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Original research

Comparison of OKULIX ray-tracing software with SRK-T and Hoffer-Q formula in intraocular lens power calculation

Mohammad Ghoreyshi [a], Ahmadreza Khalilian [a,*], Mohammadreza Peyman [b], Mohaddeseh Mohammadinia [c], Alireza Peyman [a]

[a] Isfahan University of Medical Sciences, Isfahan, Iran
[b] University Malaya, Kuala Lumpur, Malaysia
[c] Parsian Vision Research Institute, Isfahan, Iran

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Abstract

Purpose: To compare the performance of OKULIX ray-tracing software with SRK-T and Hoffer Q formula in intraocular lens (IOL) power calculation in patients presenting with cataract.
Methods: In this prospective study, 104 eyes of 104 patients with cataract who underwent phacoemulsification and IOL implantation were recruited. Three IOL brands were used and for all eyes, IOL power calculation was performed using SRK-T, Hoffer Q formula and also OKULIX ray-tracing software. For all patients, axial length and keratometry data was obtained with IOLMaster 500 device and IOL power was determined using Hoffer Q and SRK-T formula. The IOL powers were also calculated using the OKULIX ray-tracing software combined with CASIA AS-OCT and IOLMaster 500 device. Optically measured axial length of eyes were inserted to OKULIX software from IOLMaster 500 device, and anterior and posterior tomographic and corneal pachymetry data was imported from CASIA AS-OCT into the OKULIX.

The performance of each calculation methods was measured by subtracting the predicted postoperative refraction from the postoperative manifest refraction spherical equivalent (MRSE). For each of the 3 methods, the mean absolute prediction error was determined, too.
Results: The mean value absolute prediction error by OKULIX, SRK-T and Hoffer Q formulas, respectively, were 0.42 (±0.03), 0.36 (±0.02) and 0.37 (±0.02). The mean absolute prediction error by OKULIX had no significant difference between three IOL groups ($P = 0.96$), and it was confirmed that there was no meaningful statistically difference in mean absolute prediction error between the OKULIX, SRK-T and Hoffer Q formula. ($P = 0.25$). Also in each group of implanted IOLs, all three formulas worked with the same accuracy. The prediction error using OKULIX were within ±0.50 diopter in 63.5% of eyes and within ±1.00 diopter in 94.2% of eyes.
Conclusion: OKULIX ray-tracing IOL power measurements provides reliable and satisfactory postoperative results, which are comparable to other 3rd generation formulas of SRK-T and Hoffer Q.

Keywords: Ray-tracing; IOL power calculation; OKULIX

Introduction

Accurate intraocular lens (IOL) power determination is an important factor to achieve the ideal uncorrected distance visual acuity and patient satisfaction after cataract surgery.

In the past, IOL power calculations have been performed with analytical formulas based on Gaussian optics,[1−6] which is

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* Corresponding author. Number 72, Pamchal Alley, West Nazar Street, Esfahan, Iran.

E-mail address: reza2624@yahoo.com (A. Khalilian).

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an approximation in which the sine function in Snell's law is approximated by the argument: $\sin(\alpha) \simeq \alpha$.[7]

Gaussian optics is so called paraxial optics or thin lens method because this is valid for paraxial rays only, so it is a poor approximation of the real pseudophakic human eye.[8]

In the 1980, regression formulas were mostly used because of their simplicity to use like; Sanders, Retzlaff, Kraff (SRK) I and II. In the 1990s, these formulas were replaced by more accurate, newer formulas like; Haigis, Hoffer Q, SRK-T, Holladay 1, 2 and Oslen. Most of the advances in these new generation formulas concerned improved methods of estimating the effective lens position (ELP).

Despite these advancing new formulas and precision surgical improved equipment and techniques, refractive surprise after uneventful cataract surgery is still a challenge, especially in eyes with abnormal axial length (short or long axial length)[9,10] previous corneal refractive surgery or corneal pathologies like keratoconus.[11]

Ray-tracing, the gold standard in lens and optical system design, is a straightforward and promising approach in IOL power calculation.[8,12] Indeed the only method in which the prediction error can be kept as small as necessary is numerical tracing.[13] This calculation does not contain any approximation.[8]

It has been shown that the optics of pseudophakic eye can be accurately described using exact ray-tracing technique.[14]

OKULIX (Tomey Corporation) is a numerical ray-tracing software, which is developed at the University of Mainz, Germany, and has been explained in detail by Preussner et al.[8,13,15] It is able to determine the monochromatic optical capacities of pseudophakic, human eye.[12] In this technique, single light rays limited only by pupillary size are evaluated. Rays undergo different refractions on different surfaces, where the refractive index changes (intravitreal, lens, aqueous humor, and cornea). The shape of surface is mainly described by their central curvature radii.[8] Axial length, IOL curvature radii, IOL central thickness, asphericity and refractive index, as well as corneal topography measurements [anterior/posterior corneal keratometric values and central corneal thickness (CCT)], are also used in OKULIX software for more precise IOL power calculation.

Anterior segment optical coherence tomography (AS-OCT) can measure the entire shape of anterior/posterior corneal surfaces with a near-infrared light.[16] It has been found that AS-OCT based topography and CCT data agree well with conventional pachymetric measurements.[17,18] These data can be transferred to OKULIX software for IOL calculations. The curvature, central thickness, refractive index, and the asphericity of the target IOL were retrieved from a database in the software.

The aim of this study was to determine the performance of the IOL power calculation using OKULIX, in cataractous eyes by comparing its prediction error with other routine formulas; Hoffer Q[19] and SRK-T.[20]

Methods

This prospective study included 104 eyes of 104 Iranian patients (55 male and 49 female, mean age 60.91 ± 14.90 years; range from 6 to 81 years) candidate for cataract surgery and IOL implantation from January 2015 to April 2016.

Our predetermined exclusion criteria were eyes with axial length higher than 26 mm or less than 21 mm or measured with contact applanation or immersion ultrasound A-scan, cases with preoperative or postoperative astigmatism greater than 2 diopters, keratoconus, previous trauma or surgery (such as laser refractive surgery and corneal transplantation). Eyes with complicated cataract surgery (such as posterior capsule tear with or without vitreous loss, anterior capsule extended tear, sulcus or anterior chamber positioned IOL, corneal suturing) were excluded, too. Because of compounding (correlation) of data with bilateral eyes, we have included only one eye from each bilateral cataract surgery.

Preoperative examination

For all patients, axial length and keratometry data was obtained with IOLMaster 500 device (Carl Zeiss Meditec AG, Jena, Germany), and IOL power was measured using Hoffer Q and SRK-T formulas.[19,20] These two formulas were included in IOLMaster 500 device and IOLs A-constant for SRK-T formula and personalized anterior chamber depth (PACD) for Hoffer Q formula were optimized from User Group Laser Interference Biometry (ULIB) online table (as of Oct 31, 2016) available at: www.ocusoft.de. Target refraction was set to zero.

The IOL powers were also calculated using the OKULIX ray-tracing software combined with CASIA AS-OCT (SS-1000, TOMEY Corp). This device is a non-contact, three dimensional system based on the principle of *Swept Source* OCT. Its scanning speed is 30,000 A-scan/second with radial scan direction (16 images) and 512 lines A-scan per image sampling. The anterior and posterior tomographic and corneal pachymetry data was imported into the OKULIX. The predicted postoperative refraction was chosen for best focus for the default pupil diameter of 2.5 mm. Optically measured axial length of eyes were inserted to OKULIX software from IOLMaster 500 device. Target refraction was set to zero too.

IOLs brands which were implanted are alphabetically listed below:

1 Alcon; Acrysoft IQ: SN60WF
2 Bausch and Lomb: enVista MX60
3 HOYA: NY-60/250/251 isert.

Surgical technique

All cataract surgeries were done by the same surgeon (M.G.). The cataract was removed by phacoemulsification

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