INTRODUCTION

Intraocular lens (IOL) power calculations are known to be difficult in eyes that have had corneal refractive surgery and several methods have been proposed to estimate IOL power. Among the methods not requiring preoperative data, the aphakic refraction technique has been successfully used to calculate IOL power in post-refractive cases and other conditions that cause unreliability in standard keratometry and ultrasonic or optical biometry. This paper looks at two complex cases of cataract surgery in eyes with previous corneal refractive surgery (LASIK for high myopia and radial keratotomy) in which pre-refractive-surgery corneal power and refraction were unknown. Aphakic autorefracation technique was used to calculate IOL power. The method resulted in an inaccurate estimation of IOL power. The reasons for failure in both cases are analyzed and exposed so that certain limitations of this method that should be taken into account when considering its application in complex cases can be illustrated.

CASE REPORT

Limitations of Intraoperative Aphakic Refraction Technique for Intraocular Lens Power Calculation

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ABSTRACT: Intraocular lens (IOL) power calculations are known to be difficult in eyes that have had corneal refractive surgery and several methods have been proposed to estimate IOL power. Among the methods not requiring preoperative data, the aphakic refraction technique has been successfully used to calculate IOL power in post-refractive cases and other conditions that cause unreliability in standard keratometry and ultrasonic or optical biometry. This paper looks at two complex cases of cataract surgery in eyes with previous corneal refractive surgery (LASIK for high myopia and radial keratotomy) in which pre-refractive-surgery corneal power and refraction were unknown. Aphakic autorefracation technique was used to calculate IOL power. The method resulted in an inaccurate estimation of IOL power. The reasons for failure in both cases are analyzed and exposed so that certain limitations of this method that should be taken into account when considering its application in complex cases can be illustrated.

KEY WORDS: Intraoperative Aphakic Refraction Technique, Intraocular Lens Power Calculation, LASIK, Radial Keratotomy.

J Emmetropia 2011; 2: 31-35

Mackool et al.4 describe a technique in which the cataract is removed and a subjective refraction is performed 30 minutes later. Using a nomogram developed by the authors, the power of the IOL is calculated and the IOL is then implanted. Recently, Ianchulev5 described a similar approach using intraoperative automated refraction. Both Mackool4 and Ianchulev5 multiplied the measured refractive error by a fixed, albeit different value ~1.75 for Mackool4 and 2.01 for Ianchulev5 assuming an IOL constant of 118.84 and 118.4 respectively.

This method would completely eliminate the need for axial length (AL) and corneal power measurements and it has been reported to successfully calculate proper IOL power not only in eyes with previous refractive surgery4,5, but also in eyes with other problems that cause unreliability in standard keratometry and ultrasonic or optical biometry, such as corneal irregularities, vitreoretinal abnormalities (asteroid hyalosis, posterior staphyloma) or ocular fixation issues (nystagmus) and silicone filled eyes4,6-8.

Two cases of eyes with previous corneal refractive surgery in which aphakic autorefracation technique was used to calculate IOL power are reported here. The method resulted in an inaccurate estimation of IOL power. The reasons for failure in both cases are analyzed and exposed to illustrate certain limitations of
this method that should be taken into account when considering its application in complex cases.

CASE REPORTS

Case I

A 33 year old man with a cataract diagnosed in his right eye presented for evaluation. The ocular history was significant for LASIK surgery and enhancement in both eyes 12 years previously at another center and retinal detachment along with vitrectomy in his right eye. Pre-refractive surgery corneal power and refraction were unknown. He remembered –24 D approximately in both eyes. Uncorrected distance visual acuity was counting fingers in the right eye.

Biomicroscopy showed a mature cataract in his right eye and evident corneal thinning in both eyes. Ultrasound AL was 35.7 mm and 35.40 mm and anterior chamber depth (ACD) was 3.91 mm and 3.89 mm in the right and left eye respectively. Mean corneal power in the right eye, measured by manual keratometry, was 36.62 diopters (D). Corneal topography showed an apparent decentered ablation. Due to the low vision of this eye, the patient was not able to fixate and there were significant variations between maps. Although a reliable corneal power map could not be obtained, the least unreliable one was selected for IOL calculations (fig. 1). The 3 mm total mean power obtained from Orbscan topography, 31.88 D was used as post-refractive surgery corneal power.9 Because neither preoperative nor postoperative data were available to calculate IOL power, this value was used as post-refractive corneal power and together with an assumed pre-LASIK k-reading of 43.5 D, the double-k SRK-T formula was applied to calculate IOL power, following recommendations for eyes without preoperative data.1,10 The formula predicted an IOL power of +10 D (120.0 as A-constant). The Haigis formula yielded an IOL power value of +10 D. IOL power obtained in post-refractive patients are expected to be +18 D or higher, assuming an approximate post-LASIK refraction of emmetropia or mild myopia is achieved. Therefore, the value predicted by both formula, +10 D, was considered to be erroneous and therefore a decision was made to calculate the IOL power by means of the autorefraction technique in aphakia.5 Once the cataract had been emulsified and a capsular tension ring had been implanted, the patient was removed from the operating room and an automated refraction (Humphrey Automatic Refractor Model 597K, Carl Zeiss) was performed 20 minutes later. Surprisingly, this showed an aphakic refraction of +1.375 D, which using the nomogram previously published,5 would yield an intraocular lens power of +2.76 D (120.0 as A-constant). This value seemed even more unlikely than that previously calculated (10 D), however, considering the absence of any more data and the complexity of the case, a decision was made to implant a +7 D intraocular lens (Corneal ACRD), which was the average value of both data. On postoperative day one, automated refraction result was –3.25 –0.5 x 100 and corrected visual acuity was 20/400. In this examination, the pupil was still dilated. One week later, the result of automated autorefracti was +5.5 –1.5 x 175 (the pupil had already recovered its baseline size). Subjective refraction was +9.5 –1.5 x 180 and a corrected distance visual acuity of 20/70 was reached. In the same visit, the pupil was dilated with topical tropicamide 1% and phenylephrine 10% and the result of the automated refraction when the pupil was well dilated was –3 –0.75 x 65, which was similar to the result on postoperative day one. The same difference between subjective and automated refraction was observed in two subsequent visits. Since subtle signs of zonular weakness had been observed during surgery, an intraocular lens exchange was discarded and one month later, a piggy-back11 was performed with implantation of a +14 D power intraocular lens (Acrysof MA50BM, Alcon, Inc.). On postoperative day one, uncorrected distance visual acuity was 20/40 and subjective refraction was –1.5 x 5, with corrected distance visual acuity of 20/40. In this situation of emmetropia, the automated refraction of the eye showed a result of –4 –1.5 x 5 with an undilated pupil and –9 –1.5 x 35 with pupil dilatation. Reliable topography maps were obtained after cataract surgery (fig. 2), showing a well centered ablation zone. The values of 3 mm total mean power (26.74 D) and 4 mm total optical power (25.04 D) –two recommended readings to estimate post refractive surgery corneal power9 were obtained, with 4 mm total optical power being the closest value to
axial map was calculated, 38.4 D. This was used as obtained and the mean of the 3 mm central area of the Orbscan topography in the left eye was measured by manual keratometry, was 27.59 mm and ACD was 3.2 mm and 3.1 mm in the right and left eye respectively. Mean corneal power was 24.42 D, which was the value that was back-calculated from double-k SRK-T formula for an emmetropic IOL power of +21 D.

**Case II**

A 36 year old woman with diagnosis of cataract in her left eye presented for evaluation. Her ocular history was significant for radial keratotomy in both eyes performed 13 years previously in another country, retinal detachment in her left eye as well as a vitrectomy. Pre-refractive surgery corneal power and refraction were unknown. She remembered myopia near –8 D in both eyes. Corrected distance visual acuity was 20/50 and 20/400 in the right and left eye respectively, with subjective refraction of –3.75 –0.5 x 10 and –3.75 in the right and left eye respectively. Biomicroscopy showed a subcapsular posterior cataract in her left eye and provided mistaken myopic keratometry readings, which was the case when the intraoperative reading was obtained or on postoperative day one. This may be due to one of two related hypotheses: either the mistaken myopic readings are due to an increase in spherical aberration in the peripheral areas of the cornea or they are caused by averaging of the central, emmetropic refractive error of the eye with the peripheral, more myopic refractive error of the eye.

**DISCUSSION**

Mackool and Ianchulev et al proposed an alternative method for the prediction of IOL power: a purely optical method. This method is based on the assumption that the intraoperative aphakic spherical equivalent obtained through subjective or automated refraction will correlate closely with the final adjusted emmetropic IOL power. This method will obviate the need for keratometry and AL measurements, which are used in today’s biometric formulas.

The two case reports described here illustrate, however, possible limitations to this method. We decided to use it for the first time when we faced the daunting problem of estimating IOL power in such a complicated scenario as case I. Not only was there the history of corneal refractive surgery for –24 D and the absence of pre-refractive-surgery data, but there was also the long axial length and the encircling buckle.
Objective refraction is more accurate than automated because the patient was unable to fixate the target of the topographer due to the low visual acuity. After cataract surgery, a properly centered topography was obtained and the value of the 4 mm total optical power of this map\textsuperscript{9} closely matched the value for corneal power that was back-calculated form the double-k SRK-T formula.

With regard to the second case, the eye of the patient in question, which had a history of radial keratotomy as well as long axial length and encircling buckling procedure, experienced a transitory hyperopic shift during phacoemulsification surgery. The eye suffered a corneal flattening of 4 D from a preoperative mean power of 39 D to an intraoperative and early postoperative value of 35 D. Corneal power returned to near baseline values 4 weeks after surgery. This regression correlated with a myopic shift in refraction of approximately 4 D. The possibility of this happening has been described previously in post-radial keratotomy cases. Patients with previous 8-incision radial keratotomy will commonly show variable amounts of transient hyperopia in the immediate post-operative period following cataract surgery, which should gradually resolve after three to twelve weeks\textsuperscript{15-20}. This is felt to be due to stromal edema around the radial incisions, which produces a temporary enhancement of central corneal flattening\textsuperscript{21}. Surgeons should be aware of this possibility so that an early postoperative IOL exchange can be avoided. What is also important here is that an intraoperative aphakic measurement in these eyes will measure the eye with lower than baseline keratometric readings, and as this effect is transitory, estimations of IOL power based on these measurements will lead to a myopic result. Finally, in our case, the last measurement of the eye showed a myopia of \(-2.5 \pm 1\) x 10 with the 19.5 D implant, indicating that either the Haigis formula or double-k SRK-T method had predicted the correct value\textsuperscript{22}.

Thus, on the basis of these two case reports, we conclude that 1) the success of intraoperative aphakic refraction technique for biometry in eyes with previous refractive might be influenced by the type of autorefractor used to measure the aphakic state, and this method should be correlated with the aphakic subjective refraction and 2) this method of IOL estimation does not appear to be a good alternative in cases with a previous history of radial keratotomy because of the possibility of a transient corneal flattening.

The aim of this paper has been to draw attention to potential limitations of the intraoperative aphakic refraction technique in making an accurate estimation of the IOL power that should be taken into account when considering its application in complex cases. Of course, the failure of the method in these two particular cases does not invalidate its usefulness in other settings which have been previously reported in the literature\textsuperscript{4-8}.

The failure of Haigis and double-k SRK-t methods to calculate the correct IOL power was caused by the erroneous post-refractive corneal power used in the calculations. Corneal topography was not well centered procedure, aggravated by the fact that the low visual acuity made it impossible to obtain reliable topographies. Thus, the aphakic method, which obviated the need for AL or keratometric values, appeared to be the best option. The reasons for the failure of this method to accurately estimate IOL power were clearly related to the failure of the automated refraction to accurately measure the eye, particularly when the pupil was well dilated. The intraoperative aphakic measurement was obviously carried out with a dilated pupil and the first postoperative measurement in which the eye appeared to be myopic was taken with a well dilated pupil. It was not until the visit on the first postoperative week that the automated refractometry measured the hyperopic result because the pupil was not dilated at this time. The agreement between subjective refraction and autorefraction after laser in situ keratomileusis was studied previously by using two different types of autorefractor\textsuperscript{13}. For both cycloplegic and noncycloplegic conditions, the Humphrey autorefraction measurements (which was the autorefractor we used in case I) were significantly more myopic than the subjective refractions, while the difference between mean values for the Grand Seiko autorefractor and subjective refraction with cycloplegia was not statistically significant. The two autorefractors used in that study\textsuperscript{13} have different measurements, principles and dramatically different infrared beam sizes; the infrared beam of the Humphrey autorefractor fills the patient’s entire pupil, whereas the infrared beam of the Grand Seiko autorefractor is only about 2 mm in diameter. Thus, any autorefractor that has an infrared beam large enough to include either transition zones of the ablated cornea and/or untreated peripheral areas of the cornea will provide false myopic autorefraction readings in post-corneal refractive surgery patients. This hypothesis explains the discrepancy between subjective refraction and autorefraction in our patient when the pupil was dilated. One could argue that in our case the difference was exaggerated by the amount of LASIK correction in the cornea (–24 D) and the narrow optical zone used which can be observed in the topography (fig. 2). In addition, it measured a hyperopic refraction that was lower than the real one under non-cycloplegic conditions, which has also been reported by Bailey et al.\textsuperscript{13}. The results of the method may well have been different if a different kind of autorefractor had been used. Certainly, Mackool maintains that, according to his experience, the subjective refraction is more accurate than automated refraction for the estimation of IOL power\textsuperscript{14}.

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