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Intraocular pressure (IOP) after cataract extraction surgery

Pressão intraocular (PIO) após cirurgia de extração de catarata

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ABSTRACT

Objective: *To describe the variation of intraocular pressure (IOP) in patients with glaucoma submitted to cataract surgery.* ***Methods:*** *Retrospective study of 101 eyes of 75 patients with medium age of 78.91 ± 7.9 submitted to cataract surgery by facoemulsification by two surgeons, without complications and with at least 6 months of follow-up. The eyes were divided in two groups: eyes with glaucoma (G) and eyes without glaucoma (NG). The IOP was evaluated with Goldmann tonometry.* ***Results:*** *51 eyes without glaucoma and 50 eyes with glaucoma. The medium IOP was 16.08 ± 3.04 before surgery, 14.69 ± 2.7 at 12 months and 14.21 ± 3.56 at 24 months. The medium value of IOP reduction before surgery to 12 months was 1.49 ± 2.98. IOP measured before surgery differed statistically from IOP at 12 and 24 months (p<0.001 e p=0.001 respectively, T. Student). Between the two groups of eyes there wasn't a statistically significant difference in the variation of IOP (p>0.05, T Student). A model of linear regression stepwise was calculated for the variation of the IOP from before surgery to 12 months. The variables with more predictive value were IOP before surgery (R2=0.249, p=0.03) and age (R2=0.18, p=0.01).* ***Conclusion:*** *In our study cataract surgery results in IOP reduction, that is maintained at 12 months.*

Keywords*: Intraocular pressure; Glaucoma; Cataract extraction; Facoemulsification; Ocular tonometry*

RESUMO

Objetivo: Determinar se existe variação da PIO em doentes com glaucoma submetidos à cirurgia de catarata. **Métodos:** Estudo retrospectivo de 101 olhos, de 75 doentes com média de idade de 78,91 ± 7,9 anos submetidos à cirurgia de catarata por facoemulsificação por dois cirurgiões, sem complicações associadas e com *follow-up* superior a 6 meses. Os olhos foram subdivididos em dois grupos: olhos com glaucoma (G) e olhos sem glaucoma (SG). A PIO foi avaliada por tonometria de Goldmann. **Resultados**: Analisaram-se 51 olhos do grupo (SG) e 50 olhos do grupo (G). A PIO média nos dois grupos era no pré-operatório 16,08 ± 3,04, sendo aos 12 meses 14,69 ± 2,7 e aos 24 meses 14,21 ± 3,56. A diminuição média de PIO do pré-operatório para os 12 meses foi de 1,49 ± 2,98. A PIO pré-operatória apresentou uma diferença com significado estatístico da PIO aos 12 e 24 meses (p<0,001 e p=0,001, respectivamente T. t pares) na amostra global. Não se detectou uma diferença com significado estatístico na variação de PIO entre estes 2 grupos de olhos (p>0,05, teste *T Student*). Determinou-se um modelo de regressão linear *stepwise* para a variação de PIO do pré-operatório para os 12m. As variáveis com valor preditivo eram a PIO pré-operatória (R2=0,249, p=0,03), e a idade (R2=0,18, p=0,01). **Conclusão:** O nosso estudo revela que a cirurgia de catarata por facoemulsificação leva a uma diminuição significativa da PIO, que se mantém aos 12 e 24m.

Descritores: Pressão intraocular; Glaucoma; Extração de catarata; Facoemulsificação; Tonometria ocular

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Introduction

Cataract and glaucoma are the first and second leading causes of blindness worldwide and often co-occur in the same patient. Studies suggest glaucoma is a risk factor for cataract. According to the literature, filtration surgery, peripheral iridotomy and certain intraocular pressure (IOP)-lowering drugs can also increase the risk of cataract.

The therapeutic decision-making algorithm in patients with cataract causing visual impairment and glaucoma is often challenging.

Various factors affect therapeutic decisions, such as patient age, the type and the degree of glaucoma, response and tolerance to antiglaucoma therapy, and target IOP.[1]

Several studies on changes in IOP following phacoemulsification with intraocular lens (IOL) implantation have been published in literature.[2,3] Reported changes in IOP range from +1.3 to -2.5 mmHg.[4]

Some papers conclude that IOP reductions after phacoemulsification are mild and transient, but more recent studies suggest they are sharper and more sustained than previously reported.[4,5]

Changes in IOP seem to depend on the type of glaucoma and baseline IOP. Eyes with primary angle-closure glaucoma (PACG) have a shallow anterior chamber, high preoperative IOP, and show greater postoperative IOP reductions, while eyes with primary open-angle glaucoma (POAG) have a lower preoperative IOP and show milder reductions.[5] Among the latter, pseudoexfoliative glaucoma is associated with sharper IOP reductions.

In addition, some authors suggest this IOP reductions are proportional to preoperative IOP, that is, the higher the baseline IOP the sharper the postoperative reduction,[2-4] as recently reported by Mansberger et al. in a multicentre study.[6]

Modern cataract surgery is minimally invasive, producing a mild inflammatory reaction and rapid visual recovery. Furthermore, because it does not involve manipulation of the conjunctiva, subsequent filtration surgery can still be performed.[1]

Therefore, cataract surgery can be an alternative for selected glaucoma patients. In POAG, it can be indicated when the IOP responds to therapy with one or two drugs and there is no severe glaucomatous damage. In cases of primary angle narrowing or PACG, cataract surgery can be indicated even earlier and can be the primary therapeutic option.

The primary objective of this study was to measure changes in IOP in patients diagnosed with glaucoma. Secondary objectives were:

- To compare changes in IOP in glaucoma versus non-glaucoma eyes;
- To correlate changes in IOP with central corneal thickness (CCT), spherical equivalent (SE) refractive error, axial length, age, and gender.

Methods

Retrospective study of 101 eyes subjected to phacoemulsification performed by two surgeons, with no associated complications and a follow-up of at least 6 months. Eyes were divided into two groups: glaucoma (G) and non-glaucoma eyes (NG).

Preoperatively, all eyes in group G had been treated with pressure-lowering eye drops, surgery (trabeculectomy or iridectomy) or both.

Baseline IOP was defined as the mean of the last three consecutive evaluations measured through Goldmann tonometry, when recorded in the medical record. Where only two records were available they were also averaged. Where only one measurement was available, it was used as the baseline IOP.

IOP was recorded before surgery and 1 day, 1 week, 1 month, 3 months, 6 months, 12 months, 24 months, and 36 months after surgery.

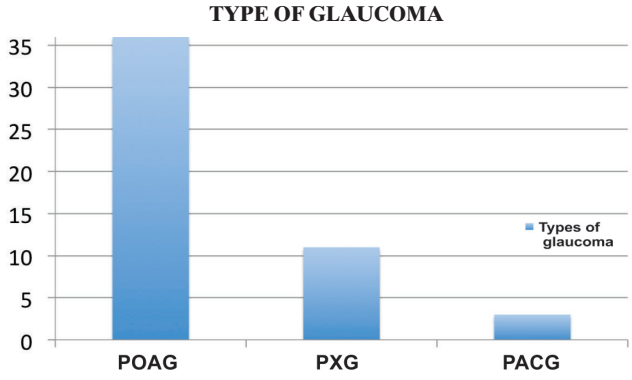
CCT was measured using an Oculus Pentacam® HR Scheimpflug camera, SE was determined with a TopCon TRK-1P kerato-refractometer, and axial length was measured using an Alcon Ultrascan Imaging System® ecograph. Best corrected visual acuity (BCVA) was also measured on every visit using a Snellen chart.

Results

Fifty-one eyes in group NG and 50 eyes in group G from 75 patients were studied. Mean age was 78.91 ± 7.9 years. There were 29 (38.7%) male and 46 (61.3%) female patients. The sample included 36 eyes with POAG, 11 eyes with pseudoexfoliative glaucoma (PXG) and 3 eyes with PACG (Graph 1). Table 1 illustrates the characteristics of the sample.

Graph 1

Sample distribution according to the type of glaucoma



Changes in postoperative IOP

Mean IOP was 16.08 ± 3.04 mmHg preoperatively, 14.23 ± 2.69 mmHg on postoperative (PO) month 6, 14.69 ± 2.7 mmHg on PO month 12, and 14,21 ± 3.56 mmHg on PO month 24 for the sample as a whole (Chart 2).

Chart 2

Changes in IOP (mmHg) throughout the study.

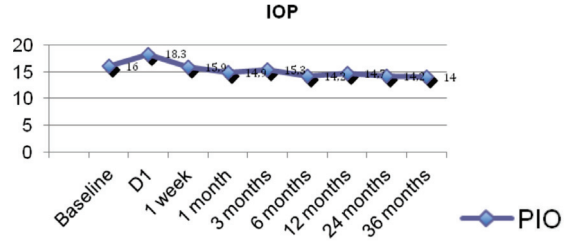


Table 1

General characteristics of the sample, NG eyes, G eyes, POAG, PXG, and PACG. Mean and standard deviation for CCT (ìm), SE (dioptres, D), axial length (mm), vertical disc diameter (VDD, mm), preoperative VA, and VA 12 months after surgery

	CCT(μm)	SE(D)	Axial lenght (mm)	VDD (mm)	Pre-op VA	12 month VA
Total samplel	522.84±28,2	-0.77±2.86	23.2±1.17	0.56±0.26	0.21±0.16	0.74±0.25
(NG)	524.53±30,42	-0.84±2.83	23.42±1.26	0.26±0.07	0.25±0.16	0.79±0.23
(G)	520.16±24,85	-0.68±2.93	22.98±1.04	0.67±0.21	0.18±0.16	0.71±0.27
POAG	516.44±25,35	-0.24±3.07	22.96±1.07	0.69±0.21	0.21±0.16	0.71±0.26
PXC	541.5±7,78	-1.76±2.44	23.16±1.04	0.60±0.23	0.11±0.11	0.71±0.28
PACG	537	-2.56±0.64	22.54±0.7	0.77±0.16	0.18±0.19	0.45±0.35

Statistically-significant differences were found between preoperative IOP and IOP on PO months 12 and 24 ($p<0.001$ and $p=0.001$, respectively, paired t-test).

The mean decrease in IOP from the baseline to PO month 12 was 1.48 ± 2.98 (range: -8 to +5).

For a more detailed study of the decrease in IOP from the baseline to PO month 12, a hierarchical cluster analysis was performed. Four eye groups were identified:

- **Group 1** (27 eyes): mean change from baseline to PO month 12: -3.12 ± 0.91
- **Group 2** (26 eyes): mean change from baseline to PO month 12: -0.21 ± 0.75
- **Group 3** (13 eyes): mean change from baseline to PO month 12: 3.04 ± 1.05
- **Group 4** (10 eyes): mean change from baseline to PO month 12: -6.30 ± 0.67

The following variables were then assessed in the four subgroups above: sex, age, IOP (mmHg) at different time points, SE (D), axial length (mm), CCT (ìm), preoperative VA, VA on PO month 12, and disc diameter (mm) (Table 2).

Groups 1 and 4 had a higher baseline IOP and showed a higher decrease in IOP.

An analysis of variance was conducted for the variables above in all four groups. Significant differences between groups were found for the following variables: preoperative IOP, 12-month IOP, and 36-month IOP ($p<0.05$).

Postoperative change in IOP per preoperative IOP group

The total sample was subdivided into 4 groups based on preoperative IOP: group 1, 32-20 mmHg; group 2, 19-18 mmHg; group 3, 17-15 mmHg; and group 4, 14-9 mmHg.

Mean changes from preoperative IOP to PO months 6, 12, 24 were evaluated for each subgroup, and significant ($p<0.05$) changes were found in:

- **Group 1** on PO months 6, 12 and 24;
- **Group 2** on PO months 12 and 24;
- **Group 3** on PO months 6 and 12;

The mean reduction in IOP on PO month 12 was 4.2 mmHg in group 1, 2.86 mmHg in group 2, and 1.08 mmHg in group 3. In group 4 a slight increase in IOP (0.4 mmHg) was observed (Table 3).

Table 2

Assessment of groups according to age (years), preoperative IOP (mmHg), 12- and 24-month IOP, SE (D), axial length (mm), CCT (ìm), preoperative VA, 12-month VA, and disc diameter (mm)

Variable	Group	Mean	Standard deviation
Age	1	77.0741	5.58794
	2	80.6538	8.02467
	3	77.2308	13.39872
	4	81.1000	5.82046
Preoperative IOP	1	17.1926	2.14600
	2	14.9308	2.90665
	3	14.0385	2.77235
	4	18.5000	2.50555
12 month IOP	1	14.0741	2.03670
	2	14.7192	2.89165
	3	17.0769	2.69139
	4	13.2000	2.34758
24 month IOP	1	15.10	2.601
	2	14.13	3.643
	3	11.50	7.724
	4	14.60	2.966
CCT	1	524.9286	31.92651
	2	522.3125	27.11880
	3	531,5000	24.93324
	4	513.4286	34.70282
RE	1	-1.3498	2.49263
	2	-8.332	3.04475
	3	-0.6816	2.83965
	4	-0.8750	3.65230
Axial lenght	1	23.0770	1.09354
	2	23.6579	1.55722
	3	23.2215	1.16335
	4	22.7880	1.06324
xV	1	0.58	0.264
	2	0.51	0.307
	3	0.60	0.277
	4	0.60	0.173
Preoperative VA	1	0.2078	0.15240
	2	0.2142	0.15161
	3	0.2108	0.23525
	4	0.1270	0.11136
12 month VA	1	0.7720	0.27465
	2	0.7923	0.16715
	3	0.5962	0.35027
	4	0.6100	0.28848

Table 3

Mean IOP preoperatively and on PO months 6, 12 and 24 and mean change in IOP from baseline to PO months 6, 12 and 24 for the four groups

IOP group (mmHg)	Preoperative IOP	6 month IOP	12 month IOP	24 month IOP	Change from preoperative to 6 month IOP	Change from preoperative to 12 month IOP	Change from preoperative to PIO pós 24m
32-20	21.16 ± 1.47	16.20 ± 3.27	16.80 ± 3.01	16.80 ± 2.39	-4.86 ±2.85	4.2 ± 2.66	-4.0 ± 2.66
19-18	18.23 ± 0.40	15.00 ± 2.65	15.27 ± 2.82	16.13 ± 1.89	-3.33 ±2.5	-2.86 ± 2.82	-2.08 ± 2.18
17-15	16.01 ± 0.77	14.10 ± 2.64	14.77 ± 2.67	10.67 ± 5.75	-1.95 ±2.26	-1.08 ± 2.4	-4.75 ± 5.38
14-9	12.78 ± 1.14	12.88 ± 1.89	13.10 ± 2.05	13.25 ± 2.05	0.25 ± 2.25	0.4 ± 2.08	0.17 ± 2.08

Table 4

Correlation between preoperative IOP (mmHg) and decrease in IOP (mmHg)

		PIO Pré
Change preoperative to 12 month IOP	**Pearson Correlation**	**0. 459**
	Sig. (2-Tailed)	0. 000
Change preoperative to 24 month IOP	**Pearson Correlation**	**0. 247**
	Sig. (2-Tailed)	0. 160

Lastly, a correlation was found between preoperative IOP and the decrease in IOP on PO month 12 ($p<0.001$) (Table 4).

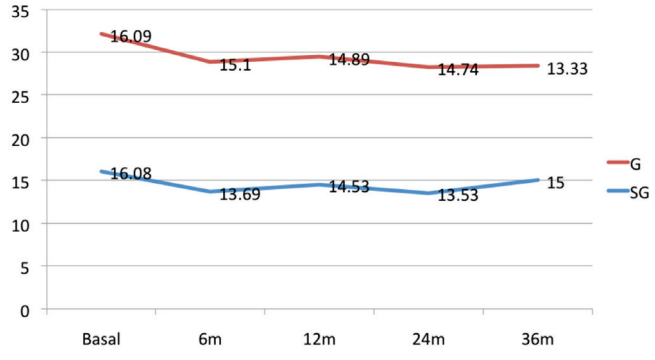
Changes in postoperative IOP in glaucoma and non-glaucoma eyes

In the non-glaucoma (NG) and glaucoma (G) eye subgroups, preoperative IOP was 16.07 ± 2.87 and 16.09 ± 3.24, 12-month IOP was 14.23 ± 2.57 and 14.89 ± 2.94, 24-month IOP was 13.53 ± 4.60 and 14.74 ± 2.49, and 36-month IOP was 15.00 ± 5.66 and 13.33 ± 2.31, respectively (Chart 3). No statistically-significant differences in IOP were found between the two groups on PO months 12, 24 and 36 ($p>0.05$, Student's t-test).

When eyes previously subjected to glaucoma surgery (n=6) were excluded from the glaucoma group, there were still no statistically-significant differences in IOP ($p>0.05$, Student's t-test) on PO months 12, 24 and 36.

Chart 3

Changes IOP (mmHg) throughout the study (months) in the NG and G groups.



Changes in postoperative IOP for different types of glaucoma

Analysis of the different types of glaucoma (Chart 4) showed that the decrease in IOP was highest in PACG eyes (-3.83), followed by PXG (-1.62) and POAG (-0.82) eyes. Differences in IOP change between PACG and POAG were statistically significant ($p<0.01$, Student's t-test).

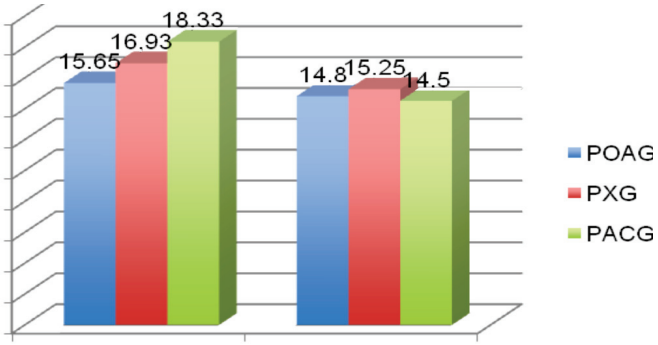
Relationship between changes in postoperative IOP and other variables

Changes in IOP were evaluated for the following intervals:

- Baseline to 12 months
- Baseline to 24 months
- Baseline to 36 months
- Baseline to 6 months

Chart 4

Changes of IOP for the 3 types of glaucoma



Correlations were investigated between changes in IOP and the following variables:

- gender
- age (55-64; 64-75; >75 years)

- G and NG groups
- types of glaucoma (POAG, PXG and PACG)
- CCT (<542; e”542 ìm)
- SE (-8 to -6; -6 to -3; -3 to -0.5; -0.5 to +2; >+2 D)
- axial length (<22; 22-24.5; 24.5-26, >26 mm)
- vertical disc diameter (<0.5; e”0.5 mm)
- preoperative VA (<0.2; e”0.2)
- 12-month VA (<0.5; e”0.5)
- diabetes mellitus.

Statistically-significant (p<0.05) associations were found for the following variables: age, SE, 12-month VA, and axial length (except for extreme axial lengths, <22 and >26).

Correlations were investigated between changes in IOP and test variables for the abovementioned intervals (Pearson's coefficient of correlation, Table 5).

Preoperative IOP, age, and 12-month VA were shown to be predictive of changes in IOP (p<0.05).

Relationship between changes in postoperative IOP and other variables

Changes in IOP were evaluated for the following intervals:

- Baseline to 12 months
- Baseline to 24 months
- Baseline to 36 months
- Baseline to 6 months

Correlations were investigated between changes in IOP and the following variables:

- gender
- age (55-64; 64-75; >75 years)
- G and NG groups
- types of glaucoma (POAG, PXG and PACG)
- CCT (<542; e”542 ìm)
- SE (-8 to -6; -6 to -3; -3 to -0.5; -0.5 to +2; >+2 D)
- axial length (<22; 22-24.5; 24.5-26, >26 mm)
- vertical disc diameter (<0.5; e”0.5 mm)
- preoperative VA (<0.2; e”0.2)
- 12-month VA (<0.5; e”0.5)
- diabetes mellitus.

Statistically-significant (p<0.05) associations were found for the following variables: age, SE, 12-month VA, and axial length (except for extreme axial lengths, <22 and >26).

Correlations were investigated between changes in IOP and test variables for the abovementioned intervals (Pearson's coefficient of correlation, Table 5).

Preoperative IOP, age, and 12-month VA were shown to be predictive of changes in IOP (p<0.05).

Table 5

Pearson's correlation between changes in IOP (mmHg) and several variables

		PIO pré - PIO pós 12m	PIO pré - PIO pós 24m	PIO pré - PIO pós 36m	PIO pré - PIO pós 6 m
Preoperative to 12 month IOP	Pearson Correlation	1	0.378	0.874	0.263
	Sig. (2-tailed)		0.52	0.53	0.022
Preoperative to 24 month IOP	Pearson Correlation	0.378	1	0.991”	0.216
	Sig. (2-tailed)	0.052		0.001	0.221
Preoperative to 36 month IOP	Pearson Correlation	0.874	0.991”	1	0.810
	Sig. (2-tailed)	0.053	0.001		0.097
Preoperative to 6 month IOP	Pearson Correlation	0.263’	0.216	0.810	1
	Sig. (2-tailed)	0.022	0.221	0.097	
Age	Pearson Correlation	-0.005	0.507”	0.368	-0.145
	Sig. (2-tailed)	0.967	0.002	0.543	0.145
Glaucoma	Pearson Correlation	-0.076	0.021	-0.561	-0.172
	Sig. (2-tailed)	0.515	0.906	0.325	0.085
CCT	Pearson Correlation	0.090	-0.408	-1.0000”	0.039
	Sig. (2-tailed)	0.574	0.104		0.789
SE	Pearson Correlation	0.040	-0.383	-1.0000”	0.073
	Sig. (2-tailed)	0.760	0.053		0.514
Axial lenght	Pearson Correlation	0.111	0.105	0.270	0.141
	Sig. (2-tailed)	0.348	0.563	0.661	0.166
Vertical disk diameter	Pearson Correlation	0.015	0.158	-0.414	0.141
	Sig. (2-tailed)	0.933	0.646	0.488	0.712
PreoperativeAV	Pearson Correlation	0.079	0.412	0.132	-0.160
	Sig. (2-tailed)	0.500	0.491	0.187	0.109
12 month VA	Pearson Correlation	0.020	0.889’	0.022	-0.101
	Sig. (2-tailed)	0.863	0.044	0.831	0.329
DM	Pearson Correlation	-0.137		-0.170	0.141
	Sig. (2-tailed)	0.236	0.000	0.087	0.157

Discussion

In this study, cataract surgery with IOL implantation reduced IOP by 1.48 ± 2.98 mmHg, on average. The decrease was sustained after 24 and 36 months both and in glaucoma and non-glaucoma eyes.

These results are in agreement with the reviewed literature. In 1970, Bigger et al.[7] had already suggested that cataract surgery decreased IOP. Three large retrospective studies found that cataract surgery had long-term effects. Shingleton et al.[2] reviewed the clinical records of approximately 150 patients subjected to cataract surgery and followed up for 3 years, dividing them into glaucoma, suspected glaucoma, and non-glaucoma eyes. They reported a mean decrease of 1.5 mmHg in all three groups after 3 years. Poley et al.[4,5] also reported reductions in IOP after at a follow-up of at least 4 years. More recently, Mansberger,[6] in a comparative study with 63 eyes subjected to cataract surgery and a control group with 743 eyes not subjected to surgery, also found a reduction in IOP which was sustained for a long period of time.

IOP reductions were found to be proportional to preoperative IOP: eyes with higher preoperative IOPs showed greater reductions, while those with the lowest preoperative IOPs showed slight increases. Such changes were sustained for 12 and 24 moths, with absolute values tending to decrease slightly over time.

These findings are in agreement with the works of Shingleton et al., Poley et al. and Friedman et al.[2–5]

As in previous studies, such as Shingleton[2] and Tong et al.[8], we found no statistically-significant differences in the decrease in IOP between glaucoma and non-glaucoma eyes.

Decreases in IOP were higher for PXG and PACG eyes, in agreement with Poley et al.[5] Some of the mechanisms explaining reductions in IOP after phacoemulsification support this finding.

Several mechanisms are proposed to explain reductions in IOP following phacoemulsification:

1. The procedure increases anterior chamber depth, thus increasing the drainage of aqueous humour through the trabecular meshwork and leading to a reduction in IOP (an effect that is more pronounced in eyes with narrow angles).[9,10]
2. IOL implantation may produce mechanical stress on the zonule of Zinn, thus enlarging the spaces in the trabecular meshwork and decreasing the resistance to drainage of aqueous humor[2,11,12]. Nonetheless, the precise mechanism is still unclear.

Several risk factors for POAG are described in the literature. There is considerable and reliable evidence that high IOP, advanced age, race, family history, and decreased corneal thickness are risk factors.[13] Data on diabetes mellitus and myopia as risk factors are less convincing. The relevance of gender and other systemic factors such as high blood pressure and ischemic vascular diseases has not been established.

According to a study by Kuzin et al.,[14] myopia, a flatter cornea, and a longer axial length should be regarded as risk factors for POAG.

In light of some of the factors above, the primary objective of this study was to investigate whether there were any statistically-significant associations between potential risk factors for POAG described in the literature and changes in IOP following cataract surgery. We then investigated the level of correlation between these factors and changes in IOP.

We found that age, SE, 12-month VA, and axial length were significantly associated with changes in IOP.

A multivariate analysis model was then used to study the correlations. Pearson's coefficient of correlation between changes in IOP and the demographic/clinical factors above were evaluated and the following results were found:

- The older the patient, the higher the change from preoperative IOP to 24-month IOP ($r=0.507$, $p<0.001$);
- The better the final VA, the higher the change from preoperative IOP to 24-month IOP ($r=0.889$, $p<0.044$).

Our study has some limitations, namely its retrospective design, the fact that six eyes previously subjected to glaucoma surgery (trabeculectomy or iridectomy) were included in the glaucoma group, and the method for measuring IOP.

Previously-operated eyes were included in the glaucoma group in order to analyse IOP response to cataract surgery in several types of glaucoma without any limitations, and hence under different therapeutic regimens, as in the study by Poley.[5] This may be regarded as a bias, but when previously-operated patients were not considered in the glaucoma group, there were still no statistically-significant differences ($p>0.05$, Student's t-test) in IOP between the two patient groups in any of the 3 time points (12, 24 and 36 months).

Finally, as regards IOP measurement, Goldmann tonometry can underestimate the actual immediate (1st day) postoperative IOP value, as described by Valbon et al.[15] In this study, the authors measured the IOP of patients subjected to phacoemulsification using an ORA (Ocular Response Analyser) device and concluded that the gold-standard IOP measure, i.e. Goldmann correlated IOP, was decreased immediately after surgery due to corneal oedema, altering the biomechanics of the cornea.

Conclusion

In our study, decreases in IOP following phacoemulsification were proportional to preoperative IOP: eyes with higher preoperative IOP values showed greater decreases in IOP.

No significant differences in IOP reduction were found between glaucoma and non-glaucoma eyes.

IOP reductions were slight but significant, and were sustained after 24 months.

IOP reductions were also higher in PACG eyes compared to POAG eyes.

Our results do not suggest that cataract extraction surgery can be replaced by combined surgery; instead, they suggest that this may be an alternative in selected patients depending on target IOP, drug therapy, and the degree of glaucoma.

Further studies are needed to evaluate the effect of cataract extraction on different types of glaucoma, as the procedure may be indicated earlier for PACG eyes.

In this study, the most predictive factors for changes in postoperative IOP were age, preoperative IOP, and 12-month VA.

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