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Predicted Refraction versus Refraction Outcome in Cataract Surgery following Trabeculectomy

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Abstract

Purpose—To determine whether the manifest refraction after cataract surgery in eyes that had undergone previous trabeculectomy was different from the predicted refraction.

Setting—University based tertiary glaucoma service and three glaucoma private practices.

Methods—Retrospective, interventional, case-control study. The medical records of patients with glaucoma and medically treated glaucoma suspects who underwent cataract extraction between January 1, 2004 and February 11, 2006 were reviewed. The axial length was measured by contact A-scan ultrasonography. The study group included 27 eyes of 25 patients who underwent phacoemulsification with intraocular lens implantation after trabeculectomy, while the control group included 52 eyes of 49 glaucoma patients or medically treated glaucoma suspects who underwent phacoemulsification with intraocular lens implantation only. The main outcome measure was the difference between the post-phaco manifest refraction and predicted refraction between the two groups.

Results—The difference between the mean final refraction and mean predicted refraction in the study group (-0.852 ± 1.056 D) and the control group (-0.501 ± 0.542 D) was not statistically significant ($p=0.115$). The mean intraocular pressure in the study group decreased significantly after trabeculectomy (25.9 ± 8.9 to 9.6 ± 4.3 mm Hg, $p<0.001$), and increased significantly after phacoemulsification (9.6 ± 4.3 to 12.5 ± 5.3 , $p=0.001$). Lower pre-phacoemulsification intraocular pressure was weakly correlated with a myopic shift in final refraction ($r=0.269$, $p=0.017$).

Conclusion—Though numerous variables can potentially influence the refractive outcome in cataract extraction following trabeculectomy, our study shows that the refractive outcome in these cases remained reasonably predictable. However, lower pre-phacoemulsification intraocular pressure was weakly correlated with a myopic shift in final refraction.

The success rate of cataract surgery after trabeculectomy (**bleb survival and/or maintenance of IOP control**) approaches 80-90%¹⁻³. Successful pseudophakic rehabilitation after glaucoma filtering surgery requires accurate intraocular lens (IOL) power calculation, which depends on several factors including axial length (AL), corneal curvature and anterior chamber depth. Changes in these three parameters following glaucoma surgery have been reported.

Decreases in axial length by 0.1 to 0.9 mm have been reported after glaucoma surgery⁴⁻⁷. It is suggested that the AL change after trabeculectomy can occur when the eye loses a significant amount of intraocular pressure (IOP) by the external flow of aqueous humor through a surgical fistula⁵. Besides, a thickened choroid accompanying a low IOP after glaucoma surgery might

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have an effect on AL measurement⁸. Furthermore, a possible increase in IOP in posttrabeculectomy eyes after cataract extraction can result in a longer AL depending on scleral rigidity. Lastly, contact AL measurements, such as A-scan ultrasonography, can induce bias by probe deformation of the eye resulting in falsely low postoperative readings of AL, especially in hypotonous eyes. This may predispose to a greater myopic refractive error than expected.

Induction of with-the-rule corneal astigmatism after trabeculectomy with or without using mitomycin C has been reported^{5, 9-13}. However, it tends to resolve over longer follow-up.

Several studies¹⁴⁻¹⁸ have shown that the anterior chamber tends to shallow in the postoperative period following trabeculectomy, and that maximal shallowing occurs by the fifth day. However, most anterior chambers tend to re-form spontaneously by 2 weeks after surgery.

As a result of AL, corneal curvature and anterior chamber depth changes following trabeculectomy, optimum IOL calculation and subsequent predictable refractive error are less easily obtained. In this study we aim at finding whether the final refractive outcome in patients undergoing phacoemulsification of cataract with IOL implantation following trabeculectomy is different from the predicted refraction.

Methods

A retrospective, interventional, case-control study was conducted after approval was obtained from the Office for the Protection of Research Subjects (OPRS), Institutional Review Board (IRB) at the University of Illinois at Chicago. The study included patients from practices of three glaucoma specialists in private practice who were all trained at the University of Illinois program, as well as patients from the glaucoma service at the University of Illinois. All the practices were in the Chicago land metropolitan area.

The medical records of patients with glaucoma or medically treated glaucoma suspects, 18 years or older, who underwent cataract extraction between January 01, 2004 and February 11, 2006 at four glaucoma practices were reviewed. Exclusion criteria included surgical complications (other than hypotony, flat/shallow AC, bleb leak, choroidal detachment and hyphema), previous eye surgery (other than laser), intraoperative relaxing incisions or capsular tension ring, narrow angle glaucoma, uveitis, significant maculopathy, pseudoexfoliation or other ocular pathology. Charts with missing data were excluded too. The database used in each practice to identify charts of patients having had phacoemulsification with IOL following Trabeculectomy was different. In the three glaucoma private practices, those were identified through computerized medical records of patients who have had the two procedures, or patients diagnosed with glaucoma or glaucoma suspect status who have had cataract extraction, and included about 80 charts. In the university setting, we reviewed all cataract surgeries done by the participating surgeons within the time frame of the study to identify the ones who had previous Trabeculectomy and/or carried the diagnosis of glaucoma or glaucoma suspect. This included more than 400 charts. The control group patients were selected in a similar fashion, where in each participating practice approximately two patients were included for every study group patient.

The study group included 27 eyes of 25 patients who underwent phacoemulsification (phaco) with intraocular lens implantation after antimetabolite-augmented trabeculectomy, while the control group included 52 eyes of 49 glaucoma patients or medically treated glaucoma suspects (diagnosed by the treating ophthalmologist upon untreated IOP higher than 21 mmHg and/or larger than 0.4 cup to disc ratio with suspicious looking cupping) who underwent phaco with intraocular lens implantation only. The axial length was measured by contact A-scan ultrasonography.

The data collected included time between trabeculectomy and phacoemulsification, age at phacoemulsification, pre-phaco manifest refraction, pre-phaco axial length, pre-phaco intraocular pressure (IOP), predicted refraction, time between phaco and last post-phaco visit with refraction, post-phaco manifest refraction, and post-phaco IOP on day of last refraction. Charts with missing data were excluded. The main outcome measure was the difference between the post-phacoemulsification manifest refraction and predicted refraction between the two groups.

The data were described in terms of means and standard deviations. Parametric hypotheses were reported from t-tests and correlation analysis.

Results

The study results are summarized in table 1. The main outcome, namely the difference between the final refraction and predicted refraction in the study group (-0.852 ± 1.056 D) compared to the control group (-0.501 ± 0.542 D), was not statistically significant ($p=0.115$).

The mean manifest refraction did not change significantly after the trabeculectomy in the study group (Pre-trabeculectomy -0.77 ± 2.72 , Post-trabeculectomy -1.83 ± 3.36 , $p=0.238$).

The mean intraocular pressure (IOP) in the study group decreased significantly after trabeculectomy (25.9 ± 8.9 to 9.6 ± 4.3 mm Hg, $p<0.001$), and increased significantly after phacoemulsification (9.6 ± 4.3 to 12.5 ± 5.3 , $p=0.001$), while in the control group there was no significant difference ($p=0.758$) between the pre-phacoemulsification (15.5 ± 3.9 mm Hg) and post-phacoemulsification (15.3 ± 3.6 mm Hg) mean IOP.

Lower pre-phacoemulsification IOP was weakly correlated with a myopic shift in final refraction ($r=0.269$, $p=0.017$) (Figure 1). Myopic shift exceeding 1 diopter in final refraction was more prevalent in prephacoemulsification hypotonous eyes ($IOP \leq 5$ mmHg) (table 2) and eyes undergoing cataract surgery within ten months after trabeculectomy (table 3). All in all, the difference between outcome refraction and predicted refraction was within one diopter in only 51.8% of eye in the study group compared to 82.7% in the control group, while there was a myopic shift of more than one diopter in 44.4% of the study group eyes compared to only 17.3% of the control group eyes.

Discussion

Though numerous variables could potentially influence the refractive outcome in cataract extraction following trabeculectomy, especially when measuring the axial length (AL) with contact A-scan ultrasonography, this study shows that the refractive outcome in such cases might still be reasonably predictable. However, lower intraocular pressure (IOP) measured before the cataract surgery was weakly correlated with a myopic shift in final refraction.

Successful pseudophakic rehabilitation after glaucoma filtering surgery requires accurate IOL power calculation, which depends on several factors including AL, corneal curvature and anterior chamber depth. Changes in these three parameters following glaucoma surgery have been reported⁴⁻¹⁸.

In this study, the time between trabeculectomy and phacoemulsification in the study group was 120-3126 days, well beyond the usual 2 weeks time reported for the anterior chamber to reform after trabeculectomy, making its depth unlikely to influence the final refraction.

Trabeculectomy can induce many refractive changes. Cunliffe *et al*¹⁴ measured changes in refraction and keratometry in 16 patients undergoing trabeculectomy. Their keratometry data

confirmed that of Hugkulstone⁹ and showed a shift toward ‘with-the-rule’ astigmatism which returned to the pre-operative value by 10 months after surgery. Given the retrospective nature of our study, where keratometry readings were not obtained before trabeculectomy or after cataract surgery, the impact of keratometry changes after trabeculectomy on the final refraction after cataract surgery could not be evaluated. It might be that because some of our patients had their cataract removed as early as 4 months after trabeculectomy, the refractive outcome in these eyes might have been influenced by the potential changes in keratometry following trabeculectomy.

Decreases in AL have been reported after glaucoma surgery⁴⁻⁷. It is suggested that the AL change after trabeculectomy can occur when the eye loses a significant amount of IOP by the external flow of aqueous humor through a surgical fistula⁵. Cashwell and Martin⁴ determined that the AL measurement decreased in 32 of 62 eyes after successful trabeculectomy. They reported that young age, exposure to an antimetabolite, low postoperative IOP, a myopic refractive error and the complications of choroidal detachment and hypotony maculopathy were strongly associated with a postoperative decrease in AL. Similarly, Kook *et al*⁵ showed that the mean AL at each postoperative visit after successful mitomycin C-augmented trabeculectomy was significantly shorter than preoperatively ($p < 0.05$). In their study, a higher preoperative and a lower postoperative IOP resulted in a shorter AL. The authors reported that AL continued to change over 6 months and had not fully recovered even at 12 months. Besides, a thickened choroid accompanying a low IOP after glaucoma surgery might affect the AL measurement⁸. In our study, the AL measurement was performed on some eyes within the first year after trabeculectomy, when it might not have yet stabilized, hence potentially influencing the postphacoemulsification final refraction in these eyes. A possible increase in IOP in posttrabeculectomy eyes after cataract extraction, such as was encountered in our study, can result in a longer AL after cataract extraction depending on the scleral rigidity, inducing a myopic shift in final refraction. Cashwell *et al*⁴ showed that there was an average decrease of 0.46 mm in AL after trabeculectomy in phakic eyes, which then increased an average of 0.275 mm after cataract surgery. Given the retrospective nature of our study where AL measurements were not obtained before trabeculectomy or after cataract surgery, comparable changes in AL in our patients could not be evaluated. Furthermore, although statistically significant, the rise in IOP after phacoemulsification in the study group may have only borderline clinical significance.

Lastly and most importantly, contact AL measurements, such as A-scan ultrasonography, can induce bias by probe deformation of the “softer” post-trabeculectomy eye resulting in falsely low postoperative readings of AL. This may predispose to a greater myopic refractive error than expected, especially if combined with the potential increase in AL after cataract extraction due to the increase in IOP. However, our study, similar to the retrospective study conducted by Tan *et al*¹⁹ in which one surgeon performed all surgeries without the use of antimetabolites, showed that the refractive outcome in eyes undergoing cataract extraction by phacoemulsification after antimetabolite-augmented trabeculectomy remained reasonably predictable. This could be explained by:

1. The average corneal curvature changes, which could not be traced in this retrospective study, might have been minimal to impact the IOL power calculations (0.9 diopters in IOL power for every diopter change in keratometry, compared to 2.5 diopters in IOL power for every 1 mm change in axial length, according to the formula: $IOL\ power = A - 2.5L - 0.9K$).
2. The average age at phacoemulsification was above 70 in the study groups, indicating high scleral rigidity and subsequently high resistance to expansion due to increased IOP following cataract surgery, rendering myopic shift secondary to this factor less likely.

3. The absence of significant indentation of the cornea while obtaining the AL reading by the A-scan ultrasound probe.

On the other hand, lower pre-phacoemulsification IOP in this study was weakly correlated with a myopic shift in the final refraction (graph). Moreover, myopic shift exceeding 1 diopter in final refraction was more prevalent in prephacoemulsification hypotony eyes ($IOP \leq 5$ mmHg) (table 2). It might have been that in “soft”, low IOP eyes, some indentation of the cornea during measuring the AL with the A-scan ultrasound probe did occur, or the AL increased more significantly in this group of eyes in response to the increase in IOP after cataract surgery. Further studies to evaluate outcome refraction in eyes with hypotony after trabeculectomy undergoing cataract extraction are warranted.

As mentioned, the corneal curvature¹² and axial length⁵ might potentially continue changing within the first 10 months posttrabeculectomy. We compared final refraction in eyes having cataract surgery within the first 10 months posttrabeculectomy to eyes having it later. The date of trabeculectomy was known in 21 out of the 27 eyes in the study group. Myopic shift exceeding 1 diopter in final refraction was more prevalent in the group of eyes undergoing cataract surgery within the first 10 months posttrabeculectomy (table 3). However, due to the small sample numbers and hypotony in 2 of the 7 eyes undergoing cataract surgery within 10 months posttrabeculectomy, further studies are warranted to evaluate the relationship between the timing of cataract surgery after trabeculectomy and final refraction.

Our study had inherent limitations due to its retrospective nature, such as different IOL power calculation formulas used by different practices and multiple participating surgeons.

In conclusion, though numerous variables can potentially influence the refractive outcome in cataract extraction following trabeculectomy, such as changes in corneal curvature, anterior chamber depth and IOP, and possible error in measuring the axial length with A-scan ultrasonography due to the potential deformation of the eye with the probe following trabeculectomy resulting in falsely low readings, our study shows that the refractive outcome in these cases remained reasonably predictable. However, special attention should be given to measuring axial length with contact methods after trabeculectomy when the intraocular pressure is low, as it may result in indentation of the cornea and falsely lower readings. The use of non-contact methods, such as the laser interferometer (IOL-master), should be considered in these cases.

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Figure 1. Correlation between Prephaco IOP and Myopic Shift in Final Refraction

Group 1: Study Group (Trab followed by Phaco)

Group 2: Control Group (Phaco only)

Prephaco = Pre-Phacoemulsification

IOP = Intraocular Pressure

Lower pre-phacoemulsification IOP was weakly correlated with a myopic shift in final refraction ($r=0.269$, $p=0.017$)

Table 1**Outcome Summary**

	Study	Control	P-value
Number of Eyes	27	52	
Mean Time between Trabeculectomy and Phacoemulsification (Days)	584.6±657.9 (Range 120-3126)		
Mean Age at Phaco	71.59±7.65	75.48±9.43	0.069
Mean Pre-Phaco Manifest Refraction (S.E.)	-1.83±3.36	-0.66±3.20	0.157
Mean Pre-Phaco Axial Length (mm)	23.24±0.91	23.54±0.99	0.190
Mean Pre-Phaco Intraocular Pressure (mmHg)	9.63±4.34	15.52±3.89	<0.00001*
Mean Predicted Refraction (S.E.)	-0.14±0.50	-0.33±0.44	0.092
Mean Time between Phaco and Last Post-Phaco Visit with Refraction (Days)	228.6±236.1	207.1±208.3	0.68
Mean Post-Phaco Manifest Refraction (S.E.)	-0.99±1.23	-0.83±0.80	0.478
Mean Post-Phaco Intraocular Pressure on Day of Last Refraction (mmHg)	12.48±5.31	15.34±3.64	0.006*
Mean Difference between Outcome and Predicted Refraction (S.E.)	-0.85±1.06	-0.50±0.54	0.115

Phaco = Phacoemulsification

S.E. = Spherical Equivalent in Diopters

Table 2
Prephaco Hypotony and Myopic Shift in Final Refraction

Prephaco IOP	# of Eyes	# of Eyes with > 1 D Myopic Shift	% of Eyes with > 1 D Myopic Shift
≤ 5 mmHg	6	4	67%
> 5 mmHg	73	17	23%

Table 3
Myopic Shift in Final Refraction in Early Post-trab Phaco

Trab to Phaco Time	# of Eyes	# of Eyes with > 1 D Myopic Shift	% of Eyes with > 1 D Myopic Shift
4 - 10 months	7	5	71.4 %
> 10 months	14	4	28.6 %