A New Method of Calculating Intraocular Lens Power After Photorefractive Keratectomy

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ABSTRACT

PURPOSE: To find a method of calculating intraocular lens (IOL) power that may be independent of preoperative data, in eyes that have developed a cataract after refractive surgery.

METHODS: Prior to and 1 month after PRK, the SRK/T formula was used to calculate IOL power in 88 eyes of 65 patients with a preoperative spherical equivalent refraction between -16.25 to +0.25 D (mean -5.39 ± 3.19 D). IOL power was calculated by utilizing the spherical equivalent refraction as target both before and after PRK. Utilizing the postoperative corneal radius measurement (R2), an underestimation of the IOL power was found. For this reason, the mean postoperative corneal radius (R3) that gave the same IOL power found before surgery was calculated for each patient. The R3/R2 ratios were plotted against the axial eye length and a linear regression formula was used to calculate R2 correcting factors that gave the new corneal radius (R4). Patients were divided into classes according to axial eye length, and the mean R3/R2 ratios for each class were calculated and used to recalculate the new mean radius (R5). IOL power for emmetropia was calculated in all patients by utilization of R3, R4, R5, the historical method, and the "true corneal power" method.

RESULTS: Within ±0.50 D from the IOL power calculated with R3, R4 gave 35 (39.3%) IOLs, while R5 gave 40 (45.5%) IOLs; the clinical history method gave 24 (27.3%) IOLs and "true corneal power" gave 23 (26.1%) IOLs, with a statistically significant difference *P*<.001).

CONCLUSIONS: Our theoretical method, based on correlation between axial eye length and corneal radius correcting factors, may represent an effective method of calculating IOL power after PRK, especially if the history of the patient is unknown. [*J Refract Surg* 2002;18:720-724]

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Calculation of intraocular lens (IOL) power for patients undergoing cataract surgery is mainly based on the measurement of the corneal power, axial eye length, and estimation of the effective lens position.[1] Over the years, several formulae have been proposed to make this calculation, and nowadays the so-called third generation formulae are considered to be those that obtain the best results in terms of IOL power prediction.

After refractive surgery for myopia, both keratometry and corneal topography tend to overestimate the corneal power[2-7], and consequently the calculated IOL power is underestimated, as has been described.[8-15] To overcome this problem, several techniques have been proposed, most of which require knowing the preoperative keratometric power and the exact amount of treatment, and regrettably in most patients such information is not available. The purpose of our study was to find a method that could give reliable results even for these patients.

PATIENTS AND METHODS

Eighty-eight eyes of 65 patients (29 males and 36 females) consecutively treated with photorefractive keratectomy (PRK) for myopia, or myopic or mixed astigmatism were included in this non-randomized, prospective clinical study. The age of the patients at the time of refractive surgery ranged between 19 and 56 years (mean 33.5 ± 9.2 yr).

Patients were asked to discontinue wearing contact lenses for at least 1 month before undergoing the last refractive evaluation, which was performed the day the patient underwent PRK.

Before and 1 month after treatment, all patients underwent a complete ophthalmic examination, including automatic keratometry and axial eye length measurement with an IOL Master (Zeiss, Jena, Germany). Patients with systemic and ocular diseases that could potentially interfere with the healing process of the cornea or with refractive outcome (eg, diabetes, collagenopathies, dry eyes, uveitis, corneal and lens opacities, glaucoma) were not included in the study.

Treatments for sphere and cylinder were performed by combining objective and subjective refraction, thereby achieving the best corrected visual acuity. Whenever a discrepancy between keratometric and subjective (clinical) cylindrical data was noted, we used the subjective refraction cylinder data and not the keratometric data for planning the refractive procedure

All treatments were performed under topical anesthesia with oxybuprocaine eye drops (Novesina, Novartis Farma, Italy). The lids were opened with a speculum, the epithelium was debrided with mechanical brush epithelial removal, and all treatments were performed with a 193-nm excimer laser (Nidek EC-5000, Gamagori, Japan) operating in scanning mode. After treatment, a smoothing of the surface was performed using 0.04% hyaluronic acid. A bandage contact lens was applied under sterile conditions on the treated eye immediately following surgery, and was not removed until complete re-epithelialization. During this period, operated eyes received diclofenac sodium 0.1% eye drops twice a day for the first 2 days, nethylmicin preservative-free eye drops until re-epithelialization, and preservative-free artificial tears for 1 month; after re-epithelialization, clobetasone eye drops were prescribed to all patients for 1 month in a tapered dose, as follows: one drop four times a day for the first week, one drop three times a day for the second week, one drop two times a day for the third week, and one drop once a day for the last week.

For all patients, we postulated that the lens power before and after PRK would not change, since with PRK we treat the corneal surface and not the lens.

Before and after PRK, the SRK/T formula was used to calculate the power of a standard IOL (Memorylens [CIBA Vision, Duluth, GA], foldable, 6.0-diameter, with a recommended A constant of 119, and anterior chamber depth of 5.6 mm), utilizing as target the spherical equivalent refractive error before and after PRK (eg, if a patient had a spherical equivalent refraction of -5.00 diopters (D) before PRK and +1.00 D after PRK, we used as target -5.00 D before PRK, and +1.00 after PRK) utilizing the preoperative (K1) and postoperative (K2) keratometric power (Fig 1).

Because an underestimation was found between these two values (Fig 1), we calculated a mean keratometric power (K3) for each patient, which gave

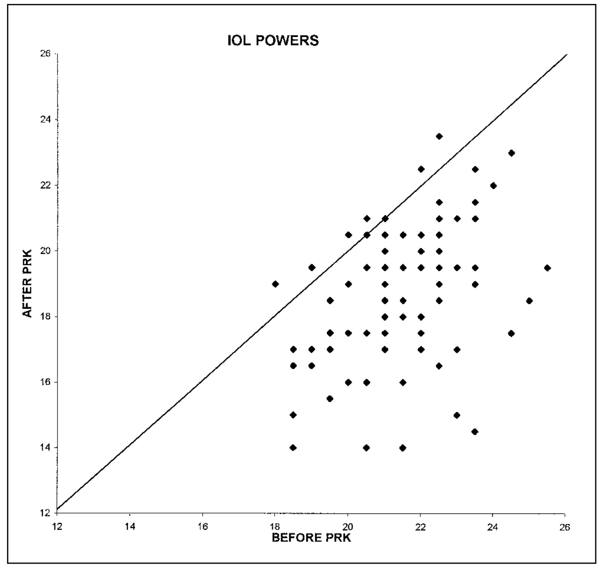

Figure 1. Correlation between IOL power calculated before and after PRK utilizing as target the preoperative and postoperative refractive error.

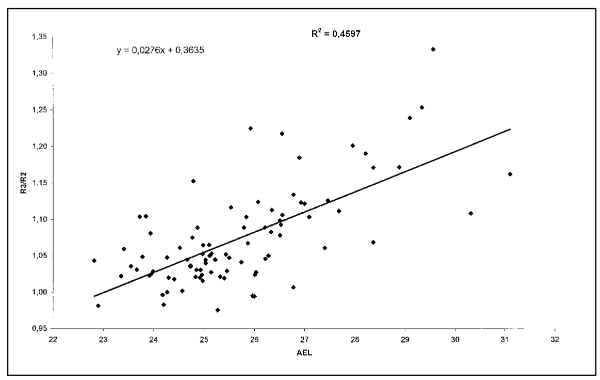

Figure 2. Correlation between the R3/R2 ratios and the axial eye length.

the same IOL power we had determined before surgery. From K3, we calculated the corneal radius (R3) by utilizing n = 1.332 (according to the Zeiss IOL Master).

At this point, we calculated a ratio between the calculated radius (R3) and the measured postoperative radius (R2) for each patient and correlated them with one easily available postoperative parameter, the axial eye length. We found a fairly good correlation (r^2 = 0.4597) between axial eye length and these ratios with a linear correlation formula (Y= 0.0276 X + 0.3635) (Fig 2).

We used this linear regression formula to calculate the correcting factors which, when multiplied

Table 1
Correcting Factors for Calculating Corneal Radius According to Axial Length of the Eye

Axial Eye Length (mm)	Correcting Factor
22 to 22.99	1.01
23 to 23.99	1.05
24 to 24.99	1.04
25 to 25.99	1.06
26 to 26.99	1.09
27 to 27.99	1.12
28 to 28.99	1.15
⩾29	1.22

by R2, gave the new radius (R4). We also divided the patients into classes according to axial eye length, and calculated the mean ratio for each class (Table 1), which we used to calculate mean radius (R5). R4 and R5 were then utilized to calculate different IOL powers for emmetropia in all patients.

To test the reliability of our methods we compared our results with those obtained with the historical method[16,17] and with the "true corneal power[18] method" and tested the differences with a paired *t*-test.

To further validate our results, we tested our method with the data of some cases reported in the literature[9-11], and in particular we calculated with our formulas the expected postoperative refractive error by utilizing the power of the implanted IOL.

RESULTS

Before PRK, the refraction of the patients ranged between -14.00 and +1.50 D (mean -4.66 ± 3.21 D) of sphere, the cylindrical power between -4.50 and 0 D (mean -1.44 ± 1.22 D), and the spherical equivalent refraction between -16.25 and +0.25 D (mean -5.39 ± 3.19 D).

One month after PRK, the refraction ranged between -0.50 and +3.50 D (mean 0.88 ± 0.83 D) of sphere, the cylindrical power between -0.50 and +2.50 D (mean +0.36 ± 0.46 D), and the spherical equivalent refraction between -0.50 and +3.50 D (mean +1.07 ± 0.88 D).

The IOL values obtained after PRK showed an underestimation compared to those obtained after PRK (Fig 1).

The IOLs for emmetropia calculated by utilizing the historical method and the true corneal power were underestimated compared to the IOLs calculated with R3 (Figs 3, 4). The number of eyes that showed ±0.50 D and ±1.00 D of difference and the mean differences between calculations (the measured radius, R4, R5, historical method, and true corneal power) and the true IOL power (utilizing R3) are shown in Table 2. The differences obtained with R4 and R5 were significantly smaller than those obtained with the other two methods ($P<.001$).

With our methods, we calculated the expected postoperative refractive errors by utilizing the implanted IOL in the cases described by Siganos and colleagues[9] and Morris and colleagues[11], shown in Table 3.

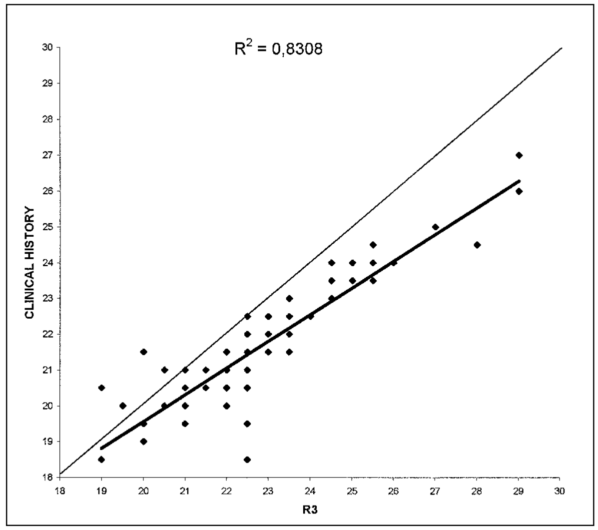

Figure 3. Correlation between IOL power calculated utilizing the historical method and those obtained utilizing R3.

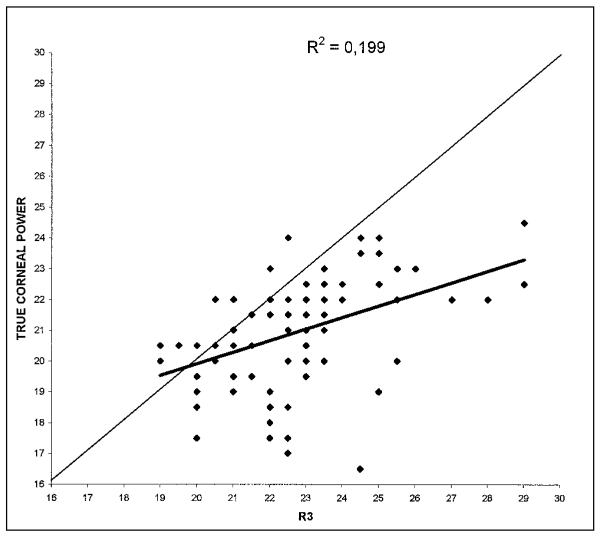

Figure 4. Correlation between IOL power calculated utilizing the true corneal power method, and those obtained utilizing R3.

Table 2
Number (%) of Eyes Between ±0.50 D and ±1.00 D of Theoretical IOL Power, Utilizing Correcting Factors and Historical Method; Difference Between IOL Power Calculated With Different Methods and the Theoretical IOL Power

Method of Calculation	±0.50 D	±1.00 D	Mean Difference (D)
R4*	35 (39.77)	50 (56.82)	0.20 ± 2.87
R5†	40 (45.45)	58 (65.91)	-0.14 ± 1.46
Historical method	24 (26.13)	49 (55.68)	1.14 ± 0.86
True corneal power	23 (26.14)	40 (45.45)	1.81 ± 2.01

*R4: new corneal radius obtained with regression formula
†R5: new corneal radius obtained from classes of axial eye length

Table 3
Expected Refractive Error Calculated With SRK/T Formula and R4 or R5, With the Implanted IOL

Authors	Implanted IOL Power (D)	Refractive Error (D)	R4* (D)	R5† (D)
Siganos et al[9]	11	3.50	2.67	3.00
Morris et al[11]	11	4.00	4.60	4.80

*Expected refractive error calculated with SRK/T formula and R4, with the implanted IOL
†Expected refractive error calculated with SRK/T formula and R5, with the implanted IOL

DISCUSSION

Keratometry and corneal topography analyses have been reported to underestimate corneal power changes by 20% to 30% after PRK.[4] For this reason, underestimations of IOL power calculations in the case of patients who had undergone cataract extraction with IOL implantation after PRK have been described.

Three main methods of overcoming this problem have been described: the clinical history method, the contact lens method, and the true corneal power method.

Clinical History Method

This method was described by Guyton[16] and Holladay[17] in 1989 for eyes after refractive keratotomy, and later by Hoffer.[18]

This method, based on refraction-derived keratometric values, requires the knowledge of three parameters[19]: preoperative corneal power, preoperative, and postoperative refraction.

Calculation of True Corneal Power

Most videokeratography and standard keratometry convert the corneal radius into corneal power by using the standardized keratometric index of 1.3375. This index is invalid after PRK and laser in situ keratomileusis (LASIK) because these procedures change the relationship between the anterior and posterior surface of the cornea.[19]

However, there is no agreement on the value to be used in these cases, as some authors[20,21] suggest using n = 1.376, and others[22] suggest the higher value n = 1.4083.

Contact Lens Overcorrection

This method, described by Soper and Goffman[23], is based on three parameters[19]: base curve of plano contact lens in diopters, spherical equivalent refraction without contact lenses, and contact lens over-refraction. This method is slightly less accurate than standard keratometry for determining corneal powers in persons with normal corneas, clear media, and good visual acuity and can be performed in a person in which no knowledge of the preoperative parameters is available, but unfortunately is not reliable if the media opacities give visual acuity worse than 20/70.[24]

In our opinion, the clinical history method and the calculation of the true corneal power seem accurate and easy to calculate. However, with regard to the clinical history method, PRK has been performed on many patients in different surgical centers, and the preoperative keratometric power and the exact amount of PRK correction are regrettably unavailable. We found a poor correlation with regard to the true corneal power method.

Among the existing formulae, we decided to use the SRK/T because this third generation formula seems to be more accurate for IOL calculation. In our study, we correlated axial eye length, an easily available measurement, to the amount of treatment, since we assumed that in most patients there is an axial myopia; we excluded from the study patients with lens opacities or with keratoconus. Even if our two methods need to be tested in a large prospective evaluation to assess validity and determine which one is best, the one with correction factors related to axial eye length showed a slightly better correlation (r^2 = 0.5032) compared with the linear regression formula (r^2 = 0.3592).

We think that our methods, which are based on a radius of curvature correcting factor related to the axial eye length, might represent an effective method of calculating IOL power after PRK if preoperative keratometric power or the amount of treatment are unknown.

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