The Relationship Between Preoperative Anterior Chamber Parameters and Postoperative Refractive Error in Cataract Surgery

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ABSTRACT

Purpose: Postoperative refraction has become important with improvements in cataract surgery. In this study, our aim was to investigate the effects of phacoemulsification-intraocular lens (P-IOL) implantation on anterior chamber angle (ACA), anterior chamber volume (ACV), anterior chamber depth (ACD), and to assess relationship between these parameters and axial length (AL) and postoperative refractive error.

Materials and Methods: We retrospectively reviewed data from 231 patients who underwent P-IOL implantation between January 2012 and June 2014. Scheimpflug imaging system was used for the determination of ACA, ACV and ACD values at preoperative and postoperative month 3. Partial coherence laser interferometry was used for preoperative AL, target postoperative refractive error and IOL power calculated by SRK-T formula. Spherical equivalent (SE=spherical error plus cylindrical error /2) at postoperative month 3 was recorded. Postoperative refractive error was calculated as mean error (ME=postoperative refraction-target refraction) and mean absolute error (MAE=absolute of ME). Data obtained at preoperative period and postoperative month 3 were compared.

Results: Preoperative ACA, ACV, ACD were 30,2 ±12,1°, 130,7 ±41,2 mm³, 2,6 ±0,4 mm while postoperative ACA, ACV, ACD were 42,7 ±5,8°, 172,1 ±28,2 mm³, 4,1 ±0,7 mm respectively. Anterior chamber parameters were increased after P-IOL implantation, as all differences being statistically significant (p=0.001). No significant correlation was found between ME and ACA, ACV, ACD, AL. Again, no significant correlation was found between MAE and ACA, ACV, ACD. Only a weak correlation was found between MAE and AL.

Conclusion: Anterior chamber parameters measurements after P-IOL are significantly increased compared to preoperative values. There was no significant correlation between preoperative ACA, ACV, ACD and AL, and postoperative refractive error.

Key Words: Phacoemulsification, Pentacam, IOL Master, Refractive error.

INTRODUCTION

As a result of advances in cataract surgery, decreased vision caused by postoperative high astigmatism resulting from large corneal incisions has been overcome by widespread use of phacoemulsification-intraocular lens (P-IOL) implantation via small corneal incisions.[1] However, the expectations from cataract surgery have been increased and patients begin to request full visual acuity by achieving emmetropia rapidly after surgery. In this context, one of the major problems faced by cataract surgeons is prediction of postoperative refractive outcome and implantation of GIL with optimal power in each patient now. Thus, all staff together with surgeon should have to care attention regarding IOL labeling, IOL power estimation and implantation of accurate IOL into appropriate patient. Although there are many factors producing postoperative refractive outcome, measurements comprising significant error are IOL power calculation formula selected by biometric parameters such as axial length (AL), keratometry (K), anterior chamber volume (ACV), anterior chamber angle (ACA) and anterior chamber depth (ACD) and IOL characteristic.[2]

Analyses of anterior chamber parameters are an important part of ophthalmological examination. Anterior segment parameters can be measured by several methods. Many authors investigated changes in distinct anterior chamber parameters after standard phacoemulsification using several techniques.[3-6] Clinical trials demonstrated that cataract extraction leads increased ACD, widened iridocorneal

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angle and decreased intraocular pressure (IOP).[4,5] In this retrospective study, our aim was to investigate effects of standard, uncomplicated P-IOL surgery on ACV, ACA and ACH measured by Scheimpflug imaging system and to assess relationship between these parameters, axial length (AL) as measured by optic biometry and postoperative refractive error.

MATERIALS AND METHODS

Patient selection

We retrospectively reviewed data from 231 patients (aged>40years) who presented to our clinic with decreased vision and underwent standard, uncomplicated phacoemulsification surgery and intracapsular, single-piece IOL implantation with diagnosis of cataract between January, 2012 and June, 2014. The patients with ocular disorders (glaucoma, uveitis, retina diseases etc.) other than cataract, those with history of previous ocular surgery or trauma, those with corneal abnormality affecting K values, those with pseudo-exfoliative substance deposition, those using systemic drugs that may have influence on anterior chamber and IOP parameters, patients with preoperative astigmatism >-1.00 diopter (D) and those with AL <22 mm or >24 mm were excluded. In addition, eyes in which IOL measurement by optic biometry system was failed due to cataract intensity were also excluded. We included eyes with all remaining cataract types which fulfilled above-mentioned inclusion criteria. Refractive error, IOL and anterior chamber measurements were performed at least 48 hours after withdrawal of contact lens use in patients with history of contact lens use. In patients with systemic diseases such as hypertension and diabetes mellitus, P-IOL implantation surgery was performed after approval of relevant departments.

Measurements

In all patients included, age, gender and cataract types (cortical, nuclear, posterior subcapsular) as detected by biomicroscopy were recorded. In addition, preoperative and postoperative best-corrected visual acuity (BCVA) and IOP values were also recorded. ACA, ACV and ACD values were measured using Scheimpflug imaging system (Pentacam, Oculus, Wetzlar, Germany) while AL value was measured using partial coherence laser interferometry (IOL Master 500, Carl Zeiss Meditec, Jena, Germany). IOL power calculated for Alcon SA60AT IOL (Alcon Laboratories, Fort Worth, Texas, USA) and preoperative target refractive value were measured using SRK-T formulation while refractive errors were measured using autorefractor keratometry (Nidek ARK-510A, Nidek Co Ltd., Aichi, Japan). ACA, ACV and ACD were measured at baseline and on postoperative month 3 while AL and target refractive values were measured at baseline and on postoperative month 3. Refractive errors were recorded on postoperative day 1, week 1 and month 1 and 3.

Spherical equivalent (SE=spherical error plus cylindrical error /2) for refractive error at postoperative month 3 was calculated. Postoperative refractive error was calculated as mean error (ME=postoperative refraction-target refraction) and both ME and mean absolute error (MAE=absolute of ME) were recorded.

Surgical procedure and postoperative follow-up

Surgical interventions were performed under topical anesthesia by multiple surgeons. Pupil dilatation was achieved by cyclopentolate hydrochloride 1% and tropicamide %1 preparations. Corneal incision site (superior or temporal) were determined according to K measurements and a 3-planes corneal incision (2.4 mm in width) was made. Local anesthesia was achieved by intracameral lidocaine 0.5%. Trypan Blue stain was used to visualize anterior capsule in patients with mature cataract and a capsulorhexis (5.5-6 mm in diameter) was performed. The nucleus was emulsified using "Stop and chop" technique (InfinitiTM Vision System, Alcon Laboratories) and same phacoemulsification device was used in all patients. After clearance of cortex using bimanual irrigation-aspiration, Alcon SA60AT IOL with appropriate diopter was implanted into capsule, which was predicted to achieve emmetropization by IOL Master 500. Cefuroxime (1 mg/ml, 4 cc) was given to anterior chamber. One 10/0 nylon suture was placed to cornea in cases with suspected leakage from anterior chamber. The sutures were removed one week after surgery. After surgery, topical antibiotic drop (ofloxacin 0.3%, 4x1) and topical steroid drop (dexamethasone 0.1%, 4x1) were initiated, which were withdrawn on control visit at month 1. The control visits were scheduled on day 1, week 1 and month 3. In all control visits, detailed biomicroscopic examination including cornea, anterior chamber and posterior segment was performed.

Statistical analysis

All statistical analyses were performed using SPSS version 20.0. Normal data distribution was assessed using histograms and analytic methods (Kolmogorov-Smirnov test). Descriptive statistics are presented as mean and standard deviation for data with normal distribution. Pearson's correlation test was used to assess relationships among variables. In data with normal distribution, correlation coefficient <0.05 and p<0.05 were considered as statistically significant.

The study was approved by local Ethics Committee (approval#71306642/050-01-04/130; 21.05.2014). The study was conducted in accordance to Helsinki Declaration and Good Clinical Practice Guideline. All patients gave written informed consent for use of data anonymously.

RESULTS

Overall, data from 336 patients were screened retrospectively. Final analysis included data from 231 patients who fulfilled inclusion criteria. Of the patients, 105 (45%) were male and 126 (55%) were female. Surgical outcomes from right eye of 128 patients and left eye of 103 patients were analyzed. Mean age was 65.9±14.9 years (min-max: 43-82).

Preoperative ACA, ACV, ACD were 30,2 ±12,1°, 130,7 ±41,2 mm³, 2,6 ±0,4 mm while postoperative ACA, ACV, ACD were 42,7 ±5,8°, 172,1 ±28,2 mm³, 4,1 ±0,7 mm respectively. Figure 1 shows correlation between preoperative and postoperative AVC.

In the patients, preoperative refractive value was -2.1±4.7 D and target refractive value was-0.2±0.3 while postoperative refraction was measured as -0.23±0.74 D. Mean IOL power implanted was recorded as 21.3±3..3 D. The AL as measured by IOL Master was found as 23.3±2.5 mm (Table 1).

It was found that postoperative ACA, ACV and ACD values were significantly increased when compared to preoperative values (p=0.001; Table 2).

Postoperative refractive value was between -0.5 and 0.5 D in 71.5%, between -1 and 1 D in 89.4% and between -2 and 2 D in 100% of patients (Table 3).

No significant correlation was detected between ME and ACA, ACV, ACD and AL (p>0.05). Again, no significant correlation was found between MAE and ACA, ACV, ACD. Only a weak correlation was found between MAE and AL (p=.02; Pearson's correlation coefficient: 0.22; Table 4).

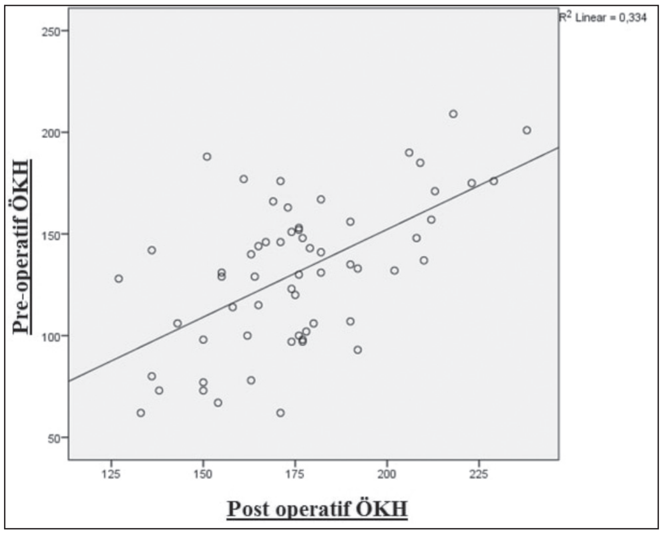

Figure 1. *Correlation of preoperative and postoperative anterior chamber volume (mm³). ACV=Anterior chamber volume.*

Table 1. *Demographic characteristics, preoperative and postoperative values.*	
	(Mean ±standard deviation)
Gender (Male/Female)	105/126
Side (Right/ Left)	128/103
Ag	65.9 ±14.9
Preoperative anterior chamber volume (mm³)	130.7 ±41.2
Preoperative anterior chamber depth (mm)	2.6 ±0.4
Preoperative anterior chamber angle (°)	30.2 ±12.1
Preoperative refraction (Diopter)	-2.1 ±4.7
Postoperative anterior chamber volume (mm³)	172.1 ±28.2
Postoperative anterior chamber depth (mm)	4.1 ±0.7
Postoperative anterior chamber angle (°)	42.7 ±5.8
Postoperative refraction (Diopter)	-0.23 ±0.74
Target refraction (Diopter)	-0.2 ±0.3
Axial length(mm)	23.3 ±2.5
IOL power(Diopter)	21.3 ±3.3
IOL: Intraocular lens	

Table 2. *Analysis of differences in preoperative and postoperative anterior chamber parameters.*			
	Preoperative	**Postoperative**	**p value**
Anterior Chamber Angle (°)	30.2±12.1	42.7±5.8	0.0001
Anterior Chamber Volume (mm³)	130.7±41.2	172.1±28.2	0.0001
Anterior Chamber Depth (mm)	2.6±0.4	4.1±0.7	0.0001

Table 3. *Postoperative refraction values.*			
		Percent (%)	**Cumulative percent(%)**
Postoperative refraction	-0,5 to +0,5 Diopter	71.5	71.5
	-1 to +1 Diopter	17.9	89.4
	-2 to +2 Diopter	10.6	100.0
	Total	100.0	

Table 4. *Correlation of preoperative anterior chamber parameters with postoperative refraction.*

		OH	MOH	AU	pre-depth	pre-angle	pre-volume	post-ref
ME	PC	1	**0.733****	-0.173	-0.032	0.027	-0.083	-0.099
	Sig. (2-tailed)		**0.001**	0.077	0.725	0.769	0.365	0.342
MAE	PC	-0.733**	1	0.223*	0.080	-0.047	0.122	0.027
	Sig. (2-tailed)	**0.001**		**0.022**	0.381	0.610	0.180	0.791
AL	PC	-0.173	0.223*	1	0.149	0.057	0.112	0.321**
	Sig. (2-tailed)	0.077	**0.022**		0.101	0.531	0.218	**0.002**
pre-depth	PC	-0.032	0.080	0.149	1	0.290**	0.858**	-0.154
	Sig. (2-tailed)	0.725	0.381	0.101		**0.000**	**0.001**	0.061
pre-angle	PC	0.027	-0.047	0.057	0.290**	1	0.263**	-0.155
	Sig. (2-tailed)	0.769	0.610	0.531	**0.000**		**0.000**	0.057
pre-volume	PC	-0.083	0.122	0.112	0.858**	0.263**	1	-0.149
	Sig. (2-tailed)	0.365	0.180	0.218	**0.000**	**0.001**		0.070
post-ref	PC	-0.099	0.027	0.321**	-0.154	-0.155	-0.149	1
	Sig. (2-tailed)	0.342	0.791	**0.002**	0.061	0.057	0.070	

***: Correlation coefficient p: 0.01 (2-tailed); *: Correlation coefficient p: 0.05 (2-tailed). ME: Mean error (postoperative refraction-target refraction); MAE: Mean absolute error (Absolute value of mena error); AL: Axial length; pre-depth: Preoperative anterior chamber depth; pre-angle: Preoperative anterior chamber angle; pre-volume: Preoperative anterior chamber volume; post-ref: Postoperative refraction; PC: Pearson's correlation.*

DISCUSSION

Phacoemulsification method, first introduced in 1967 by Kelman, can be considered as one of the most important advances in cataract surgery.[7] Ongoing development of novel tools and formulas leads continuous improvement in IOLS implanted during phacoemulsification surgery over time. Currently, by several measurements and estimations as a result of advances in technology, it is aimed to achieve emmetropia at postoperative period by implanting IOL with optimal power in each patient.

To date, many studies have been conducted about effects of phacoemulsification surgery on anterior chamber parameters, refractive success after cataract surgery and preoperative accurate biometry, ACV, AL measurement, formulas used to calculate IOL power in eyes with different ALs, different IOL types and factors affecting on postoperative refractive success such as surgery-induced astigmatism. However, there is no study investigating relationship between anterior chamber parameters and refractive errors after cataract surgery in the literature.

In a study investigated changes in ACA, ACD and ACV after cataract surgery, Uçakhan et al. found significant increases in postoperative ACA, ACD and ACV values.[8] In a study by Doğanay et al., a significant difference was found between preoperative and postoperative anterior chamber parameters with stabilization after month 1.[9] In agreement with literature, we found that ACA, ACV and ACD were significantly increased on month 3 after cataract surgery in our study (p=0.001).

When success was assessed in achieving target refractive value following P-IOL surgery, it was seen that postoperative refractive value was between -0.5 and 0.5 D in 71.5%, between -1 and 1 D in 89.4% and between -2 and 2 D in 100% of patients. In a large series by Simon et al.,[10]deviation from target refractive value was estimated as ±1 D in 1196 eyes (94%) whereas ±0.5 D in 867 eyes (67%). Authors reported that only comorbid ocular pathology affected refractive success by regression analysis.[10] Authors found that age was the only significant factor when regression analysis was performed by excluding comorbid ocular pathology, emphasizing refractive error was higher in patients with advanced age. In our study, postoperative refractive success was found to be higher since patients with comorbid ocular pathology were excluded. In addition, higher postoperative refractive success in our clinic is associated with extreme care of all surgeons and staff on IOL labeling, IOL power estimation and implantation of accurate IOL to accurate patient and repeated controls of IOL by staff, nurses and surgeons.

It was found that our clinic had significantly higher postoperative refractive success compared to other clinics.[11] Again, this finding emphasizes the importance of caring attention to selection of accurate formula for IOL power estimation in each patient, accurate preoperative measurements using accurate tools, accurate IOL labeling and implantation of accurate IOL to accurate patient by surgeons, clinic staff and operating room staff.

It is known that preoperative AL value influences on postoperative refractive error. In a study on patients with varying AL values, Juan et al.[12] found that best uncorrected postoperative visual acuity was achieved in patients with AL value of 22-25 mm.[12] Authors reported that preoperative AL value affects refractive success and uncorrected visual acuity after cataract surgery.

In a study by Norrby et al.,[13] sources of errors for IOL power estimation was investigated and authors found that preoperative prediction of postoperative IOL position accounted for 35% of errors; followed by postoperative refraction decision for 27%, preoperative AL measurement for 17%, and difference in pupil size for 8% of errors.[13]

In a study by Ueda et al.,[14] it was found that cataract density as measured from dilated pupil by Pentacam and difference between postoperative and preoperative AL values as measured by IOL Master were correlated with postoperative refractive error.[14] One should consider that postoperative refractive error will be higher in patients with high-density cataract.

It is well-known that refraction measured at early period after cataract surgery will differ from final refraction towards myopia. It has been thought that this may be due to factors such as non-transparent cornea at early postoperative period in some cases, partial dilatation of pupil and anterior dislocation of IOL compared to last position. However, refraction assessed early postoperative period may provide more accurate results in cases with higher visual acuity at preoperative period and less dense cataract. It was thought that this may be due better fixation of such patients during biometry.[15]

Despite advances in contemporary cataract surgery, undesired refractive outcomes can be seen due to inaccurate biometry measurements. Accurate ACD measurement is extremely important for a detailed biometry. Accurate K and AL measurements are prerequisite for calculation of optimal IOL power. Biometric formulas developed in recent years (Haigis Holladay II) use preoperative ACD to predict effective lens position (ELP).[16] A 0.1 mm error in ACD measurement leads 0.1 D deviation in postoperative refraction. It is required to measure preoperative ACD accurately for accurate prediction of postoperative IOL position.[17] Thus, devices used in preoperative measurements are also important. Given that Pentacam is a familiar, operator-independent, ease to use anterior segment analyzer with high reliability and reproducibility, ACD, ACA and ACV measurements were performed using Pentacam in our study.[18, 19] In general, autorefractometer is a widely accepted method to demonstrate refraction status, particularly in pseudophakic patients due to lack of accommodation component.[20, 21] We also used autorefractor keratometry to detect postoperative refraction in our patients.

Moreover, accurate AL measurement is highly important to estimate IOL power accurately; in previous studies, AL measurement is major source of error in IOL power calculation.[22,23]

IOL Master is a non-contact tool which can measure K values, ACD and AL in one session. This appears an important advantage over sonographic biometry (US-BM) which is time-consuming, contact method requiring topical anesthesia. Previous studies suggested 10-folds better accuracy of measurements with IOL Master when compared to US-BM.[24,25] In our study, AL measurements were performed using IOL Master. The cases in which measurements could not be performed by IOL Master due to mature cataract or dense posterior subcapsular cataract were excluded.

SRK-T formula is widely used in calculation of power of IOL that would be implanted in cataract surgery worldwide and it is preferred formula in cases with AL and ACD values comparable with mean values for population, we used SRK-T formula in our study. It is well-known that formula used to calculate IOL power has an important role in postoperative refractive error. In the literature, there are many studies comparing results using different IOL power formula in cases with different AL and ACD values. In a study by Lagastra et al.,[26] it was found that postoperative refractive error was ±0.5 D in 55% and ±1.00 D in 91% of patients and that satisfactory postoperative refractive outcome was achieved when IOL power was calculated by SRK-T formula in cases with comparable AL values with population average.[26]

In patients with high myopia and short eyes, using fourth generation formulas including ACD into calculation such as Barret, Haigis or Holladay II is helpful in reducing postoperative refractive error.[27-29] We excluded eyes with extremely longer and shorter AL and used SRK-T formula to calculate IOL power; thus, this may explain lack of correlation between ACD and postoperative refractive error in our study.

In our study, only patients underwent implantation of single-piece, acrylic, foldable IOL (Alcon SA60AT) in order to prevent potential effect of factors such as differences in IOL and ELP on postoperative refraction.

In a study on 95 cases with corneal astigmatism >0.5 D, Rho et al. used corneal incision at most perpendicular axis or closest 10 degree and compared keratometric data at baseline and on postoperative month 2.[30] It was shown that selecting corneal incision site according preoperative perpendicular meridian in patients with preoperative corneal astigmatism>0.50 D significantly decreased keratometric astigmatism at superior, temporal and superotemporal regions. We excluded patients with preoperative or postoperative astigmatism >-1.00 D in order to prevent effects of high astigmatism on results.

Our study has some limitations. Although patients underwent surgery were included to the study, surgeries by multiple surgeons can impair standardization. In addition, ELP has been increasingly addressed in postoperative refractive error but not evaluated in our study; we aimed to compensate this disadvantage by using same lens type in all patients.

In conclusion, ACA, ACV and ACD values measured after phacoemulsification surgery were significantly increased compared to preoperative values. No significant correlation was detected between postoperative refractive error and preoperative ACA, ACV, ACD and AL. One should be careful regarding accurate biometric measurements before surgery, IOL power estimation using appropriate formula in each patient, small corneal incision at optimal quadrant, accurate IOL labeling and accurate IOL implantation to accurate patient.

Conflict of interest

Authors declares no conflict of interest

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