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Original Article

The Effect of Uneventful Phacoemulsification on Intraocular Pressure and Anterior Segment Parameters in Pseudoexfoliation Syndrome

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Abstract

Objectives: The aim of this study was to evaluate the effects of cataract surgery on anterior segment parameters and intraocular pressure (IOP) in non-glaucomatous pseudoexfoliation syndrome (PXS) eyes.

Methods: The cohort consisted of 65 patients who were to undergo cataract surgery; the participants were divided into 2 groups: patients with PXS (n=35) and controls without PXS (n=30). A complete ophthalmic examination, measurement of IOP (using an applanation tonometer), and evaluation of anterior segment parameters using a Sirius Scheimpflug/Placido topography device (CSO Italy, Firenze, Italy) were performed on all patients both prior to and 1 month after surgery.

Results: No significant difference was observed between groups in terms of preoperative IOP, pupil diameter, central corneal thickness, anterior chamber depth (ACD), anterior chamber volume (ACV), iridocorneal angle (ICA), or corneal volume (CV) values. A reduction in the postoperative mean IOP value was noted in both groups, with a difference of slightly >2 mmHg in the PXS group (PXS: p=0.000, control: p=0.002). Postoperatively, a statistically significant increase was observed in both groups in the ACD, ICA, ACV, and CV measurements. When comparing the preoperative and postoperative differences of the groups, the only parameter noted to be statistically significantly different was postoperative widening of the ICA. A greater degree of widening was noted in the PXS group (13.83±6.06°) compared with the control group (10.47±6.69°) (p=0.039).

Conclusion: IOP values decreased and ACD values increased significantly following phacoemulsification in the PXS and the normal eyes. These findings support results reported in the literature. However, the results related to ICA changes are a new, previously unreported contribution. To more fully comprehend the effects of cataract surgery on patients with PXS in terms of ICA changes, prospective studies with a larger cohort are needed.

Keywords: Cataract surgery, glaucoma, iridocorneal angle, phacoemulsification, pseudoexfoliation

Introduction

First described in 1917 by Lindberg, pseudoexfoliation syndrome (PXS) is an age-related disease. It is characterized by an accumulation of extracellular material in the anterior segment of the eye, which may include the lens epithelium or intraocular lens (IOL), corneal endothelium, pupillary border, iridocorneal angle (ICA), ciliary processes, and zonules. Pigment deposition on the endothelium and a patchy increase in trabecular meshwork (TM) pigmentation are also common (1,2). The disease is widespread and prevalent around the world; however, numbers do seem to vary within regions (3,4). The etiology and pathogenesis of PXS can be considered multifactorial, involving both genetic and environmental factors.

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PXS is associated with glaucoma, cataract, poor pupil dilation, and zonular weakness. The presence of PXS is related to an increase in intraocular pressure (IOP) and cataract formation. Pseudoexfoliative material is deposited throughout the TM, Schlemm's canal, and collector channels. This leads to increased outflow resistance, an indirect side effect, which may explain the elevated IOP in many PXS patients (5,6).

Several clinical reports have shown that cataract surgery using phacoemulsification can successfully reduce IOP. The effect of cataract surgery to correct IOP in PXS patients, with or without glaucoma, has also been evaluated. An IOP response was observed in both groups. The positive effect may result from specific changes to the anterior segment morphology, including anterior chamber depth (ACD) as well as the ICA (7–12).

This study is an evaluation of the effects of cataract surgery in non-glaucomatous PXS based on anterior segment parameters and IOP.

Methods

The study cohort consisted of 65 patients who were to undergo cataract surgery, and 2 groups were formed: those with PXS (n=35) and controls without PXS (n=30). A complete ophthalmic examination and measurement of IOP using applanation tonometry was performed on all patients both prior to and 1 month post surgery. Patients with an IOP >21 mmHg, corneal pathology, a history of glaucoma or optic disc changes suggesting glaucomatous cupping, uveitis, previous eye surgery or eye trauma, or posterior segment pathology, as well as those using topical or systemic medications that might influence anterior segment parameters, were excluded from the study.

The IOP of all of the patients was measured twice by a single ophthalmologist. The 2 measurements were performed between 9:00 am and 12:00 pm for both preoperative and postoperative visits. The Lens Opacities Classification System, version II was used to grade cataract severity. A Sirius Scheimpflug/Placido topography device (CSO Italy, Firenze, Italy) was used for morphological evaluation of the ACD, anterior chamber volume (ACV), ICA, central corneal thickness (CCT), pupil diameter (PD), and corneal volume (CV). Measurements were taken both at the preoperative visit and again 1 month after surgery. Axial length (AL) was also recorded preoperatively via optical biometry (IOL Master; Carl Zeiss AG, Oberkochen, Germany).

All of the operations were performed under topical anesthesia and using the same technique. A single-piece, foldable, acrylic posterior chamber IOL (Optima SAF6125; Med C Tibbi Malzeme, Bursa, Turkey) was implanted into the capsular bag in all cases. Patients who developed complications during surgery and those who required iris manipulation were excluded from the research.

Statistical analysis was performed with IBM SPSS for Windows, Version 22 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as the mean±SD. A parametric (Student's t-test and analysis of variance) and nonparametric tests (Mann-Whitney U and Kruskal-Wallis) were used to compare continuous variables in accordance with the data distribution. Fisher's exact test was used to compare the categorical data. Pearson's correlation test was used to evaluate relationships between variables. A value of $p < 0.05$ was considered statistically significant.

Written, informed consent was obtained from all of the participants. The study protocol was reviewed and approved by the institutional ethics committee of Izmir Katip Celebi University (ID: 231)(11.08.2016). This study was conducted in accordance with the Declaration of Helsinki.

Results

The PXS group consisted of 35 patients with a mean age of 73.7±1.09 years; the control group comprised 30 patients with a mean age of 70.8±1.68 years (p=0.145). The gender distribution of both groups was statistically similar. There was no significant difference in axial length between the groups (Table 1). Preoperative IOP, PD, CCT, ACD, ACV, ICA, and CV values are summarized in Table 2. No statistically significant difference was seen between the groups in these measurements.

Table 1. Demographic features, preoperative vision, axial length and cataract grades in PXS and control groups

	PXS group	Control group	p
Age (years)	73.71±6.46	70.83±9.21	0.145[a]
Gender			
Male	21	15	0.419[b]
Female	14	15	
Vision			
<1/10	14	8	0.451[b]
≥1/10 and <5/10	20	20	
≥5/10	1	2	
Axial length (mm)	23.13±0.98	22.99±0.85	0.545[a]
Cataract grades			
1	-	-	0.153[b]
2	17	15	
3	10	13	
4	8	2	

[a]Independent samples t-test; [b]Pearson chi-squared test; PXS: Pseudoexfoliation syndrome.

Table 2. Preoperative values in anterior segment parameters and IOP in PXS and control groups

	PXS group	Control group	P
IOP (mmHg)	16.03±3.46	15.93±2.93	0.921[c]
PD (mm)	2.59±0.49	2.63±0.52	0.792[c]
CCT (µm)	0.545±0.30	0.546±0.35	0.917[a]
ACD (mm)	3.15±0.38	3.26±0.46	0.310[a]
ACV (mm³)	121.54±28.83	131.80±38.38	0.528[c]
ICA (°)	39.48±6.78	41.03±8.88	0.439[a]
CV (mm³)	56.73±3.68	57.50±4.07	0.400[a]

ACD: Anterior chamber depth; ACV: Anterior chamber volume; CCT: Central corneal thickness; CV: Corneal volume; ICA: Iridocorneal angle; IOP: Intraocular pressure; PD: Pupil diameter; PXS: Pseudoexfoliation syndrome; [a]Independent samples t-test and analysis of variance; [c] Mann-Whitney U test and Kruskal-Wallis test.

Table 3. The preoperative and postoperative difference in anterior segment parameters

	Preoperative	Postoperative	p
IOP (mmHg)			
PXS group	16.03±3.46	13.74±2.56	0.000[c]
Control group	15.93±2.93	14.50±2.22	0.002[c]
PD (mm)			
PXS group	2.59±0.49	2.63±0.46	0.642[c]
Control group	2.63±0.52	2.59±0.39	0.886[c]
CCT (µm)			
PXS group	0.545±0.30	0.553±0.32	0.014[c]
Control group	0.546±0.35	0.559±0.59	0.059[c]
ACD (mm)			
PXS group	3.15±0.38	3.99±0.28	0.000[c]
Control group	3.26±0.46	4.03±0.29	0.000[c]
ACV (mm³)			
PXS group	121.54±28.83	164.06±24.38	0.000[c]
Control group	131.80±38.38	169.53±30.30	0.000[c]
ICA (°)			
PXS group	39.48±6.78	53.31±5.37	0.000[c]
Control group	41.03±8.88	51.50±5.94	0.000[c]
CV (mm³)			
PXS group	56.73±3.68	58.81±4.06	0.000[a]
Control group	57.50±4.07	59.52±4.46	0.003[a]

ACD: Anterior chamber depth; ACV: Anterior chamber volume; CCT: Central corneal thickness; CV: Corneal volume; ICA: Iridocorneal angle; IOP: Intraocular pressure; PD: Pupil diameter; PXS: Pseudoexfoliation syndrome; [a] Independent samples t-test and analysis of variance; [c] Mann-Whitney U test and Kruskal-Wallis test.

The postoperative values of all of the parameters examined were compared with the preoperative values (Table 3). A reduction in postoperative average IOP was observed in both groups, with a difference of slightly >2 mmHg in the PXS group. In both groups, a statistically significant postoperative increase was seen in ACD, ICA, ACV, and CV. Central corneal thickness also increased, however, it only achieved statistical significance in the PXS group.

A comparison of the preoperative and postoperative differences between the 2 groups is provided in Table 4. Postoperative widening of the ICA was the only parameter noted to be statistically significantly different. When compared, a more pronounced widening of the ICA was observed in the PXS group. Differences between preoperative and postoperative ICA changes in both groups are illustrated in a boxplot graph (Fig. 1).

Table 4. Comparison of the difference between preoperative and postoperative values of all parameters

(preop-postop)	PXS group	Control group	P
IOP (mmHg)	2.28±3.38	1.43±2.09	0.446[c]
PD(mm)	0.03±0.35	-0.04±0.38	0.418[a]
CCT (µm)	0.01±0.19	0.01±0.44	0.952[c]
ACD (mm)	0.84±0.41	0.77±0.44	0.499[a]
ACV (mm³)	42.51±24.68	37.73±25.10	0.443[a]
ICA (°)	13.83±6.06	10.47±6.69	0.039[a]
CV (mm³)	2.08±2.95	1.96±3.29	0.449[c]

ACD: Anterior chamber depth; ACV: Anterior chamber volume; CCT: Central corneal thickness; CV: Corneal volume; ICA: Iridocorneal angle; IOP: Intraocular pressure; PD: Pupil diameter; PXS: Pseudoexfoliation syndrome; [a] Independent samples t-test and analysis of variance; [c] Mann-Whitney U test and Kruskal-Wallis test.

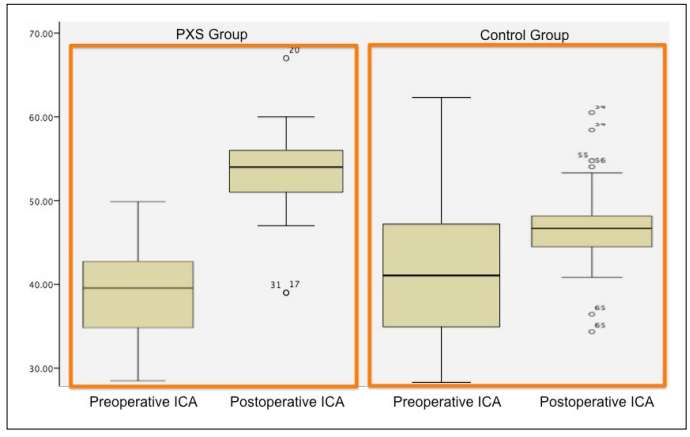

Figure 1. Boxplot graph of the preoperative and postoperative ICA change in the PXS and control groups.
ICA: Iridocorneal angle; PXS: Pseudoexfoliation syndrome

Correlations between ICA changes and other changes of anterior chamber parameters following surgery were also evaluated in the study groups. The only significant correlation of interest was that between ICA and ACD change (Pearson's correlation coefficient=0.825 and p value=0.000).

Discussion

Significant changes in anterior segment parameters have been reported following phacoemulsification cataract surgery (9,10,13–15). However, to date, there are very few studies in the literature addressing anterior chamber parameter differences post phacoemulsification surgery and comparing patients with and without PXS (16–19). In the current study, consistent with the findings of several similar studies (16–18), an IOP reduction following cataract surgery was noted. The exact mechanism of this IOP reduction following cataract surgery is still not fully understood. Hypothetically, postoperative improvements in TM function and aqueous humor access to the TM could be responsible (8,9). One could reason that widening of the drainage angle and aqueous access to the filtering portion of the TM would lead to improvement. Although angle opening may partially account for IOP reduction, there are several other potential contributors, such as ultrasound activation of cytokines, endogenous prostaglandin release, and an increase in aqueous outflow with expansion of the TM and lumen of the Schlemm's canal (8,10,20,21).

The degree of IOP reduction following phacoemulsification has been shown to be greater in patients with exfoliation syndrome (PXS) with a normal preoperative IOP when compared with eyes without PXS (8,9,17,22). Damji et al. (8) reported a significant association between the volume of irrigation during phacoemulsification and IOP reduction in PXS eyes. They suggested that one or more of the following factors may be responsible for this finding: flushing of exfoliation material and pigment from the anterior segment, deepening of the anterior chamber angle, or ultrasound energy and low-grade inflammation leading to enhanced aqueous outflow. The volume of irrigation solution utilized during phacoemulsification was not evaluated in the current study.

Although we found the reduction of IOP to be greater in PXS group than in the controls, the difference between groups was not statistically significant. Moghimi et al. (9), Damji et al. (8), Merkur et al. (18), and Dosso et al. (17) reported a greater reduction in IOP after surgery in PXS patients with or without glaucoma. When evaluated separately, it was observed that some of the before mentioned studies had enrolled patients without any inclusion criteria related to IOP level, and that in some cases, patients and controls had been included based on an IOP value of <30 mmHg. Although both groups in our study showed a significant postoperative reduction in IOP, the statistically insignificant difference between groups may be a result of several factors. The patients with or without PXS had an IOP level <21 mmHg, a lower IOP than that of many other studies. It has been demonstrated that the reduction in IOP after cataract surgery is positively related to preoperative IOP (14, 20). In the current study, the sample size was relatively small. More robust studies are needed to gain a clearer picture of any direct correlations.

In PXS eyes, the crystalline lens can be anteriorly dislocated due to zonular weakness. As a result of cataract surgery, a backward shift of the iris following removal of the crystalline lens might contribute to mechanisms that influence a widening of angle in PXS eyes. A study by Pereira et al. (23) highlighted this effect in patients without PXS. ACD is considered one of the most important anterior chamber parameters that changes post cataract surgery in patients with and without PXS. Gungor et al. (24) showed that ACD changes following cataract surgery were greater in a PXS group than in the controls. Ucakhan et al. (15) and Doganay et al. (21) also reported similar findings. In our study, the postoperative ACD level increased in both groups, however, there was no significant difference between the groups. In the postoperative period, CCT was greater, but only achieved statistical significance in the PXS group. This difference may be due to the prolonged regression of postoperative corneal edema in patients with pseudoexfoliation.

A previously unreported finding observed in this study involved ICA changes. We used Scheimpflug imaging to measure anterior segment parameters, including ICA. In the literature, parameters obtained with Scheimpflug imaging have been shown to correlate well with gonioscopy, (25–27) and while Scheimpflug devices cannot directly visualize the angle, they have the advantage of producing 3-dimensional data to use in the analysis. Altan et al. (28) found that in nonglaucomatous eyes with a preoperative open ICA, uneventful phacoemulsification reduced IOP, increased ACD, and widened the ICA. Takmaz et al. (29) and Simsek et al. (30) presented similar results from their study of nonglaucomatous eyes using Sirius Scheimpflug/Placido topography. In a prospective study evaluating anterior segment OCT, Huang et al. (10) also reported a similar result. For measurement of the ICA, they set the angle opening distance at 500 μm. Following cataract surgery, the value increased in patients with narrow and open iridocorneal angles. To the best of our knowledge, there are no publications outlining the effect of ICA changes in PXS patients without glaucoma in the literature. We found that both groups in our study had a significant ICA improvement after surgery. When the study groups were compared, the increase in the ICA change in the PXS group was significantly larger than in the patients without.

This finding supports the original hypothesis of Damji et al. (8) ICA changes in conjunction with other parameters could be used to provide a greater insight concerning the impact of cataract surgery in PXS patients. In addition, zonular weakness in PXS patients may cause the ICA to widen further by causing a backward shift of the iris and lens after cataract surgery. Kristianslund et al. (31) reported that cataract surgery offered protection against the development of glaucoma, especially in PXS patients. Their explanation for this finding, in addition to the washout hypothesis of Damji et al. (8), was that the removal of the biologic lens and the central anterior capsule reduced the release of pseudoexfoliative material and pigment. While we did not find any supportive data for either hypothesis, significant ICA change in PXS group could be a meaningful indication of the process. It may be that both hypotheses could be working in conjunction.

Limitations of our study include the small number of patients and the absence of additional imaging methods, such as anterior segment optical coherence tomography and gonioscopy.

To conclude, our findings support previous studies in terms of IOP and ACD changes following cataract surgery in patients with and without PXS. Additional prospective studies with larger cohorts are necessary to further investigate the effect of cataract surgery and the resulting ICA change, particularly in patients with PXS.

Disclosures

Ethics Committee Approval: The study protocol was reviewed and approved by the institutional ethics committee of Izmir Katip Celebi University (ID: 231)(11.08.2016). This study was conducted in accordance with the Declaration of Helsinki.

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Authorship Contributions: Involved in design and conduct of the study (SSA, SU); preparation and review of the study (SSA, SU.); data collection (SSA, EDE, MAE); and statistical analysis (SSA, EDE).

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