ORIGINAL ARTICLE

Corneal power changes and refractive outcomes of phacoemulsification cataract surgery in patients with pseudoexfoliation glaucoma and primary open angle glaucoma

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ABSTRACT

Purpose: To compare the refractive deviations after phacoemulsification surgery in patients with pseudoexfoliation glaucoma (PEG) and primary open angle glaucoma (POAG) and to investigate the effect of anterior segment parameters on these deviations.

Materials and Methods: Preoperative and postoperative 6th month values of spherical equivalents, axial lengths, anterior chamber depths, corneal powers of POAG and PEG patients who had undergone phacoemulsification surgery were compared retrospectively.

Results: A total of 41 patients, 24 with PEG and 17 with POAG, were included in the study. There were no statistically significant differences between the groups in terms of axial length, preoperative intraocular pressure (IOP), 6-month postoperative IOP, IOP reduction, lens thickness, anterior chamber depth, surgically induced astigmatism, preoperative central corneal thickness (CCT), 6-month postoperative CCT, CCT thinning, 6-month postoperative spherical equivalent (SE), and deviation from the target refraction. There were no statistically significant differences in the measurements of anterior corneal power, posterior corneal power and net corneal power between the PEG and POAG groups preoperatively and at 6 months postoperatively. ($p>0.05$ for all).

Conclusion: This study demonstrates that PEG and POAG patients undergoing cataract surgery have similar clinical outcomes, including anterior segment parameters and refractive outcomes.

Key words: Phacoemulsification, primary open angle glaucoma, pseudoexfoliation glaucoma, corneal power.

INTRODUCTION

Pseudoexfoliation glaucoma (PEG) is a subtype of glaucoma characterized by high intraocular pressure (IOP) fluctuations, and resistance to IOP lowering therapies and has a worse prognosis compared to primary open angle glaucoma (POAG).[1,2] Patients with PEG are more prone to complications during cataract surgery due to weakness of the ciliary zonules and suboptimal pupil dilation.[3,4] The corneal accumulation of pseudoexfoliation (PEX) material is known to affect corneal densitometry.[5] Recent advances in surgical techniques and intraocular lenses in phacoemulsification have transformed cataract surgery into a refractive procedure. Consequently, intraocular lens (IOL) calculations play a critical role in achieving the goal of emmetropia. New IOL calculation formulas continue to be developed to provide the most accurate estimates. Among the commonly used formulas, the SRK-T IOL calculation formula stands out because it determines the IOL power based on keratometry and axial length measurements.[6,7] The deposition of PEX material in the zonular fibers can significantly affect the intraocular position of the IOL after surgery. All of these factors contribute to a greater deviation from the desired refractive outcome after phacoemulsification surgery in patients with pseudoexfoliation glaucoma.[8,9] Accurate

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measurement of corneal power has become increasingly important in a variety of diagnostic and therapeutic applications.[10] Scheimpflug camera systems allow precise measurement of corneal power with high repeatability.[11] In addition, advances in optical coherence tomography (OCT) technology allow faster and higher resolution detection of corneal power measurements.[12]

The aim of our study was to evaluate the refractive deviations following phacoemulsification surgery and to investigate the impact of anterior segment parameters, such as corneal power, on these deviations in patients with PEG and POAG.

MATERIALS AND METHODS

Patients who underwent phacoemulsification surgery in a tertiary referral hospital between January 2017 and January 2023 were consecutively included in this retrospective study. Written permission was obtained from the local ethics committee, and this study was performed in accordance with the Declaration of Helsinki.

The inclusion criteria were patients aged > 18 years old with best-corrected visual acuity (BCVA) levels of 0.6 logMAR or below due to cataracts, patients without complications during and after surgery, and patients with IOP ranging from 10 to 21 mmHg. According to Lens Opacities Classification System III stage 3 and 4 nuclear cataracts were included in the study. In this study, only the first eye of patients who underwent surgery in both eyes during this period was included. Exclusion criteria were previous intraocular surgery, history of ocular trauma, poor OCT imaging quality, presence of diabetes mellitus and the presence of narrow angles detected by gonioscopy. The diagnosis of POAG was made based on the presence of open angles in gonioscopy, the typical glaucomatous appearance of the optic disc on fundus examination, glaucomatous retinal nerve fiber layer thinning on OCT, and visual field findings. The diagnosis of PEG was made based on similar findings, as well as the detection of PEX material during biomicroscopic and gonioscopic examination.

Demographic data of patients, BCVA measured using Snellen chart, slit lamp examination, and fundus examination data were recorded. Preoperative and postoperative 6. months IOP measurements were taken by the same ophthalmologist in the morning and afternoon using Goldmann applanation tonometry, and the averages of the measurements were recorded. The spherical equivalent is calculated by adding the sum of the sphere power with half of the cylinder power. Corneal power values were measured using the anterior segment module of the OCT (Optovue, Inc., Freemont, CA) device preoperatively and at the 6th month after phacoemulsification surgery. Axial length, lens thickness, and anterior chamber depth (ACD) were measured using an optical biometer (Lenstar LS900, Haag-Streit AG, Koeniz, Switzerland) device. The SRK-T formula was used for the target dioptric calculation. The spherical IOL Acrysoft SA60 AT and the aspheric IOLs Alcon IQ and Sensar AAB00 were used. Phacoemulsification surgery was performed under topical anesthesia by a single experienced surgeon (NE) using a 2.2 mm main incision aligned with the steep axis, and a single-piece posterior chamber IOL was used.

Descriptive statistics were presented as mean ± standard deviation. The Chi-squared test was used for categorical variables, and paired samples t-test and Mann-Whitney U test were used for dependent and independent continuous variables, respectively. A p-value < 0.05 was considered statistically significant. Analyses were performed with the SPSS software package version 20.0 (IBM, Armonk, NY).

RESULTS

A total of 47 patients with glaucoma were included in the study. Six patients were excluded from the study due to missing data. Of the patients included, 24 had PEG and 17 had POAG. There were 14 female and 10 male patients in the PEG group and 7 female and 10 male patients in the POAG group. The mean age of the PEG patients was 73.1 ± 7.1 years and the mean age of the POAG patients was 70.1 ± 6.3 years. There were no significant differences in terms of age and gender between the groups (p=0.484, p=0.279; respectively). There were no statistically significant differences between the groups in terms of axial length, preoperative intraocular pressure (IOP), 6-month postoperative IOP, IOP reduction, lens thickness, anterior chamber depth, surgically induced astigmatism, preoperative central corneal thickness (CCT), 6-month postoperative CCT, CCT thinning, 6-month postoperative spherical equivalent (SE), and deviation from the target refraction. Table 1 shows the comparison of clinical and demographic data between groups.

Preoperative and 6-month postoperative corneal power data of PEG and POAG patients are shown in Table 2. There were no statistically significant differences in the measurements of anterior corneal power, posterior corneal power and net corneal power between the PEG and POAG groups preoperatively and at 6 months postoperatively. (p>0.05 for all).

Table 1: *Demographic and clinical data of PEG and POAG patients.*

Data	PEG	POAG	P value
Age	73.1 ± 7.1	70.1 ± 6.3	0.484*
Sex (female/male)	14 / 10	7 / 10	0.279**
Axial lenght (mm)	23.10 ± 0.78	23.57 ± 0.71	0.680*
Preoperative IOP (mmHg)	17.04 ± 3.74	16.41 ± 3.35	0.931***
6-month postoperative IOP (mmHg)	14.26 ± 3.14	13.82 ± 2.63	0.692*
IOP reduction (mmHg)	2.75 ± 1.6	2.59 ± 1.42	0.770***
Lens thickness (mm)	4.34 ± 0.43	4.48 ± 0.41	0.781*
Anterior chamber depth (mm)	3.35 ± 0.49	3.26 ± 0.45	0.606*
Surgically induced astigmatism (D)	0.45 ± 0.16	0.42 ± 0.14	0.412***
Preoperative CCT (µm)	522.33 ± 41.38	527.41 ± 21.11	0.083*
6-month postoperative CCT (µm)	517.54 ± 40.92	522.53 ± 19.78	0.056*
CCT thinning (µm)	4.79 ± 4.16	4.88 ± 3.90	0.718***
6-month postoperative (SE) (D)	-0.47 ± 0.46	-0.37 ± 0.49	0.516***
Deviation from target refraction (D)	0.39 ± 0.21	0.35 ± 0.26	0.491*

CCT, Central corneal thickness; mmHg, millimeters of mercury; IOP, Intraocular pressure; µm, micrometer; mm, millimeter; SE, Spherical equivalent; D, Dioptri; PEG, pseudoexfoliation glaucoma; POAG, primary open angle glaucoma
P*: Independent-Samples T-test
P**: Pearson Chi-Square test
P***: Mann Whitney-U test

Table 2: *Preoperative and 6-month postoperative corneal power data of groups.*

	Preoperative	**6-month postoperative**	**P value**
PEG			
Anterior corneal power (D)	50.07 ± 1.53	49.95 ± 1.29	0.487
Posterior corneal power (D)	-6.13 ± 0.21	-6.10 ± 0.15	0.555
Net corneal power (D)	44.10 ± 1.40	43.96 ± 1.21	0.398
POAG			
Anterior corneal power (D)	49.54 ± 2.19	49.53 ± 2.01	0.923
Posterior corneal power (D)	-6.04 ± 0.27	-6.09 ± 0.31	0.195
Net corneal power (D)	43.62 ± 1.95	43.59 ± 1.74	0.876

D, Dioptri; PEG, pseudoexfoliation glaucoma; POAG, primary open angle glaucoma
P : Paired Samples T Test

Table 3 shows the comparison of the two groups by IOL type. There were no statistically significant differences in age, sex (female/male), glaucoma type (PEG/POAG), and deviation from target refraction based on IOL type. ($p>0.05$ for all) These results indicate that there are no statistically significant differences in these measurements between the spherical and aspheric groups.

DISCUSSION

This study compared the clinical outcomes of PEG and POAG patients undergoing cataract surgery with different IOL types. The results revealed no significant differences between the two glaucoma groups in terms of age, gender, visual parameters, or refractive outcomes. Moreover, the type of IOL used did not significantly influence the measured parameters. These results suggest that both PEG

Table 3: *The comparison of the two groups by IOL type.*

Data	Spherical	Aspheric	P value
Age	71.7 ± 7.0	71.9 ± 6.7	0.819*
Sex (female/male)	10 / 8	11 / 12	0.623**
Glaucoma type (PEG/POAG)	8 / 10	16 / 7	0.105**
Deviation from target refraction (D)	0.35 ± 0.26	0.39 ± 0.20	0.305*

D, Dioptri; IOL, Intraoculer lens
P*: Independent-Samples T-test
P**: Pearson Chi-Square test

and POAG patients can achieve comparable visual and refractive outcomes after cataract surgery, regardless of the type of IOL selected.

There are a limited number of studies in the literature that specifically investigate refractive error following cataract surgery in patients with PEG and POAG.[8,9,13,14] These studies have generally focused on comparing the refractive outcomes of glaucoma patients with those of normal subjects. As expected, glaucoma patients tend to have greater deviations from the target refraction compared to normal individuals, regardless of the glaucoma type.[8,14] A detailed study on this topic was conducted by Manoharan et al. They found that long axial length in POAG, chronic angle-closure glaucoma, and pseudoexfoliation glaucoma are risk factors for refractive error. However, they did not directly compare the refractive outcomes between the POAG and PEG groups. Nevertheless, based on the odds ratio results, pseudoexfoliation glaucoma was found to be more prone to refractive error compared to POAG. The specific month of postoperative measurements in their study was not clearly stated, but they mentioned that measurements were taken at follow-up visits ranging from 1 month to 1 year.[8] Another study by Tekcan et al.[14] indicated that PEG led to greater refractive error than POAG at 3 months postoperatively, and this did not differ among different IOL formulas. However, they reported no significant differences in refractive error between POAG and the normal group. In our study, no significant differences were found between the PEG and POAG groups at 6 months postoperatively. One possible reason for the lack of significant differences in our study may be the absence of initial differences in preoperative anterior segment parameters between the groups. In the study by Tekcan et al., the preoperative ACD was significantly lower in the PEG group compared to the POAG group.[14] Another reason could be the timing of the postoperative evaluation at 6 months. Especially in pseudoexfoliation glaucoma patients, the recovery of ocular structures may take longer due to the accumulation of pseudoexfoliation material. Ishikawa et al. also found no significant differences in refractive error between pseudoexfoliation syndrome and the control groups.[15] However, they evaluated both glaucomatous and non-glaucomatous patients together in their study. Elgin et al. reported that ACD increased to a greater extent in the PEG group compared to the POAG group at 1 month postoperatively[13], which may explain the difference in refractive error in the early postoperative period. However, the long-term effects remain controversial. Another study found no significant differences in refractive error at 6 months postoperatively between PEX syndrome and PEG.

Another unique aspect of our study is the evaluation of corneal power using anterior segment OCT. Tang et al. reported good repeatability of corneal power measurements using Fourier-domain OCT, particularly in eyes with altered anterior-posterior corneal curvature ratios due to surgery or disease.[12] One study emphasized the importance of corneal front analysis for accurate IOL calculations.[10] In our study, there were no significant differences in corneal power between the two groups in the preoperative and postoperative periods. The absence of significant differences in visual parameters, including corneal power measurements, anterior segment parameters, and CCT, indicates that both PEG and POAG patients have similar ocular characteristics before and after cataract surgery. Additionally, the lack of significant differences in refractive outcomes, such as SE and deviation from target refraction, suggests that both IOL types provide comparable refractive accuracy in glaucoma patients. The analysis of other intraoperative and postoperative parameters also showed no significant differences. Factors such as axial length, pre- and postoperative IOP, lens thickness, anterior chamber depth, surgically induced astigmatism, pre- and postoperative CCT, and deviation from target refraction

did not show significant differences, which is similar to the findings of Elgin et al. who reported similar postoperative changes in eyes with POAG and PEG.13 Interestingly, we found no significant differences in outcomes based on the type of IOL used.

It is important to acknowledge the limitations of this study, including the relatively small sample size and the single-center design. Future research with larger sample sizes and multicenter studies may further validate these findings. In addition, long-term follow-up studies are warranted to assess the stability of visual parameters and refractive outcomes over extended periods.

In conclusion, this study demonstrates that PEG and POAG patients undergoing cataract surgery have similar clinical outcomes, including visual parameters and refractive outcomes, regardless of the type of IOL used. These findings contribute to our understanding of the management of glaucoma patients undergoing cataract surgery and provide valuable insights for clinicians in selecting appropriate IOLs for these patients.

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