, conjunctival flap technique); a small sample size that would fail to uncover differences in complications that are relatively uncommon, and a limited follow-up of only 6 months. Moreover, because of the retrospective nature of this study, preoperative cataract severity was not available for analysis, and a consistent criterion for use of pupil stretching techniques according to a pupil diameter cutoff was not used. However, all the physicians in this study were experienced surgeons familiar with the surgical approaches. A number of publications favor the consensus that one- or two-site phacotrabeculectomy surgery provides very similar results.[61-65] The use of a fornix-based vs a limbal-based conjunctival flap seems not to matter whether a trabeculectomy alone[66] or combined phacotrabeculectomy is undertaken.[67,68] Many of the important clinical concerns following phacotrabeculectomy are often evident within 6 months of follow-up, such as CME and loss of glaucoma control.

Similar outcomes in our two study groups may be explained in several ways: (1) pupillary manipulation does not jeopardize eyes that undergo combined cataract and glaucoma surgery; (2) use of antimetabolites with trabeculectomy overrides the tendency to increase subconjunctival fibrosis from any increased inflammation that may arise from iris manipulation; and (3) surgeons are adapting to different clinical courses by adjusting dosing of topical steroids and timing of trabeculectomy flap suture release. Whether one or all of these explanations are applicable to the patients enrolled in this study, the results suggest that many of the outcomes of combined phacoemulsification and trabeculectomy are not adversely impacted by pupil enlargement during cataract surgery, although

IOP control may be relatively impaired. In the future, surgeons may consider more aggressive antimetabolite use or increased frequency and duration of topical steroid use for eyes that require pupillary enlargement during combined phacoemulsification and trabeculectomy.

This study supports the use of intraoperative pupillary enlargement for minimizing common intraoperative complications, such as capsular rupture and CME, with no apparent introduction of other difficulties, such as postoperative problems. However, there may be a small sacrifice in glaucoma control suggested by the slightly higher mean IOP in the pupillary manipulation group.

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