Anterior Chamber Depth Change Following Cataract Surgery in Pseudoexfoliation Syndrome; a Preliminary Study

Mohammad Reza Fallah Tafti, MD; Hossein Abdollah Beiki, MD; S. Farzad Mohammadi, MD; MPH, FICO; Golshan Latifi, MD; Elham Ashrafi, PhD; Zahra Fallah Tafti, MS
Eye Research Center, Farabi Eye Hospital, Tehran University of Medical Sciences, Tehran, Iran

Abstract

**Purpose:** To assess the pseudophakic anterior chamber depth (PP-ACD) or effective lens position (ELP) change after cataract surgery in patients with pseudoexfoliation syndrome (PEX).

**Methods:** Consecutive eyes with PEX and cataract underwent standard phacoemulsification and were implanted with single-piece acrylic posterior chamber intraocular lenses (IOLs). Eyes with severe PEX and with axial length (AL) greater than 24 mm or less than 22 mm were not included. Eyes with capsular complication or unstable bags that needed capsular tension ring insertion were excluded. The SRK-II formula was applied to calculate IOL power for postoperative emmetropia. PP-ACD or ELP was measured using anterior segment optical coherence tomography. Data obtained at one and six months post operation were evaluated during analysis.

**Results:** Twenty-six eyes of 26 subjects (mean age: 72 years; range: 60–84 years) were studied. PP-ACD was deepened (mean change: 0.08 mm) and a concurrent hyperopic shift (0.3 D) was observed postoperatively between month 1 and month 6 (P values ≤0.002). PP-ACD and postoperative refraction changes were correlated with age and AL (P values <0.025), respectively. Increased hyperopic shift and PP-ACD deepening in eyes with posterior capsule opacification (PCO) was noted postoperatively at six months, but the difference was not statistically significant (P values = 0.15 and 0.2, respectively).

**Conclusion:** After cataract surgery in eyes with PEX syndrome, a significant backward movement of the IOL occurs postoperatively in the first six months, which is associated with a concurrent small hyperopic shift.

**Keywords:** Cataract Surgery; Effective Lens Position; Pseudoexfoliation

**INTRODUCTION**

Accurate determination of effective lens position (ELP), in addition to precise ocular biometry, is necessary to optimize refractive outcomes after cataract surgery. ELP

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or pseudophakic anterior chamber depth (PP-ACD), defined as the distance from the central corneal endothelium to the anterior intraocular lens (IOL) surface, is an indicator of the axial position of the IOL. Studies have shown that errors in PP-ACD prediction might account for 22% to 38% of the total refractive prediction error.\[1\] Errors in predicting the axial position of the IOL have a greater influence on postoperative refractive errors than IOL tilt and decentration. Forward movement of the IOL from predicted ELP results in myopia, and backward movement results in hyperopia.\[3\]

Capsular bag fibrotic reactions, zonular status, and IOL characteristics such as edge and haptic design, optic-haptic angulation,\[3,4\] diameter, and IOL material play important role in the axial position of the IOL and final ELP or PP-ACD.\[1,3-5\]

It is not always easy to predict the axial position and stability of IOLs, especially in eye-related conditions such as pseudoexfoliation syndrome (PEX), where the capsular bag is essentially unstable. Zonular instability, increased posterior capsule opacification (PCO), or anterior capsular contraction can influence the axial positional stability of IOLs or even lead to postoperative IOL tilt and decentration.\[6,7\]

The purpose of this study is to assess PP-ACD change to determine the stability of the axial position of the IOL and its refractive impact following cataract surgery in patients with PEX.

**METHODS**

This study was a prospective case series, conducted from April to December 2013. The study protocol followed the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of the Eye Research Center, Farabi Hospital, Tehran, Iran.

Patients with visually significant cataract (defined as best corrected visual acuity (BCVA) ≤ 20/40 and PEX) who consulted at the cataract clinic were consecutively enrolled in the study.

Patients were examined comprehensively and the following exclusion criteria were applied: (1) eyes with severe PEX (defined as phacodonesis on examination or significant anterior chamber depth (ACD) difference between the two eyes), implying weak zonules; (2) eyes with capsular complications such as anterior capsular tear, posterior capsular rupture, zonular dehiscence, vitreous presentation, unstable capsular bag necessitating capsular tension ring insertion, or capsulorrhexis ≤ 4 mm; (3) eyes that underwent iris stretching or required insertion of iris retractor; (4) eyes with an axial length (AL) > 24 or < 22 mm; and (5) patient with a history of significant ocular trauma or previous intraocular surgery.

Written informed consent was obtained from all patients prior to enrollment. Preoperative examinations were conducted that included visual acuity (VA) testing, slit lamp examination with assessment of zonular instability, and assessment for glaucoma. Additional preoperative data such as demographic information were recorded.

Refraction was performed using an autorefractor kerometer. (Topcon, modelKR-8900, Tokyo, Japan); keratometry was performed using a Javal kerometer (Haag Streit, Ohio, USA) preoperatively and then one and six months postoperatively by a single experienced operator.

ACD was also measured using anterior segment optical coherence tomography (OCT) (Visante OCT; Carl Zeiss Meditec, Dublin, CA) preoperatively and then one and six months postoperatively by a single experienced operator.

Scans were centered on the undilated pupil and obtained along the horizontal meridian using the enhanced anterior segment single protocol. Three consecutive images were captured and the image with the best quality in terms of centration, visibility of corneal light reflex, and minimal tilt was selected for analysis. Measurements were conducted using the chamber tool of the machine.

A-scan ultrasound axial length and Javal keratometry readings were used to calculate IOL power with the SRK-II formula to measure postoperative emmetropia.

**Surgical Technique**

Surgery was performed under topical anesthesia by a single experienced surgeon. A 3.2 mm temporal clear incision was made in the cornea. A 5 to 5.5 mm centered capsulorrhexis to ensure complete overlap of the IOL optic followed by phacoemulsification using chop technique were performed. A one-piece acrylic IOL (AcrySof SA60AT, Alcon Laboratories, Inc., Fort Worth, TX) was implanted in the bag using a disposable cartridge and the IOL dedicated injector system.

At the start of the surgery, the horizontal white-to-white (HWTW) diameter of the cornea was measured using a caliper. Eyes with capsular complications were excluded from the study.

The postoperative regimen consisted of topical antibiotics four times a day for one week, as well as topical 1% prednisolone acetate every two hours, which was tapered gradually over one month. Patients visits were scheduled one day, one week, and one month, and six months after surgery.

Slit lamp examination, uncorrected and BCVA measurement, autorefraction (Topcon, modelKR-8900, Tokyo, Japan), A-scan ultrasound (Echoscan, model
U3300, Nidek Inc., Tokyo, Japan), and anterior segment OCT were repeated at one and six months after surgery.

The main outcome measures were change in the ELP or PP-ACD measured using Visante OCT and change in refraction at one and six months postoperatively.

Statistical Analysis
Statistical analysis was performed using SPSS software version 17 (SPSS, Inc., Chicago, IL, USA). The paired t-test was used to compare the differences between parametric data at one and six months after surgery in the same patients. Correlations between continuous data were analyzed with the Pearson correlation coefficient. P value of less than 0.05 was considered statistically significant.

RESULTS
Thirty five eyes of 34 patients with PEX and age-related cataract were included in this study. Posterior capsular rupture in one eye, capsular instability, and need for capsular tension ring (CTR) insertion in five eyes, and loss to follow up of two eyes resulted in the exclusion of eight eyes. Thus, data from 26 eyes of 26 patients (15 women [57.7%] and 11 men [42.3%]) with a mean age of 72.31 ± 7.71 years (range, 60-84 years) were included for analysis. Preoperative baseline characteristics are shown in Table 1.

The mean preoperative corrected distance visual acuity (CDVA) was 0.83 ± 0.19 logarithm of the minimum angle of resolution (logMAR) units which improved to 0.06 ± 0.05 logMAR at the end of one month after cataract surgery (P < 0.001).

The ACD value measured using Visante OCT deepened significantly from the preoperative mean value of 2.63 ± 0.43 mm to 3.97 ± 0.39 mm at one month and to 4.06 ± 0.36 mm at six months after cataract surgery (P values < 0.001).

It is noteworthy that the change in ACD was negatively correlated with preoperative ACD (R = −0.4, P = 0.04).

Six months postoperatively, six eyes (23.1%) showed some PCO but no eyes demonstrated anterior capsular fibrosis or phimosis and clinically significant decentered or tilted IOL.

The ELP or PP-ACD reading also increased significantly from 3.97 ± 0.39 mm at one month to 4.06 ± 0.36 mm at six months after cataract surgery (mean change: 0.08 mm; P < 0.001).

The PP-ACD change was more significant in men as compared with that recorded in women (0.11 vs. 0.05 mm, P value = 0.04).

A concurrent small but significant hyperopic shift (0.3 D) was also observed between one and six months after surgery [postoperative spherical equivalent (SE) mean ± SD, −0.34 ± 0.97D and −0.047 ± 0.90D, respectively; P = 0.002]. The noted shift was towards emmetropia. Figure 1 shows the postoperative ELP or PP-ACD and SE values recorded at each visit.

The PP-ACD change was correlated with age while postoperative refraction change was correlated with AL (P values < 0.025).

Keratometry, lens thickness, and HWTW were not correlated with postoperative PP-ACD and refractive changes.

Hyperopic shift and PP-ACD deepening was more significant in eyes with PCO as compared with eyes without PCO at six months after surgery but the difference was not statistically significant (hyperopic shift 0.48 vs. 0.23 D, P value = 0.15; PP-ACD change 0.12 vs. 0.07 mm, P value = 0.2).

DISCUSSION
In this study, we evaluated postoperative changes in ELP or PP-ACD and its refractive impact in patients with PEX who underwent phacoemulsification.

Our results revealed that a significant change in the axial position of the IOL occurs within the first six months post surgery in eyes with mild to moderate PEX. This backward movement of the IOL was associated with a

Table 1. Preoperative baseline characteristics

| Characteristics                        |       |
|----------------------------------------|-------|
| Mean age±SD (y)                       | 72.31±7.71 |
| Sex (Male/Female)                     | 57.7%/42.3% |
| Mean CDVA (logMAR) ± SD               | 0.83±0.19  |
| Axial length (mm)                     | 23.11±0.64 |
| Anterior chamber depth (mm)           | 3.97±0.40  |
| Lens thickness (mm)                   | 4.38±0.53  |
| Horizontal white to white (mm)        | 11.75±0.56 |

SD, standard deviation; CDVA, corrected distance visual acuity; logMAR, logarithm of minimum angle of resolution; y, year; mm, millimeter

Figure 1. Postoperative effective lens position (ELP) and spherical equivalent values at each patient visit. ACD, anterior chamber depth; SE, spherical equivalent; preop, preoperative time period; postop, postoperative time period.
concurrent hyperopic shift of 0.3 D in refraction at six months post operation.

The axial stability and the effective position of the IOL during the first month after cataract surgery is not completely understood. Knowledge of the factors influencing postoperative IOL shift may allow better prediction of the final IOL position. A recent application of femtosecond laser in cataract surgery is its ability to ensure a more stable lens position due to predictable and programmable capsulorrhexis.

As previously mentioned, IOL characteristics such as edge and haptic design, optic-haptic angulation,[3,4] diameter, and IOL material play important roles in the axial position of the IOL and the final ELP or PP-ACD.[1,3-8]

It has been reported that single-piece IOLs show less change in ACD as compared with the change noted in multi-piece IOLs in the first month after surgery.[8] The longer the overall length of the IOL, the more it pushes the capsular equator and the more stable it is axially.[9] In addition, angulated IOLs demonstrate more postoperative axial movement than non-angled IOLs; a sharp optic edge design to prevent PCO has little influence on the axial stability of the IOL.[10,11]

In this study, we used a single type of IOL: the SA60AT IOL, which has an acrylic biconvex optic with a diameter of 6.0 mm, haptics of the same material and overall length of 13.0 mm, and no haptic angulation (0 degrees) for all patients.

Other intrinsic factors such as capsular and zonular properties are also important in determining the final axial position of the IOL inside the eye. This would be of greater importance in PEX eyes because of weaker zonules and more severe inflammatory and fibrotic responses; these can cause more pronounced capsular shrinkage and might further influence ELP and the residual refractive error postoperatively.[12,13]

Few studies have evaluated postoperative IOL stability in patients with PEX syndrome.

Ishikawa et al studied refractive deviation from predicted value after phacoemulsification in PEX syndrome. They found a significant deviation in both myopic and hyperopic directions from the predicted value as compared with the deviations in the controls in the first few days post operation.[14]

Contraction of the anterior capsule exerts traction on zonules; inherent zonular laxity causes less predictable lens positions and results in error from predicted refraction values postoperatively.

Tinoco-Ortega et al compared ELP after cataract surgery in 17 PEX and 15 non-PEX patients. They did not find any significant difference between ELP after cataract surgery in PEX eyes and normal controls; however, their report did not include data on ELP and refractive change during the postoperative period in.[15]

In this study, we excluded eyes with overt signs of zonular instability such as lens subluxation and phacodonesis and indirect signs of zonulopathy such as shallow or hyperdeep ACD (compared to the fellow eye). These are the given determinants of antero-posterior lens displacement, which would have markedly influenced the results if these were not excluded from the study.

In addition, eyes with unstable capsular bag during surgery that needed CTR insertion, which could have some effect on ELP, were excluded.

A trend towards a greater hyperopic shift and PP-ACD deepening in eyes with PCO was noted as compared with the findings in eyes without PCO six months after surgery but the difference was not statistically significant. With a larger sample size or a longer follow up time, during which more capsular events such as severe PCO and anterior capsular fibrosis or phimosis could happen, the difference might reach statistical significance. However, the occurrence of PCO and other types of late capsular complications such as anterior capsular opacity and phimosis and their effects on IOL position are not easily predictable. The traction exerted on the zonules by the fibrosis changes of PCO and the ongoing PEX process may contribute to the higher ELP change in this group.

We also found that PP-ACD was correlated with age. It has been shown that increasing age is a predictor of zonulopathy in PEX syndrome;[13] the older the patient, the more advanced the zonulopathy and greater the PP-ACD change.

The statistically significant change in PP-ACD and refraction is very small and may not seem clinically significant, and it should be mentioned that it was towards emmetropia. However, we know that the aforementioned phenomena are not limited to the first six months, and a follow up of at least one year is required before definitive conclusions are made about PEX and ELP. In addition, change in PP-ACD should be assessed following capsulotomy; which may be higher in PEX eyes due to higher rate of significant PCO.[12,13]

Our modern refractive approach in cataract surgery is open to any optimization in IOL power calculation. In fact, the major distinction between newer IOL power calculation formula and previous generations lies in their approach to predict ELP. In the past decades, factors such as axial length, preoperative ACD, age, keratometry, HWTW, and lens thickness were added to IOL power calculation formulas in order to better predict ELP or PP-ACD.

In our preliminary study, we observed a significant backward movement of IOL in eyes with PEX in the first six months after surgery, which was associated with a small hyperopic shift. In light of this controversial finding on ELP after PEX cataract surgery, the authors would like to recommend performing a larger study.
on PEX cataract cases (that includes varying severity of cataract and surgical scenarios) with a follow up period that extends beyond one year; that is the time when most capsular events (some necessitating capsulotomy) have already occurred. A concurrent group with normal capsular bags and zonules would be helpful in differentiating the findings attributable to PEX in the PP-ACD changes.

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Nil.

**Conflicts of Interest**
There are no conflicts of interest.

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