Intra-operative Autorefraction for Intraocular Lens Power Calculation in Cataract Surgery

Pornchai Simaroj, M.D., Sarintip Tung-yoo-suk, M.D., Kaevalin Lekhanont, M.D.

Department of Ophthalmology, Ramathibodi Hospital, Faculty of Medicine, Mahidol University, Bangkok 10400, Thailand.

ABSTRACT

Objective: To evaluate the correlation between the refractive state of an aphakic eye after phacoemulsification and the appropriate intraocular lens (IOL) power for emmetropia.

Methods: This was a prospective, noncomparative consecutive case series study conducted in the Department of Ophthalmology, Ramathibodi Hospital, Bangkok, Thailand. A total of 57 patients underwent phacoemulsification with foldable IOL implantation by a single surgeon. The intra-operative autorefraction was performed by another assisting surgeon prior to IOL implantation. The implanted IOL power and 1-month post-operative spherical equivalent (SE) were used to retrospectively calculate the predicted IOL power for emmetropia. The correlation between intra-operative aphakic SE and the predicted IOL power for emmetropia was evaluated.

Results: Fifty seven patients with a mean age of 67.53 years (SD = 7.52) were included in the study. A linear relationship between intra-operative aphakic SE and predicted IOL power achieving plano was found with a formula: predicted IOL power (Diopter; D) = 9.416 + 1.107 (intra-operative aphakic SE), when the intra-operative aphakic SE range was + 7.25 to +16.25 D, with A-constant of 118.7.

Conclusion: There is a linear relationship between intra-operative aphakic SE and predicted IOL power. Intra-operative autorefraction may be a simple and reliable method for IOL power calculation in cataract surgery.

Keywords: Intra-operative autorefraction, IOL power calculation, cataract surgery

Siriraj Med J 2010;62:199-201

E-journal: http://www.sirirajmedj.com

The routine method of intraocular lens (IOL) power calculation in cataract surgery needs the keratometric value and axial length.[1-2] Among the identified causes, incorrect corneal power determination is the most frequent reason for incorrect IOL power implantation, followed by error in axial length measurement and insertion of a wrong IOL.[3] Other reasons include incorrect labeling of the IOL[4] and handing the wrong IOL to surgeons by the assisting staff.[5]

Corneal refractive surgery has been very popular especially in myopic individuals since 1990.[6-7] Therefore, the number of cataract patients with previous keratorefractive surgery has been increasing over the years, causing problems of IOL power calculation. Because of the inaccuracy of standard keratometry in determining the corneal curvature in eyes after keratorefractive surgery, several alternative techniques have been introduced for corneal power estimations.[8-11] However, none of them is optimal. Consequently, we have attempted to calculate the IOL power by using intra-operative objective autorefraction, performed by a hand-held automated retinoscopy following crystalline lens removal, by which aphakic SE can be directly converted into IOL power.[12-14] This technique may be useful particularly in highly myopic eyes and surgically changed corneas because axial length and keratometric values are not necessary for IOL power calculation.

MATERIALS AND METHODS

A total of sixty patients with uncomplicated senile cataracts scheduled to undergo phacoemulsification with foldable posterior chamber IOL implantation at Ramathibodi Hospital were enrolled in a prospective non-comparative observational study. This study was conducted between April 2007 and September 2007 at Ramathibodi Hospital, Faculty of Medicine, Mahidol University, Bangkok, Thailand. Exclusion criteria included

Correspondence to: Pornchai Simaroj
E-mail: ps_smr111@hotmail.com

any ocular pathology other than a cataract, intra-operative complications, and inadequate follow-up. Informed consent was obtained from all patients and the study protocol was approved by the ethics committee of Mahidol University School of Medicine.

All surgeries were performed by a single surgeon under topical and peribulbar anesthesia (2% lidocaine with hyarulonidase). All operated eyes were dilated with topical tropicamide 1% and phenylephrine 10% (1 drop of each drug administered at 5-minute intervals for a total of 3 drops each). Standard phacoemulsification was performed through a 3-mm clear corneal incision using the stop-and-chop technique. The setting parameters of the Infiniti phacoemulsifier (Alcon, Fort Worth, Texas) were as follows: 50-60% ultrasound energy with a burst width of 5 milliseconds, 150-200 mmHg vacuum, 22-25 mL/min aspiration flow rate, and 70 cm bottle height. After cortical removal, the anterior chamber was reformed with balanced salt solution (BSS) and the microscope was pulled away. Another sterile drape was put on top of the surgical field. Intra-operative autorefraction was performed by the same assisted surgeon (S. Tung-yoo-suk) using a hand-held automated instrument (Nidex ARK-30®, Gamagori, Japan) set at 12-mm vertex distance. Multiple readings were taken until the instrument automatically averaged them. The upper drape was then removed and the surgery was continued. The anterior chamber was filled with ophthalmic visco-surgical device (OVD) [sodium hyaluronate (IAL-F®, Fidia, Italy)]. A foldable acrylic intraocular lens (SN60 WF, Alcon, Fort Worth, Texas) was implanted into the capsular bag and the OVD was aspirated out. The implanted IOL was routinely calculated by SRK-II or SRK-T formula using pre-operative axial-length and keratometric values. Post-operatively, patients received tobramycin 0.3% combined with dexamethasone 0.1% eye drops (Tobradex®, Alcon, Forth Worth, Texas) four times daily for 15 days.

All patients were scheduled for post-operative evaluation at 1 day, 1 week, and 1 month. The ultimate subjective refraction and manual retinoscopy were performed at the 1 month post-operative visit. The predicted IOL power to achieve a post-operative target refraction of plano was retrospectively calculated based on the implanted IOL power and post-operative spherical equivalent (SE) using the following formula (modified from the study of Sarinas[5]):

Predicted IOL power to achieve post-operative emmetropia (D) = Implanted IOL power + (1.5 x post-operative SE)

Finally, the correlation between the intra-operative aphakic spherical equivalent and the predicted IOL power to achieve post-operative emmetropia (calculated from the formula which was modified from Sarinas' study) were analyzed using linear regression analysis with SPSS version 13.0.

RESULTS

Sixty eyes of 60 patients were recruited into the study. Complete 4-week follow-up data were obtained from 57 patients. Three patients who were lost to follow up were excluded from the analysis. The mean age was 67.53 ± 7.52 years, and 42 (73.6%) were females. There were no intra-operative complications in any patients.

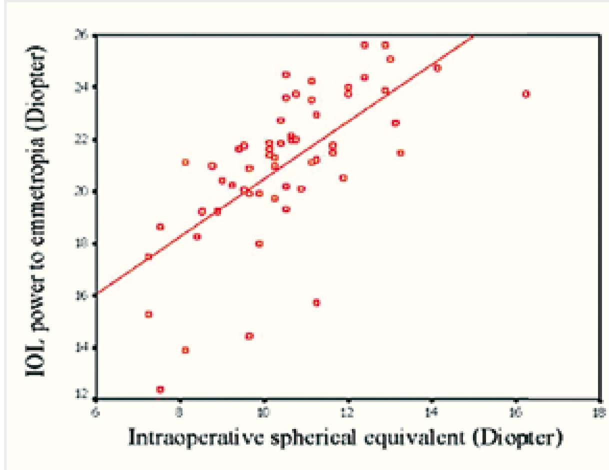

Fig 1. Correlation between intra-operative aphakic spherical equivalent and IOL power for emmetropia (linear correlation).

The mean intra-operative aphakic SE was +10.5 ± 1.76 D (range, +7.25 to +16.25 D) and mean implanted IOL power (SN60WF, Alcon, Forth Worth, Texas, A constant=118.7) was +21.4 ± 2.29 D (range, +13.5 to +25.0 D). The mean post-operative SE was -0.2 ± 0.73 D (range, -2.50 to +1.75 D).

A statistically significant linear correlation between the intra-operative aphakic SE and the predicted IOL power to achieve post-operative emmetropia was found as shown in Fig 1 and Table 1 ($P<0.01$). Therefore, the new formula for IOL power calculation was established as follows:

Predicted IOL power for emmetropia = 9.416 + 1.107 x intra-operative aphakic SE (intra-operative aphakic SE range = +7.25 to +16.25 D) (95% confidence interval = 0.785-1.429)

According to our formula, we were able to estimate the IOL power for emmetropia from intra-operative aphakic autorefraction data (Table 2). Nevertheless, the new formula was only applicable when the IOL had an A constant of 118.7.

DISCUSSION

In our study, the relationship between the intra-operative aphakic autorefraction and the predicted IOL power for emmetropia is a simple linear function (intra-operative aphakic SE ranged from +7.25 to +16.25 D). There have been several similar studies using different formulas[13,15-16], showing a comparable linear correlation.[5,13] However, one study which was performed in

TABLE 1. Correlation between intra-operative aphakic spherical equivalent and IOL power for emmetropia.

	Intra-operative aphakic spherical equivalent	IOL power for emmetropia
Intra-operative aphakic spherical equivalent	1	0.681
IOL power to emmetropia	0.681 **	1

** P < 0.01

TABLE 2. Intra-operative aphakic spherical equivalent and predicted IOL power (in the bag) for emmetropia *(A constant = 118.7)

Intra-operative aphakic refraction (spherical equivalent) (Diopter)	IOL-power for emmetropia (Diopter)
7.25	17.44175
7.5	17.7185
8	18.272
8.5	18.8255
9	19.379
9.5	19.9325
10	20.486
10.5	21.0395
11	21.593
11.5	22.1465
12	22.7
12.5	23.2535
13	23.807
13.5	24.3605
14	24.914
14.5	25.4675
15	26.021
15.5	26.5745
16	27.128
16.25	27.40475

myopic eyes (-3.0 to -27.0 D) revealed a parabolic correlation.[16]

As for our formula, 9.416 is a constant number which is added to the result of intra-operative aphakic refraction multiplied by 1.107. Consequently, the IOL power of +9.416 D has to be implanted in the eye with intra-operative aphakic refraction of zero. However, the range of intra-operative aphakic SE in our study is +7.25 to +16.25 D. Therefore, the results of our study may be a part of the parabolic correlation as in Leccisotti's study.[16]

Apart from using standard biometry in the IOL power calculation, a method with perioperatively subjective aphakic refraction has been proposed.[13] Nonetheless, this technique appeared to be more complex and infeasible. Our method was intended to improve IOL power calculation after keratorefractive surgery by using a less complicated technique of intra-operative aphakic autorefraction to calculate the suitable IOL power.

In addition, we also have extensive experience in using the new formula for IOL power calculation for secondary IOL implantation in aphakic eyes and IOL exchange in cases of wrong IOL power insertion with reasonably good outcomes.

The weakness of our study is the lack of a control group in which the IOL power is determined by partial coherence interferometry or ultrasonic biometry. Another limitation is that only the IOLs with A constant of 118.7 were used.

The most important factor that affects intra-operative aphakic SE is the corneal curvature. Corneal curvature can vary, depending on the intraocular pressure which relates to the intra-operative reformation of the anterior chamber with BSS after cataract removal. If the eye is too soft, the corneal curvature can be too flat and the SE will exhibit more plus power. On the other hand, the corneal curvature will be steeper and the SE will exhibit more minus power if the eye is too tense. Stromal hydration, which may be used to prevent leakage from the incision wound and maintain good eye pressure before the measurement, can also affect the corneal curvature which may potentially cause an error of measurement of intra-operative SE. Each surgeon may have slight differences in assessment of eye pressure during the measurement, so that this formula may not be suitable for all surgeons. Each individual surgeon needs to collect their own surgical data and establish their own formula.

In the near future, if the automated retinoscope can be attached with the surgical microscope as a single unit, it will be easier and faster to perform autorefraction intra-operatively with less risk of intra-operative infection.

CONCLUSION

From our study, the intra-operative aphakic SE and the predicted IOL power for emmetropia have a simple linear correlation with statistical significance.

Intra-operative aphakic autorefraction may be a simple and reliable alternative to standard biometry for IOL power calculation in cataract surgery particularly in patients whose accurate corneal curvature and axial length cannot be measured pre-operatively such as incorporated patients, post corneal refractive surgery patients, open globe injury patients or patients with irregular corneal surface.

REFERENCES

1. Sanders DR, Retzlaff J, Kraff MC. Comparison of the SRK-II formula and other second generation formulas. J Cataract Refract Surg. 1988 Mar;14(2):136-41.
2. Hoffer KJ. Clinical results of using Holladay 2 intraocular lens power formula. J Cataract Refract Surg. 2000 Aug;26(8):1233-7.
3. Jin GJ, Crandall AS, Jones JJ. Intraocular lens exchange due to incorrect lens power. Ophthalmology. 2007 Mar;114(3):417-24.
4. Olsen T, Olesen H. IOL power mislabelling. Acta Ophthalmol (Copenh). 1993 Feb;71(1):99-102.
5. Sarinas C. Intraoperative retinoscopy: a way to achieve emmetropia in cataract surgery. J Cataract Refract Surg. 2005 Jun;31(6):1258-60.
6. Pallikaris IG, Papatzanaki ME, Stathi EZ, Frenschock O, Georgiadis A. Laser in situ keratomileusis. Laser Surg Med. 1990;10(5):463-8.
7. Pallikaris IG, Siganos DS. Excimer laser in situ keratomileusis and photorefractive keratectomy for correction of high myopia. J Refract Corneal Surg. 1994 Sep-Oct;10(5):498-510.
8. Hoffer KJ. Calculating intraocular lens power after refractive corneal surgery. Arch Ophthalmol. 2002 Apr;120(4):500-1.
9. Koch D, Wang L. Calculating IOL power in eyes that have had refractive surgery. J Cataract Refract Surg. 2003 Nov;29(11):2039-42.
10. Aramberri J. Intraocular lens power calculation after corneal refractive surgery: Double-K method. J Cataract Refract Surg. 2003 Nov;29(11): 2063-8.
11. Cheng AC, Lam DS. Keratometry for intraocular lens power calculation using Orbscan II in eye with laser in situ keratomileusis. J Refract Surg. 2005 Jul-Aug;21(4):365-8.
12. O'Donnell FE Jr, Santos BA, Walsh D. Intraoperative autorefraction: avoiding intraocular lens power surprises. J Cataract Refract Surg. 1989 Sep;15(5):597-8.
13. Ianchulev T, Salz J, Hoffer K, Albini T, Hsu H, LaBree L. Intraoperative optical refractive biometry for intraocular lens power estimation without axial length and keratometry measurements. J Cataract Refract Surg. 2005 Aug;31(8):1530-6.
14. Leccisotti A. Intraoperative autorefraction. Ophthalmology. 2007 May; 114(5):1030.
15. Mackool RJ, Ko W, Mackool R. Intraocular lens power calculation after laser in situ keratomileusis: Aphakic refraction technique. J Cataract Refract Surg. 2006 Mar;32(3):435-7.
16. Leccisotti A. Intraocular lens calculation by intraoperative autorefraction in myopic eyes. Graefes Arch Clin Exp Ophthalmol. 2008 May;246(5): 729-33.