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Comparison of optical biometry based on partial coherence laser interferometry (PCLI) principle to conventional applanation ultrasonic biometry

Pooja H. V.[1,*], Vijay Pai[2]

[1]Senior Resident, Dept. of Ophthalmology, Adichunchanagiri Institute of Medical Sciences, Karnataka, [2]Professor and HOD, Dept. of Ophthalmology, K.S. Hegde Medical Academy, Mangaluru, Karnataka, India

***Corresponding Author:**
Email: poojahv1410@gmail.com

Abstract

Purpose: Our aim was to compare the accuracy of intraocular lens (IOL) power calculation with two techniques namely optical biometry based on partial coherence laser interferometry (PCLI) principle and conventional ultrasound biometry.

Materials and Methods: A comparative study was done in our hospital wherein 100 eyes of 100 patients undergoing phacoemulsification cataract surgery were recruited into it. Out of them, 50 eyes underwent optical biometry and 50 eyes underwent conventional applanation ultrasound biometry. Eyes were grouped according to axial length into long (>24.50), normal (22 to <24.50) and short (<22mm). Paired t- tests were applied and the mean error and mean absolute error (MAE) were calculated.

Results: The MAE calculated was 0.60 +/- 0.40D and 0.20+/- 0.30D with the conventional applanation ultrasound and optical biometry respectively. It was found that the optical biometry gives more accurate values for eyeball with small and large axial length.

Conclusion: The optical biometry parameters which uses the partial coherence laser interferometry (PCLI) principle happens to be the more precise method in IOL power calculation.

Keywords: Axial length, Optical, Partial coherence laser interferometry, Ultrasound A scan.

Introduction

In the majority of patients undergoing cataract surgery with intraocular lens implantation provides an excellent refractive outcome and can correct pre-existing refractive errors. Higher success rates have been seen with phacoemulsification and foldable intraocular lens (IOL) implantation. Also visual rehabilitation is faster with phacoemulsification. The refractive outcome following surgery is dependent on variety of factors like axial length (AL) mesurements, depth of anterior chamber, both horizontal and vertical corneal curvature readings based on keratometry, IOL quality and formulae applied in calculating IOL power.[1] Manual keratometry readings that is both horizontal and vertical corneal curvature readings and Ultrasound axial length measurements which are needed for intraocular lens power calculation have commonly been used in cataract surgery. Of all these factors described, inaccuracy in axial length measurements is the major influential factor for the refractive outcome following cataract surgery. As the refractive outcome is significantly based on the accuracy of preoperative biometry calculations, the various methods used in biometry continue to evolve. Various studies have shown that optical biometry with PCLI yields significantly better IOL power prediction than ultrasound biometry and thus the refractive outcome.[2] The current study was done to compare the accuracy in intraocular lens (IOL) power calculation with two techniques namely optical biometry based on partial coherence laser interferometry (PCLI) principle and conventional ultrasound biometry. Thus the refractive outcome after phacoemulsification cataract surgery was analysed using the two techniques mentioned above for IOL calculation.

Materials and Methods

A comparative study was done in our hospital wherein 100 eyes of 100 patients undergoing phacoemulsification cataract surgery were recruited into it. Out of them, 50 eyes underwent optical biometry which is based on the partial coherence laser interferometry principle and 50 eyes underwent conventional applanation ultrasound biometry after adjusted for age and gender. Patients with visually significant cataract in one or both eyes were included in our study. Patients previously undergone ocular surgery, glaucoma, eyes with corneal scarring, retinal detachment, dense/ total cataracts, posterior polar cataract, complicated cataracts following chronic uveitis, subluxated lens, retinitis pigmentosa, macular degeneration and eccentric fixation, trauma were excluded from the study. Informed consent was taken from all the patients and they were enrolled in our study only after having taken their consent. Ethical clearance was obtained for the present study conducted at our hospital. Nil financial interest is involved in our study. Keratometry was done using Bausch and lomb® keratometer. Axial length was calculated using Sonomed® A-scan and Lenstar® based on applanation and on partial coherence laserinterferometry (PCLI) principle respectively. All patients who had visually significant cataract underwent testing at our out- patient department, department of Ophthalmology. After routine examination which involved the best corrected visual acuity (BCVA) by Snellen's visual acuity charting, anterior segment evaluation using slit lamp biomicroscope, the axial length scans are obtained. Patient is asked to fixate on a target light (Most important is not to instill dilating drops before obtaining the measurements). The device measures the distance from the corneal vertex to the fovea accurately. Five consecutive measurements was obtained in all patients and a computed average of five serial measurements was done automatically and displayed on the screen of the Lenstar®. The applanation ultrasound biometry measurements was done following 0.5% proparacaine instillation in the patient's eye (lower fornix) 2min prior taking the ultrasound measurements. Care should be taken so that the transducer probe is aligned along the optical axis with the patient in supine position, thus minimizing the pressure on the cornea upon placement. The average of at least five readings was taken from the applanation ultrasound biometry as well. The IOL design, material and the IOL formula (SRK-T) were standardized. Eyes were grouped based on the axial length as short (<22mm), normal (22 to <24.50) and long (>24.50). All measurements were done by a single surgeon. Statistical analysis: The data was entered into MS Excel sheet and statistical analysis was performed using SPSS version 16. Sample size was defined in such a way to provide statistical power sufficient for the study, which in our study was over 90%. The results were calculated using frequency percentage. Paired t-tests was applied and the mean error and mean absolute error (MAE) were calculated.

Results

Mean age was 60.04 ± 16.26yrs. The mean axial length was 23.86 ± 1.85mm (range 20.08-26.7) with applanation ultrasound biometry and 23.53 ± 1.88mm (range 20.0- 27.3) with optical biometry. The mean absolute error corresponded to 0.42 ± 0.340D and 0.26 ± 0.20D with applanation ultrasound biometry and that due to optical biometry which uses partial coherence laser interferometry as the principle respectively. In our study we found that the optical biometry is found to give more accurate values for eyeball with small ($p = 0.02$) and large axial length ($p = 0.033$) (Fig. 1). Postoperative refraction calculated was predicted within ± 1D in 94% of cases of optical biometry when compared to 87% with applanation ultrasound biometry. Postoperative refraction was predicted within ± 1D with the conventional biometry using applanation ultrasound and optical biometry in 89% and 93% respectively in short axial length group, 86% and 89% respectively in normal axial length group and 87% and 94% respectively in long axial length group (Fig. 2).

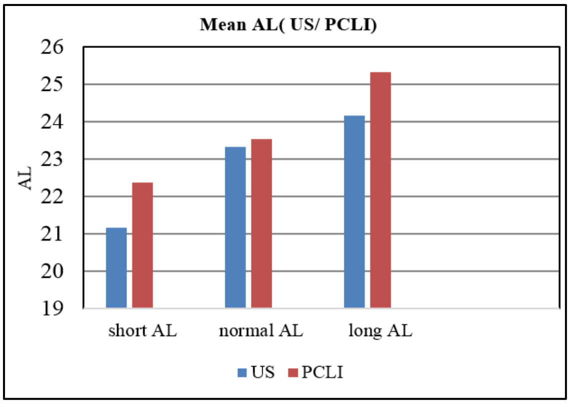

Fig. 1: Mean AL measured using the two standard techniques described namely applanation ultrasound biometry and optical biometry. AL, axial length. US, ultrasound. PCLI, partial coherence laser interferometry

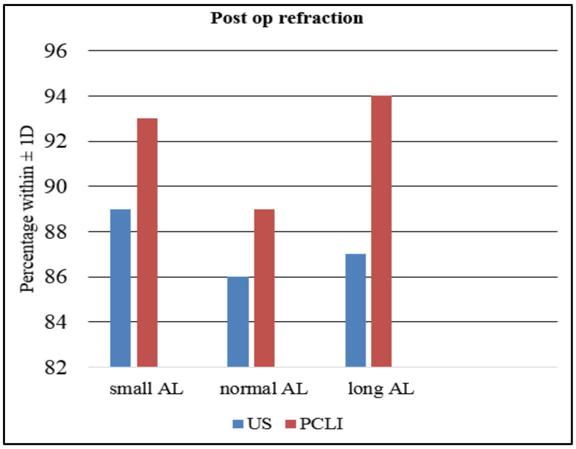

Fig. 2: The postoperative refraction of eyes that underwent ultrasound biometry and optical biometry (PCLI). AL, axial length. US, ultrasound. PCLI, partial coherence laser interferometry

Discussion

Ocular biometry is defined as the process of measuring the various anatomical characteristics of the eye that are needed for intraocular lens power calculation. Optical biometry which uses the principle of partial coherence interferometry is currently the gold standard in ocular biometry as it is very accurate, easy to perform, non-invasive and comfortable for the patient. The technology of ultrasound was started and used in diagnosing ocular pathology since late 1960s and early 1970s.[3-5] In 1990s, ultrasound calculation of AL was accurate and considered as the gold standard for IOL power calculation in cataract surgery, when in the late 1990s, optical biometry based on the principle of partial coherence laser interferometry was introduced.[6] Through the device infrared monochromatic light is sent into the eye and captured when the light gets reflected back from the retina. Based on the interference patterns received between the signal sent and that detected upon return, the axial length of the eye is calculated. Zaldiver et al showed that in long eyes, the anatomic AL is longer than the optical AL by a of mean 0.8mm, which is even greater with posterior staphyloma.[7] In a study conducted by Mirjana et al, out of 32 eyes analysed, predicted refractive was 0.01±0.02D with lenstar in nearly 95% of the observed cases.[8] The major limitation of applanation ultrasound biometry is that anatomic axial length is measured and not the optical axial length. In ultrasound technique due to the probe being in contact with the eye, thus suffers from the major disadvantage of indentation of the cornea. In this the distance from the anterior pole to the posterior pole which is the anatomic axial length is measured. The visual axis of the human eye is different from the anatomic axis. The macula is normally located on the temporal side of the disc. The optical axis is measured from the fovea out through the nasal side of the cornea. Due to which there is 5degrees horizontal tilt and 1 degree vertical tilt in optical axis in relation to the anatomical axis. The second problem with ultrasound biometry is that it gives measurements from the front of the retina, the internal limiting membrane. These two problems were sorted with the optical biometry. In addition, optical biometry uses light for measurements instead of sound, thus producing more accurate values.[9] Longer wavelengths of light is used in ultrasound biometry; whereas the shorter wavelengths gives more precise readings. As partial coherence interferometry relies on adequate foveal fixation, patients inability to fixate and maintain as in with eyes with corneal scarring, cataracts of posterior polar variety, dense cataracts, lens subluxation, degenerative conditions of the macula, and eccentric fixation. Thus the two technologies should always be kept in hand and will be complementary for the future. Advantages of optical biometry method being non- contact, ease of use and speed of testing is reported and have a better resolution and precision in deriving the intraocular distances as compared to conventional applanation ultrasound.[10,11] Both the devices accounted for excellent repeatability of measurements. Better precised axial length measurements was obtained in our study, especially in short and long eyes. Partial coherence interferometry is a method wherein no contact with the cornea is involved and all the measurements like horizontal and vertical corneal curvature readings by keratometry, depth of the anterior chamber and axial length can be obtained easily in a single sitting. Further, the precision achieved with the optical biometry using the above described principle was 10 times better than that of the applanation technique in earlier studies.[12]

Conclusion

The optical biometry is a more reliable and accurate method in IOL power calculation. It is easy to perform, gives readings which are highly accurate, non-invasive and it is comfortable for the patient. The precision in measuring the axial length has been increased with optical biometry and has proved the accuracy in calculating the IOL power in recent years. Thus the biometry, no longer is the limiting factor in intraocular lens (IOL) power calculation.

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