Three and Five Year Changes in Intraocular Pressures After Clear Corneal Phacoemulsification in Open Angle Glaucoma Patients, Glaucoma Suspects, and Normal Patients

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Purpose: This study evaluates the change in intraocular pressure (IOP) and glaucoma medication requirements after clear corneal phacoemulsification in open angle glaucoma patients, glaucoma suspects, and normal patients at 3 years and last follow-up (mean 5 y).

Patients and Methods: This study represents a retrospective analysis of patients who had clear corneal phacoemulsification and at least 3 years of follow-up. The patients were classified into 3 groups: glaucoma (G), glaucoma suspects (GS), and no glaucoma (NG). No patient had a history of previous intraocular surgery. Single factor analysis of variance, Fisher exact tests, 2-tailed paired Student *t* tests and Kaplan-Meier analysis were applied.

Results: Forty-eight patients (55 eyes) in the glaucoma group, 41 patients (44 eyes) in the GS group, and 59 patients (59 eyes) in the NG group met the above criteria. At 3 years follow-up IOP was significantly decreased in all groups; (G) group decreased 1.4 ± 3.3 mm Hg ($P = 0.0025$), GS 1.4 ± 4.2 mm Hg ($P = 0.004$), and NG 1.7 ± 3.1 mm Hg ($P = 0.0005$). At the final follow-up visit (mean near 5 y for all groups) the IOP was significantly decreased in all groups, (G) group 1.8 ± 3.5 mm Hg ($P = 0.005$), GS 1.3 ± 3.7 mm Hg ($P = 0.025$), and NG 1.5 ± 2.5 mm Hg ($P < 0.0001$). The number of preoperative and postoperative glaucoma medications in the (G) group did not show any significant change at 3 and 5 years ($P = 0.36$, $P = 0.87$). Kaplan-Meier analysis shows that at 3 years, 85% of the (G) group, 81% of GS, and 90% of the NG had IOPs less than or equal to their preoperative IOP, with the same number of glaucoma medications or less. At 5 years the percentages were 76%, 79%, and 85%, respectively.

Conclusions: This study demonstrates that cataract removal by clear cornea phacoemulsification in glaucoma patients, glaucoma suspects, and normal patients results in a small but significant decrease in IOP that is sustained at 3 years and a mean of 5 years in all groups. This study does not imply that cataract removal by phacoemulsification is a substitute for a combined procedure but may be an appropriate procedure for certain patients based on medication requirements and extent of optic nerve damage.

Key Words: intraocular pressure, phacoemulsification, glaucoma

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Friedman et al[1] in their 2002 article; "Surgical strategies for coexisting glaucoma and cataract. An evidence-based update," examined the long-term intraocular pressure (IOP) lowering effect of cataract extraction alone in glaucoma patients. They concluded that cataract extraction by phacoemulsification alone decreased the IOP in glaucoma patients. They graded the evidence as weak and detailed 3 studies[2–4] that addressed this question. The average patient follow up was less than 2 years in these reports. The purpose of this report is to reexamine the cohort in one of these studies authored by Shingleton et al[3] and report on the 3 year and last visit outcomes in eyes with glaucoma (G), glaucoma suspects (GS), and those with no glaucoma (NG). Additional glaucoma patients who met the original entry criteria that had 3 years or longer follow-up were added to increase the power of the analysis.

PATIENTS AND METHODS

The initial patient source for this retrospective study was the database for the original article by Shingleton et al.[3] To briefly review, the original study evaluated the IOP changes after temporal clear corneal phacoemulsification in patients performed by a single surgeon (B.J.S.), between 1995 and 1997. Eyes were included if they had no previous history of trauma, intraocular surgery or laser trabeculoplasty. This group included 164 eyes with no glaucoma, 75 glaucoma suspects, and 71 eyes with

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glaucoma. Glaucoma suspects included those with elevated IOP, pigment dispersion, pseudoexfoliation (PEX), or suspicious appearing optic nerves with normal visual fields. Glaucoma suspects with ocular hypertension were permitted to be on glaucoma medications for prophylactic treatment. Glaucoma eyes included those with primary open angle glaucoma (OAG), pigment dispersion, and PEX associated with glaucomatous optic neuropathy and visual field defects requiring medical treatment. Glaucoma eyes were considered stable, tolerated their medications well and had adequate control of IOP. A combined procedure was not indicated. From the active files on this cohort of patients, we identified all patients who had follow-up for at least 3 years. Twenty patients (24 eyes) in the glaucoma group (G), 34 patients (36 eyes) in the GS group, and 59 patients (59 eyes) in the NG group met the above criteria. The average age of the glaucoma patients in the initial study was 74 ± 9 years. Considering natural attrition and demographic changes over 8 to 10 years, some of patients were lost to follow-up. To increase the power of our statistical analysis we identified all patients that were seen between November 2004 and June 2005 who met the same criteria as the glaucoma patients and suspects above. These patients also had a minimum of 3 years of follow-up after uncomplicated corneal phacoemulsification alone by the same technique and surgeon detailed in the original paper. An additional 25 glaucoma patients (31 eyes) and 6 glaucoma suspects (8 eyes) were identified for analysis. Sample size and power calculations were completed for each group. Given an α of 0.05, δ of 0.16, and a power of 0.80 sample size for each group was NG = 33, GS = 42, and G = 37. As each group was larger than the calculated sample size the actual power of the groups were NG = 0.96, GS = 0.82, and G = 0.90.

Demographics for each group were tabulated along with preoperative vision, preoperative IOP, axial length, refraction, glaucoma type, number of glaucoma medications, and any other ocular or systemic diseases. At the 3-year postoperative examination, IOP and number of glaucoma medications were recorded. At the time of final examination, vision, IOP, and number of glaucoma medications were recorded with any other new ocular or systemic conditions. It was also noted if the patient transitioned from glaucoma suspect to glaucoma and if any glaucoma procedures were required. If a Neodymium:YAG capsulotomy was performed the date and pretreatment IOP was recorded. If the final IOP was greater than the preoperative IOP, the chart was examined to find the last date at which the pressure was at or below the preoperative level. The same was done if the final number of glaucoma medications increased, recording the last visit date before the medication increase. If both increased, the earlier date was noted. These dates were used in constructing a Kaplan-Meier survival curve. For other statistical analysis, paired 2-tailed Student *t* tests were used in comparing changes in IOP, antiglaucoma medications and vision within the group. Single factor analysis of variance and unpaired 2-tailed Student *t* tests were used to compare the groups.

RESULTS

Forty-eight patients (55 eyes) in the (G) group, 41 patients (44 eyes) in the GS group, and 59 patients (59 eyes) in the NG group met the above criteria. The patient demographics are shown in Table 1. The average age of the patients in the glaucoma group was significantly greater than the glaucoma suspects and normals. Forty-six patients in the glaucoma group had primary OAG and 9 had PEX glaucoma. Fourteen glaucoma suspects had PEX, 2 had pigmentary dispersion, and the remainder had ocular hypertension or suspicious appearing optic nerves. The scatter graphs in Figure 1 demonstrate that the majority of final IOPs were below initial pressures in all groups. At 3 years follow-up the IOP was significantly decreased in all groups; the (G) group decreased 1.4 ± 3.3 mm Hg ($P = 0.0025$), GS 1.4 ± 4.2 mm Hg ($P = 0.004$), and NG decreased 1.7 ± 3.1 mm Hg ($P = 0.0005$). At last visit (mean about 5 y) the IOP was still significantly lower in all groups: 1.8 ± 3.5 mm Hg ($P = 0.005$), 1.3 ± 3.7 mm Hg ($P = 0.025$), and 1.5 ± 2.5 mm Hg ($P < 0.0001$), respectively. Examining the differences between the 3 groups by 2-tailed unpaired Student *t* tests revealed there were no significant differences in IOP changes between any of the groups at 3 and 5 years. Table 2 summarizes the changes in IOP in all groups at 3 and 5 years after cataract surgery. Kaplan-Meier analysis (Fig. 2) calculates that at 3 years, 85% of the glaucoma group, 81% of GS, and 90% of the NG had IOPs less than or equal to their preoperative IOP, with the same number of glaucoma medications or less. At 5 years the percentages were: 76%, 79%, and 85%, respectively. In the GS group 7 of 44 eyes were on 1 medication preoperatively; at 5 years postoperatively 3 of 44 eyes were on 1 medication each. These numbers were too small for statistical significance ($P = 0.3$ by Fisher exact test). The number of postoperative glaucoma medications in the glaucoma group did not show any significant increase or decrease at 3 and 5 years from preoperative levels (Table 3). All groups had significant improvement in final postoperative vision at 5 years (Table 4). There were no significant differences in vision

TABLE 1. Patient Demographics

	Group		
Characteristic	**G**	**GS**	**NG**
No. eyes	55	44	59
No. patients	48	41	59
Mean age (y)	77.6 ± 7.0*	73.0 ± 10.5	68.6 ± 11.4
Men	22	16	29
Women	26	25	30
Right eyes	34	26	34
Left eyes	21	18	25
Mean follow-up (mo)	59.4 ± 19.3	66.3 ± 19.1	59.9 ± 19.1

*G vs. GS ($P = 0.013$), G vs. NG ($P < 0.0001$), GS vs. NG ($P = 0.06$).

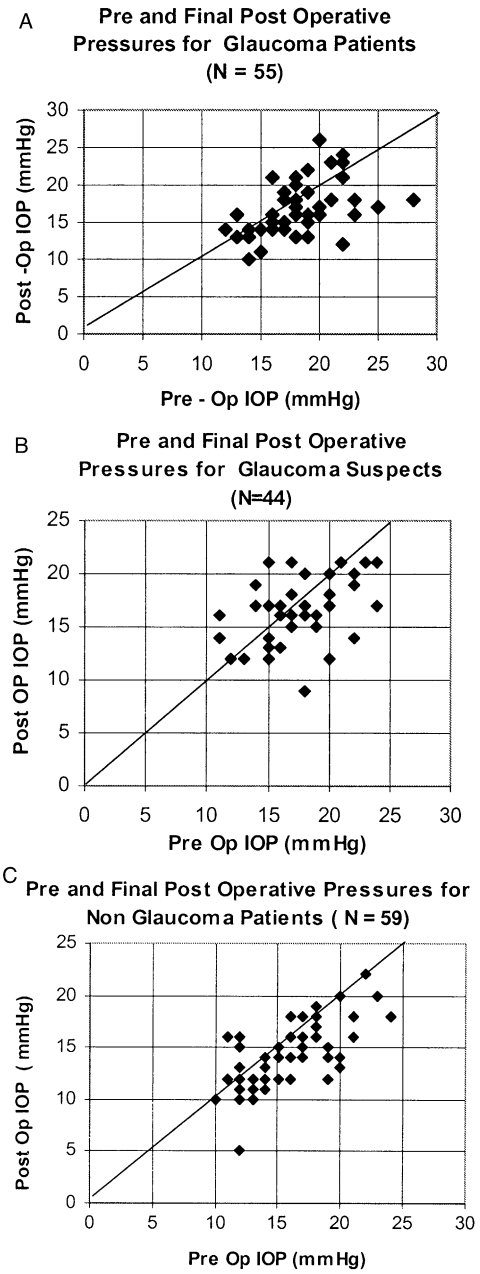
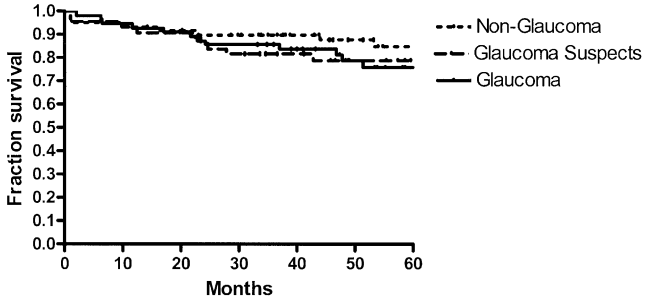


FIGURE 1. A to C, Scatter plots for preoperative and final postoperative pressures in glaucoma patients, glaucoma suspects, and nonglaucoma patients.



Percentage Survival

Years	G	GS	NG
1	91	91	93
3	85	81	90
5	76	79	85

FIGURE 2. Kaplan-Meier analysis. Fraction of eyes with IOPs less than or equal to their preoperative IOP, with the same number of glaucoma medications or less.

changes between the groups. All cases of major loss of vision were attributed to macular degeneration. Neodymium:YAG capsulotomy was performed in 13 of 55 (24%) of glaucoma eyes, 7 of 44 (16%) of glaucoma suspects, and 8 of 59 (13%) of nonglaucoma eyes. There was no difference in the Neodymium:YAG capsulotomy rates between the groups ($P > 0.2$). Comparing prelaser and last visit IOP, there was a significant elevation of 2.2 ± 2.2 mm Hg ($P = 0.004$) in glaucoma eyes. The IOP in the other groups did not show significant changes after Neodymium:YAG capsulotomy.

DISCUSSION

Review of the recent literature[1–15] indicates that cataract surgery by phacoemulsification reduces IOP. Shingleton et al[3] in 1999 documented a significant decrease in IOP of 2.08 mm Hg ($P < 0.0001$) in normal eyes, 1.91 mm Hg ($P = 0.012$) in glaucoma suspects, and a tendency toward lower IOPs in glaucoma patients at 1 year. The required medications in the glaucoma group were significantly reduced by 0.66 ($P = 0.000001$). Other studies have supported the reduction in postoperative IOP in patients with PEX.[9,10] Shingleton et al[11] in a study of 297 eyes with PEX found a 2.9 mm Hg IOP decrease at 2 years. Tong and Miller[10] reported a 2.1 to 2.8 mm Hg decrease at 6 to 8 months in eyes without glaucoma,

TABLE 2. Changes in IOPs

	NG	GS	G
Preoperative IOP (mm Hg)	15.9 ± 3.2	17.7 ± 3.6	18.4 ± 3.4
IOP reduction at 3-y visit (mm Hg)	1.7 ± 3.1 ($P = 0.0005$)	1.4 ± 4.2 ($P = 0.004$)	1.4 ± 3.3 ($P = 0.0025$)
[mean—mo]	[34.3 ± 4.8]	[40.7 ± 6.5]	[39.9 ± 6.7]
IOP reduction at last examination (mm Hg)	1.5 ± 2.5 ($P < 0.0001$)	1.3 ± 3.67 ($P = 0.025$)	1.8 ± 3.5 ($P = 0.005$)
[mean—mo]	[59.9 ± 19.2]	[66.4 ± 19.0]	[59.4 ± 19.3]

TABLE 3. Change in Medications for the Glaucoma Group

Time	Mean No. Glaucoma Medications
Preoperative	1.1 ± 0.5
3-y	1.0 ± 0.6 ($P = 0.30$)
Final visit (mean 5 y)	1.1 ± 0.7 ($P = 0.87$)

glaucoma suspects, and glaucoma patients, with no significant difference between the groups. They also noted no difference in outcomes between clear corneal and scleral tunnel techniques. In contrast, Tennen and Masket[13] noted a significant decrease of 2.19 mm Hg ($P = 0.019$) in IOP in clear corneal cases but a nonsignificant change of 1.86 mm Hg in scleral tunnel cases. Hayashi et al[15] reported that OAG patients had a 76.5% chance of survival at 2 years, survival defined similarly to the criteria used in this study. The persistent long-term reduction of IOP after phacoemulsification has been seen in several studies. Pohjalainen et al[5] reported a 3.3 mm Hg reduction in IOP at 2.8 years in eyes with glaucoma. Studies with greater than 2 years of follow-up are sparse. Suzuki et al,[16] presented 10-year follow-up on IOP after phacoemulsification and IOL implantation. They initially started with 498 patients with an average IOP of 12.2 ± 4.0 mm Hg. After 10 years, with only 42 patients remaining, IOP averaged 13.5 ± 2.3. In subgroup analysis, for eyes with an initial IOP between 15 and 20 mm Hg, IOP decreased from 16.4 ± 1.3 to 13.4 ± 2.7 mm Hg at 5 years. In their study, they found the higher the initial IOP the greater the reduction in IOP. A potential source of bias may exist in our selection of glaucoma eyes for this study. Glaucoma patients were considered stable, tolerated their medications well and had adequate control of IOP. These criteria may have biased us in selecting eyes with lower IOP and fewer medications. Those glaucoma eyes with marginal IOP control may have been directed to a combined procedure and thus would not be included in our study.

The initial paper of this cohort[3] measured a significant reduction in the need for glaucoma medications. Kim et al[6] and Yalvac et al[12] and recently Mathalone et al[17] found the need for medications in glaucoma patients significantly reduced at 12 and 24 months. Our study did not show any significant difference in medication need at 3 and 5 years in the glaucoma groups. Reduction in glaucoma medication is not necessarily based on objective criteria; new medications were introduced and prescribing patterns have changed over the past 10 years. Multicentered studies support the benefit of lower IOP and may have influenced the addition or withdrawal of medications. Three patients in the glaucoma group had their medications increased despite having pressures lower than preoperatively (considered failures on the Kaplan-Meier analysis).

TABLE 4. Vision Changes (Log MAR)

	G	GS	NG
Preoperative	0.59 ± 0.41	0.54 ± 0.29	0.53 ± 0.34
Postoperative	0.31 ± 0.30	0.22 ± 0.40	0.19 ± 0.22
Improvement	0.27 ± 0.40 ($P < 0.0001$)	0.32 ± 0.39 ($P < 0.0001$)	0.34 ± 0.34 ($P < 0.0001$)

Several mechanisms for the reduction of IOP after phacoemulsification have been proposed. The anterior chamber is typically visibly deeper in a unilateral pseudophakic eye compared with the contralateral phakic eye. Hayashi et al,[2] using Scheimmpflug videophotography, showed the anterior chamber to be 1.51 mm deeper in eyes with OAG and 1.35 mm deeper in controls at 1-year postoperative with similar increases in angle widths. Psuedophakic eyes with angle closure glaucoma showed significantly greater changes, including a greater drop in IOP. This postoperative increase in angle width with its possible effect on the trabecular meshwork may lead to increased aqueous outflow and IOP reduction.

Another mechanism for IOP reduction in psuedophakia may be traction on the ciliary body via the zonules in the presence of a contracting capsule. Such traction could potentially lead to decreased aqueous secretion and lower IOP. Neodymium:YAG capsulotomy could potentially reduce capsular/zonular traction on the ciliary body. It is interesting to note in our study, glaucoma eyes undergoing capsulotomy (13/55 eyes) had a mean increase of 2.2 ± 2.2 mm Hg in IOP after the capsulotomy. Other authors[18] have noted similar findings. Increases in prostaglandin F_2 levels postoperatively may increase uveoscleral outflow and lower IOP.[19] Miyake et al[20] proposed that blood ocular barrier permeability increased after cataract surgery resulting in a lower IOP.

This study demonstrated that cataract removal by clear corneal phacoemulsification in OAG patients, glaucoma suspects, and normal patients results in a small and significant decrease in IOP that is sustained at 3 and 5 years in all groups. Even a small decrease in IOP may be clinically significant in light of the Early Manifest Glaucoma Trial.[21]

This study does not imply that cataract removal by phacoemulsification is a substitute for a combined cataract and glaucoma procedure, which typically results in a greater IOP reduction. However, cataract surgery by clear corneal phacoemulsification may be an appropriate procedure for certain patients based on medication requirements and extent of optic nerve damage.

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