Clinical Biometry - Newer Dimensions

Dr. Ashok Kumar Nanda
Kar Vision Eye Hospital, Bhubaneswar

Abstract

Obtaining precise post operative target refraction is of utmost importance today a catatact surgery has become a refractive surgery after introduction on newer techniques and premium IOLs. Hence patients expectations are on the rise to which every practicing ophthalmologist has to meet. Biometry and application of correct IOL power calculation formula plays a crucial role in meeting these expectations. In this article reviews the publications and recent advances in the field of clinical biometry.

Introduction

Intraocular lens power calculation is a crucial step in achieving desired target refractive outcome in today's modern cataract surgery. Numerous devices and formulas are currently available allowing accurate determination of the IOL power required to reach the target refraction. 1-12 In order to accomplice target refraction , axial length, AC depth, Corneal radii of curvatures need to be measured accurately. More over proper choices of IOL power calculation formulae are as important as the use of accurate IOL constant , depending on type of IOL and post operative IOL position. Over the past decade significant developments have been made which have led to improvement in IOL power predictability and the refractive outcome. These include stable in the bag IOL placement and modification of various IOL power calculation formulas.1-2 In addition recent development in the biomedical field have led the availability of novel devices such as the Laser partial coherent interferometry (PCI) and the low coherence optical reflectometry (LOCR).11-12 To date A scan mode ultrasound biometry has been considered the gold standard for axial length and ACD measurement. The PCI based IOL Master (Carl Ziess) was introduced in 1999 and the LOCR based Lenstar LS 900 (Haagstreit, Switzerland) introduced in 2008 made the biometry much more precise. These recent technological developments have stimulated continuous modification in the process of biometry to give more predictable and accurate IOL power. This article reviews the recent publication in the field of clinical biometry.

Contact Ultrasound Ocular Biometry

A mode contact ultrasound ocular biometry has been considered the gold standard for decades.A special cristal embedded in the probe oscillates to generate a high frequency sound wave that penetrates the eye.The result is a one dimensional time amplitude representation of the echoes received along the beam path.The difference between the echo spikes recorded on the oscilloscope screen provides an indirect measurement of tissue such as globe length and lens thickness. The height of the spike is indicative of the strength of the tissue sending back the echo. There are two types of A mode ultrasound biometry available : Contact applanation biometry and Immersion Biometry.

The contact type of biometry requires the probe to be placed perpendicularly on the cornea and is prone to errors due to corneal indentation and off axis measurements. It also carries the risk of transmitting infections. The immersion type biometry requires placing a saline filled scleral shell between the probe and the eye. So as there in no direct contact of the probe on the cornea there is no error due to indentation.

Non contact Optical Biometry

Optical Biometry for accurate assessment of the axial length is becoming popular as it is faster , easy to use and non contact method. The PCI based IOL Master uses a 780nm laser diode infra red light to measure the axial length. The ACD is measured through a lateral slit illumination with this device and the anterior corneal curvature is calculated at six reference points in a hexagonal pattern at approximately 2.3 mm optical zone. The LCOR based Lenstar LS 900 uses an 820 nm superluminescent dioad laser for measuring the axial length. In addition to axial length it also measures the central corneal thickness and the lens thickness. The ACD measured by lenstar is from the endothelium unlike IOL master where it is from the epithelium to anterior lens surface. The Lenstar also measures the size and centricity of pupil, retinal thickness .The K reading is more accurate as it measures K at 32 referrence points oriented in 2 circles ; 2.3mm and 1.65 mm optic zone.

Both Lenstar and IOL master are in good agreement in terms of mean axial length , ACD and Corneal curvature.8 The mean difference in axial length measurement was 0.01mm±0.05 standard deviation between the two devices. (P=0.12). The Lenstar measures more parameters but the draw back is it take twice as long time as the IOL master to complete the measurement.12 Although the optical biometry devices are easy to use their main drawback is the failure to measure axial length in dense subcapsular cataract and mature cataracts where Laser beam cannot penetrate the lens opacity to reach the retina.

Refractive power measurement of Cornea

Measuring the corneal power is always puzzling as neither the manual nor the optical keratometers can measure the true corneal power. Instead the cornea is assumed to be a spherocyllinder with a fixed anterior to posterior corneal curvature. A very fundamental problem in the design of manual and automated keratometer is that they donot provide sufficient information to determine the corneal shape accurately. A well lit target is placed in front of the cornea which acts as a convex mirror and produces a virtual image of the target. The radius of curvature of the cornea is then predicted with various presumptions like cornea to be spherical, an assumptive back corneal surface power and assuming the paraxial corneal power to be equal to central. Non the less the obtained results are very diminutive. Whereas in most normal corneas the power calculation is easy , in post refractive surgery corneas power calculation poses a special challenge. With a change in the anterior corneal curvature and unchanged posterior curvature in these eyes & with the corneal refractive index of n= 1.3375 ; the corneal power calculation is no longer accurate. So the corneal power is under estimated due to corneal flattening which in turn leads to a hyperopic refraction after cataract surgery.13-14

Computerized videokeratography may be superior to these keratometers in assessing the corneal power in post refractive eyes. Holladay et al 15evaluated the accuracy of central corneal power measurement by scheimpflug imaging (Pentacam) for eye that had undergone refractive surgery . They used the historical method to compute the theoretical post operative keratometric reading which was then compared with the measured equivalent K reading obtained from Pentacam . The mean prediction error for the pilot group was -0.06±0.56D .Using the 4.5 mm zone determined in the pilot group the equivalent K reading value of the test group of 41 eyes of post RK patients had a mean predictive error of -0.04±0.94D (range -1.84 to ±2.27 D).They concluded that the shiempflug imaging with pentacam provides accurate corneal power in post RK eyes. But a study published by Tang et al 16 accuracy of pentacam keratometric reading was found to be inaccurate in all eyes ; virgin or post refractive state. It was found to be steeper than the true corneal power.

Anterior Chamber depth measurement

Most of the modern IOL formulas depend on the anterior chamber depth mesurerment in order to increase the accuracy of IOL power prediction. So accurate measurement of ACD is crucial to lessen the undesirable refractive outcome. All Biometric devices and the videokeratography instruments are capable of ACD measurement. Various studies have compared the ACD measurement of different biometry machines. Salouti et al 17 compared ACD readings between IOL Master, Lenstar LS and A mode contact biometry. He found ACD with IOL master was little smaller than other two [3.07±0.42(range 2.10 to 4.16)].With A mode biometry it was 3.14±0.4 (range 2.3 to 4.27) and that with Lenstar it was 3.17±0.42 (range 2.19 to 4.51) . However these difference was not statistically significant.(P=0.09). In another study by Salouti et al which compared the ACD measurement between the Orbscan (A slit scanning videokeratography sytem) and Pentacam and Galilei (a double scheimpflug imaging videokeratograohy system).it was found that the difference was 0.32mm between Orbscan and Pentacam and it was 0.3 between Orbscan and Galilei. Orbscan gave a little higher reading than Pentacam and Galilei.It is also important to remember not to measure ACD in Pseudophakics in IOL master as it is designed to measure only in phakic eyes.*

Axial Length Measurement

Difference in axial length measurement have a substancial influence on the final calculated IOL power. Numerous Studies have compared the results between the IOL master, Lenstar and the A scan biometry.8 It showed a mean difference of 0.01 mm between Lenstar and IOL master, a difference of 0.04 mm between Lenstar and Immersion biometry and a difference of 0.188mm between Lenstar and A scan contact mode. However there was no statistical difference in the result between all the three modes of biometry.

Intra Ocular Lens Power Calculation

Though there are significant improvements in the different biometry devices in terms of technological developments, there is still an ongoing debate about which IOL power calculation formulas best predicts the actual post operative refraction. There is not a single formula which suits all eyes. So it is important to know the strength and weakness of each formula and in order to choose the most appropriate formula for a particular patient.

The theoretical formulas for IOL power calculation not changed much from the date Federov described the first IOL power calculation formula since 1967.The variables that are involved in IOL power calculation are (a) Axial length, (b) IOL power, (c) Net corneal power, (d) Effective Lens Position, (e) Desired refraction and (f) Vertex distance . The only variable that can not be measured accurately pre operatively is effective lens position (ELP) . ECP was given a constant value of 4mm in the first generation IOL calculation formulas in 1980s when the IOLs were mostly Iris fixated . Later it was increased to 4.5mm when 2nd generation formulas like SRK I , SRK II and Binkhorst I were used as the IOLs were placed in sulcus

Holladay I formula introduced in 1988 utilized two variables to calculate the ELP- the axial length and the keratometry. But it was found that in shorter axial length of the eye ball (<20 mm) the formula is inaccurate . A 0.5 mm change in the predicted ELP can change the post op refraction by 1 to 3 diopters depending on the Power of IOL used. So Holladay II formula was introduced in 1996 ASCRS meeting . Olsen in 1995 introduced AC depth and the Lens thickness as additional variable which further increased the accuracy. Eye with axial length between 22 to 25 mm and K value between 42 to 46 D can have accurate predictive IOL power by using third generation formulae like: Holladay I, SRK/T and HoffersQ. In other cases we can use either fourth generation formula like : Olsen, Holladay II or Beretts .

Reduced accuracy of IOL calculation after cornel refractive surgery is a clinical problem of growing importance. There are several methods in literature to evaluate the corneal power after refractive surgery including the clinical history method (vortex corrected to the corneal plane) , the contact lens over refraction method, the Aramberri double K method,and the Latkany flat K method. Although these methods offer better accuracy in post refractive eyes, pre operative and post operative K values and refraction are also required before cataract surgery which are time consuming to perform. To save time Wang et al18 developed an internet based IOL power calculator for eyes with prior refractive surgery. Method using pre LASIK keratometry & surgically induced change in refraction vrs. method using no previous data were analysed. It was found that method using only surgically induced changes of refraction resulted in superior refractive outcome following cataract surgery. In a recent study by McCarthy et al19 it was found that the top 5 formulas that gives best outcome in Post Lasik eyes are Masket with Hoffers Q formula, Shammas.cd with Shammas PL formula, Higgis L formula, Clinical history method with Hoffers Q formula and the Latkani Flat K with SRK/T formula. They give target refraction within 1 D of emmetropia in 75 to 80% cases.

How ever non of these are fully effective in eyes with refractive corneal surgery as the flatter central cornel power resulted in hyperopic refraction after IOL implantation and newer formulae are still being developed to handle these situations .

Conclusion

Modern technology has significantly improved our ability to accurately measure ocular biometry parameters which has made us more confident in fulfilling patients expectations.But it very much essential to pay attention to proper patient selection, accurate keratometry , biometry and proper IOL power calculation formula selection. Eventually the highest variable parameter is going to establish the outcome. In order to increase the accuracy in biometry it must be operated by an experienced operator, it must be calibrated regularly, measurements must be repeated, use optical biometry as and when possible and appropriate IOL formulae should be used. It is also essential to evaluate the outcome regularly .By following each steps and understanding the strengths and weaknesses during application of these steps successful outcome is achievable.

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