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Intraocular Lens Power Calculation After Refractive Surgeries

An ESSAY

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Abstract:

The accuracy of intraocular lens (IOL) power calculation is important for the visual outcome of patients undergoing cataract extraction and IOL implantation.

But if those patients undergoing cataract extraction and IOL implantation have a previous refractive surgery the accuracy of IOL power calculation then will be lost.

Sources of errors of IOL calculation after corneal refractive surgeries: 1-Instrument error as standard keratometery and corneal topography cannot accurately measure the corneal power, 2-Index of refraction error because the relationship between the anterior and posterior corneal curvatures is changed in PRK, LASIK, and LASEK, but not in RK and 3-Formula error as most third- or fourth-generation IOL formulas Hoffer Q, Holladay 1 and 2 and SRK/T, (but not the Haigis formula) use the flatter corneal power (K) than normal K in RK, PRK, LASIK, and LASEK eyes causes an error in prediction of effective lens position (ELP) because the anterior chamber dimensions do not really change in these eyes.

Key words:

1-Instrument error - 2-Index of refraction error - 3-Formula error

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List of abbreviations

A	Intraocular lens (IOL) A constant for planned IOL style
ACD	Anterior chamber depth
AL	Axial length
AR	Aphakic refractive error (spherical equivalent)
BCL	Base curve; contact lens,
BESSt formula	Borasio Edmondo Smith and Stevens formula
CALF	Corrected axial length factor
CALF	Correction axial length factor
CF	Conversion factor
CL	Contact lens
CPC	Corneal power correction factor
Cst	Centistokes
CVK	Computerized videokeratoscopy
D	Diopters
EffRPpost	Effective refractive power
ELP	Effective lens position
Flattest MAN PO K	Flattest postoperative ks readings with manual keratometry
HEMA	Hydroxy ethyl methyl methacrylate
ILM	Internal limiting membrane
IOL	Intraocular lens
IOLm	IOL master
K	Corneal power
Kpostoperativer	Average postoperative corneal power by diopter (D) In radius r (mm)
Kpreop	Average preperative topography central simulated K
Ktpo	Postoperative simulated K value from topography
LASEK	Laser-assisted subepithelial keratectomy
LASIK	Laser in situ keratomileusis
m/s	Meters per second
Max CT	Maximum central thickness
Min CT	Minimum central thickness

n	Refractive index
n post	Postoperative keratometric index of refraction
Nc	Corneal refractive index
OL	Optical length of the eye
Pa	Power of the anterior corneal surface
pACD	Postoperative anterior chamber depth
PCI	Partial coherence interferometry
PCIOL	Posterior chamber intraocular lens
PCL	Power of contact lens
PEMM	IOL power calculated for emmetropia
PMMA	Polymethyl methacrylate
PO K=	Postoperative corneal power
PO MK/TK	Postoperative ks readings with manual keratometry and corneal topography
PO Rx	Postoperative refraction
PO Topog EffRp	Postoperative effective refractive power or average central corneal power by corneal topography
Post-lasik SE Rx	Postoperative lasik spherical equivalent refraction
postop Sim-K	Average postoperative topography central simulated K
Pp	Power of the posterior corneal surface
Pre-lasik SE Rx	Preoperative lasik spherical equivalent refraction
preop Sim-K	Average preperative topography central simulated K
PRK	Photorefractive keratectomy
PTARG	Target IOL power to produce the postoperative desired refraction (eg.emmetropia)
PTARG FlatK	IOL power calculated for planned postoperative target refraction using the postoperative flattest K.
r	Corneal curvature
r **meas**	Corneal radius (mm)
R NoCL	Refraction without contact lens
***R*a**	Radius of anterior corneal curvature
RC	Surgical change in refractive error (spherical equivalent)

Rcc	Spherical equivalent at corneal plane
RCC	Surgical change in refractive error (spherical equivalent) vertexed to corneal plane
RCF	Rosa correction factor based on axial length
RCL	Refraction with contact lens
Rcs	Spherical equivalent at spectcal plane
RK	Radial keratotomy
rN	Adjusted refractive index
RPE	Retinal pigment epithelium
RPRE	Refractive surgery preoperative refractive error (spherical equivalent)
RX	Refraction
RxTARG	Planned postoperative target refraction
SE	Spherical equivalent
SEQ	Spherical equivalent change
SEQco	Spherical equivalent change at corneal plane
SEQsp	Spherical equivalent change at spectcal plane
Shammas-PL	Shammas post lasik
Sim-K	Simulated keratometry value
SIRC	surgically induced refractive change
SNR	Signal : noise ratio
TA	Actual true central thickness
TE	Phakic IOL thickness error
TKCTR	Exact singular postoperative topography central K(at the center of the axial map instead of the Sim-K)
TKpo	Average postoperative topography central simulated K
TMS	Topographic Modeling System
TRI	Theoretical variable refractive index
VE	Sound velocity being used (such as 1,532 m/s)
VE	Velocity used by the ultrasound instrument.
WTW	White to white measurement

List of figures

List of tables

Content

Introduction

The accuracy of intraocular lens (IOL) power calculation is important for the visual outcome of patients undergoing cataract extraction and IOL implantation. Different formulas such as Holladay I, Hoffer Q, and SRK-T have been used with excellent results. All formulas use the corneal power among other factors to calculate the IOL power. The corneal refractive surgeries i.e. radial keratotomy (RK), photorefractive keratectomy (PRK), and laser in situ keratomileusis (LASIK) to correct myopia, hyperopia and astigmatism, change the corneal power; therefore, it is difficult to measure the true central corneal power after refractive surgery by any form of direct measurement, such as keratometry, or corneal topography.The phakic refractive IOL surgeries do have a variable effect on the ultrasound measurement of the axial length (AL) of the eye ***(Koch, 2006).***

When standard keratometry and biometry methods or IOL power calculation software are used on this subset of patients, there is a risk of inducing hyperopia following a prior myopic refractive correction and vice versa (***Feiz and Mannis, 2004).***

These IOL power errors can be attributed primarily to three factors: (1) inaccurate measurement of anterior corneal curvature by standard keratometry or computerized videokeratography (CVK); (2) inaccurate calculation of corneal power from the anterior corneal measurement by using the standardized value for refractive index of the cornea (1.3375); this occurs because procedures that remove corneal tissue (e.g. PRK or LASIK) change the relationship between the front and back surfaces of the cornea; and (3) incorrect estimation of effective lens position (ELP) by the third-generation formulas (e.g. Holloday I ,SRK-T, or Hoffer-Q) or fourth-generation formulas (e.g. The Haigis formula , Holladay II formula) when the postoperative corneal power values are used ***(Wang et al., 2004).***

Various methods have been proposed to improve the accuracy of corneal power estimation for IOL calculation in patients who have undergone corneal refractive surgery; these can be categorized according to whether or not they require data acquired before refractive surgery was performed. Methods requiring historical data: Clinical history method, Feiz-Mannis method, Adjusted effective refractive power (EffRPadj), Adjusted annular corneal power, Adjusted keratometry. Methods requiring no historical data: Contact lens over-refraction, Mean central corneal power from CVK, Modified Maloney method, Adjusting corneal power using a correcting factor and direct measurement using orbscan topography ***(Koch and Wang , 2003).***

To correct the AL in biphakic eyes i.e. the state of phakic eyes containing a refractive IOL regardless of its position in the eye, we must subtract the phakic IOL thickness error i.e. the false element in the total measurement of the AL from the measured AL and then add back the actual true thickness of the phakic IOL ***(Hoffer, 2000).***

Current technology and software Pentacam is a corneal and anterior segment imaging device that works on the Scheimpflug principle.Its accuracy and reproducibility have been well established. By measuring the true anterior and posterior elevation of the cornea the net power is obtained. However the existing formulae reduce the k reading by

2% allowing for the fact that the net power is approximately 2% (0.75D) lower than the anterior K value. If the true power of the cornea were to be inputted into an existing formula it would be underestimated by the formula's correction factor. Pentacam Equivalent K therefore boosts the IOL power to make it comparable with the keratometer and can be utilized into the Holladay II or other formulae. Alternatively, Pentacam's data on the front and back corneal radii and central corneal thickness can be input into the BESSt (Borasio Edmondo Smith and Stevens) formula to calculate the corneal power which can then be used as the K value in any existing formula ***(Borasio et al., 2006).***

Another recent technology and software the IOL Master is a non-contact optical coherence biometry that makes possible the exact measurement of visual axis length. Its accuracy is not affected by high ametropia, pupil size or state of accommodation. This non-contact technology makes it easy on the patient: no local anesthesia, water bath or contact probe. For IOL power calculation after previous refractive corneal surgery, one can derive the effective corneal power using either the clinical history method, or the rigid contact lens over-refraction method. Where no preoperative data is available, the IOLMaster offers the Haigis-L formula. It therefore permits selection of a suitable lens after myopic LASIK/PRK without requiring refractive pre-LASIK data or additional contact lens over-refraction. Haigis –L uses three constants and two variables (AC depth and axial length) to calculate the effective lens position ***(Haigis , 2003a).***

Aim of the work:

The aim of this work is to review the different methods of intraocular lens power calculation after refractive surgery and to highlight the advantages and disadvantages of each.

Intraocular Lens Power Calculation

The refractive power of the human eye depends on the power of the cornea, the lens, the position of the lens, and the length of the eye. Accurate assessment of these variables is essential in achieving optimal postoperative refractive results. If these biometric measurements and calculations are inaccurate, the patients may be left with a significant refractive error ***(Feiz and Mannis, 2004).***

IOL power calculation relies on three measurements:

Axial length, based on ultrasound or optical biometry; corneal power, using manual/automated keratometry or corneal topography; and anterior chamber depth, which is not independently measured. These values are used collectively in theoretic or regression formulas to determine an IOL power for a desired refractive status. Axial length measurements have been the source of most refractive surprises, although refinements in biometry techniques and instruments have decreased these errors ***(Feiz and Mannis, 2004).***

On the other hand there is a study conducted by ***Olsen (2007a)*** showed that imprecision in measurements of anterior chamber depth (ACD), axial length and corneal power contribute to 42, 36 and 22%, respectively, of the error in predicted refraction after implantation of an intraocular lens (IOL) ***(Olsen, 2007a).***