International Journal of Research in Medical Sciences
Arora C et al. Int J Res Med Sci. 2023 Apr;11(4):1234-1238
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20230867

Original Research Article

Evaluation of axial length measurements obtained using three different techniques- applanation A-scan, immersion A-scan and optical biometer

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Received: 31 January 2023
Revised: 02 March 2023
Accepted: 07 March 2023

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ABSTRACT

Background: To compare measurements of axial length obtained with manual A-scan, immersion A-scan and optical biometer and assess the accuracy of different techniques of intraocular lens power calculation.
Methods: This was a prospective randomized study done in 90 patients over a period extending from November 2019 to October 2020 in the upgraded department of ophthalmology, Government Medical College Jammu. Intraocular lens power was calculated by measuring axial length by three different techniques and further the accuracy of the axial length values obtained were compared.
Results: In this study, mean axial length measured by applanation A-scan was 22.86±0.85 mm which ranged from 20.99-24.6 mm and axial length measured by immersion technique ranged from 21.5-24.9 mm with a mean AL of 22.92±0.85 mm. AL measured by non-contact method ranged from 20-25.08 mm with a mean AL of 23.1±0.93 mm. There was a statistically significant difference between all the three techniques regarding the measured AL (p=0.0004).
Conclusions: This study concludes that the optical biometry has greater accuracy than ultrasound biometry including applanation and immersion A-scan.

Keywords: Applanation, Axial length, Immersion, Optical biometry

INTRODUCTION

The best optical rehabilitation following removal of cataractous lens is implantation of an intraocular lens. Duke Elder defined cataract as any opacity in the lens.[1] Yanoff defined senile cataract as any cataract that occurs after the age of 50 years and that has no evident cause.[2] The first posterior chamber intraocular lens was implanted in a human eye by Sir Harold Ridley at St. Thomas Hospital in London on 29 November 1949 but his patient had a refractive surprise of nearly 20D. While Ridley ushered in the era of IOLs, at the same time this event marked the beginning of IOL power calculation.[3] Fyoderv and co-workers first estimated the optical power of an IOL using vergence formulas in 1967. This historic milestone in medical science marked the beginning of a new era in rehabilitation of patients with cataract.[4,5] Choosing the correct power of the intraocular lens implant is a major determinant of patient satisfaction after cataract surgery. In some cases, however, when the fellow eye has significant ametropia with good vision, the operated eye will require an intraocular lens of power to give matching ametropia to avoid problems from anisometropia.[6] Ocular biometry involves anatomical measurement of the eye which include axial length (AL), keratometry and anterior chamber depth (ACD). The axial length, one of the variables for the determination of postoperative refraction, is the distance between the anterior surface of the cornea and the fovea and usually measured by A-scan ultrasonography or optical coherence biometry. The AL is the most important factor in IOL calculation. A 1mm error in AL measurement results in a refractive error of approximately 2.35 D in a 23.5 mm eye.

The full-term newborn eye has a mean axial length of 16-18mm and mean anterior chamber depth 1.5-2.9 mm. the mean adult values for axial length are 22-25 mm and mean refractive power -25.0±1.0D.

In an infant, the eye grows slightly to a length of approximately 19.5 mm. The eye continues to grow, gradually, to the length of about 24-25 mm. A majority of axial length elongation takes place in the first 3 to 6 months of life and a gradual reduction of growth over the next two years, and by three years the adult size is attained. The eye reaches its adult emmetropic axial length by the age of 13 years. In the adult, axial length remains practically unaltered. A slight but steady change towards hyperopia is the rule, especially after the age of 40.

In A-scan ultrasound biometry, a piezoelectric crystal oscillates to generate a high frequency sound wave that penetrates into the eye. When the sound wave encounters a media interface, part of the sound wave is reflected back towards the probe. These echoes allow us to calculate the distance between the probe and various structures in the eye.

Ultrasonography doesn't measure the distance but rather the time required for a sound pulse to travel from the cornea to the retina. The average velocity of 1555 meter/second is accepted for calculation in a normal eye.

Ultrasound biometry involves two types which includes applanation A-scan biometry and immersion A-scan.

Applanation biometry is a procedure in which ultrasound probe comes in direct contact with the cornea under the topical anaesthesia. Immersion a-scan biometry, the other variant of the ultrasound biometry is a non-contact biometry which requires placing a saline filled sclera shell between the probe and the eye.

A-scan produces one-dimensional images in which echo strengths are displayed as vertical deflections or spikes of varying heights on a displayed screen. This includes: i) initial spike (probe tip and cornea), ii) anterior lens capsule, iii) posterior lens capsule, iv) retina, v) sclera, vi) orbital fat.

The optical biometer uses the technique of partial coherence Interferometry (PCI) which measures the time required for infrared light to travel the retina. The signal is produced by the interference between the light reflected by the tear film and that reflected by the retinal pigment epithelium (RPE).

METHODS

This prospective randomized study was conducted in the upgraded department of ophthalmology, Government Medical College Jammu (Jammu and Kashmir) over a period extending from November 2019 to October 2020 after taking permission from the Institute Ethics Committee, GMC Jammu.

The study included all OPD patients with grade 2 and grade 3 nuclear sclerosis who subsequently underwent cataract surgery with posterior chamber intra-ocular lens implantation. Written informed consent was taken and patients aged above 40 years and of either sex were included in the study. The patients with grade 4 cataract, posterior sub-capsular cataract, complicated cataract, prior eye surgeries, corneal scars or corneal diseases, glaucoma, retinal diseases were excluded from this study.

Methodology and sample size

Median effect size of 0.3 was used to calculate the sample size at α value 0.05 and power (1-β) of 0.8 or 80%. A total size of 82 was calculated by using these parameters and a total sample size of 90 (assuming 30 in each of 3 groups) was finalized, assuming 5% attrition.

Axial length was calculated by all the three techniques viz applanation a-scan, immersion a-scan and optical biometer. The IOL power to be implanted was randomly selected. Axial length measurement was performed first by optical biometer, then immersion a-scan followed by applanation a-scan. To maintain the integrity of the corneal epithelium this order was considered necessary which may get compromised by ultrasound probe's contact. The mean of the three values was used as axial length for the calculation of IOL power. Topcon's Aladdin HW3.0 was used for optical biometry and matrix immersion A-scan and Prager scleral shell was used for performing immersion a-scan biometry. The IOL power was calculated using the keratometry readings obtained with the optical biometer.

The Bausch and Lomb keratometer and echorule Biomedix A-scan were used to perform applanation a-scan biometry. The corneal curvatural (k) readings were taken with Bausch and Lomb Keratometer. The echorule ultrasonic biometer uses hand-held transducer probe for measuring the axial length.

Various formulae including the SRK/T formula, the Holladay formula and the Hoffer-Q formula were used to calculate the IOL power.

After the IOL power calculation by all the three techniques of biometry, the patients underwent small incision cataract surgery with posterior chamber intraocular lens implantation (SICS WITH PCIOL implantation).

For choosing one of the three IOL powers, the patients were randomly grouped as group A- patients in whom PCIOL implanted was as per the IOL power calculated by applanation a-scan, group B- patients in whom PCIOL implanted was as per the IOL power calculated by immersion a-scan, group C- patients in whom PCIOL

implanted was as per the IOL power calculated by optical biometer.

Quantitative variables were compared and analysed using ANOVA (for three groups) and repeated measure ANOVA and qualitative variables were compared and analysed using Chi-square test. 'p' value of less than 0.05 was considered as significant for statistical significance.

RESULTS

In this study, the mean age of patients was 64.21±7.2 years (range 48-82 years). 27.78% of patients of each group were <60 years of age; 55.56% were between 61-70 years of age and 16.67% of patients were >70 years of age.

30% patients in group A were females and 70% were males. In group B and group C each, 37% patients were female whereas 63% were males. There was no significant difference between the three groups regarding gender (p=0.821). There was no significant difference between the laterality of the eye operated of study subjects.

Table 1: Distribution of age (years) of study subjects.

Age(years)	Frequency	Percentage
≤60	25	27.78
61-70	50	55.56
>70	15	16.67
Mean±SD	64.21±7.2	
Median (25th-75th percentile)	65 (60-68.75)	
Range	48-82	

Table 2: Comparison of k_1 (dioptres) of study subjects between group A, B and C.

K_1 (dioptres)	Mean±SD	Median (25th-75th percentile)	Range	P value	Test performed
K_1 (group A)	42.78±1.54	43 (41.812-43.75)	39.5-46.75	<0.0001	Repeated measure ANOVA
K_1 (group B)	43.98±1.76	44.23 (43.08-44.93)	40.03-48.02		
K_1 (group C)	43.98±1.76	44.23 (43.08-44.93)	40.03-48.02		

Table 2: Comparison of k_2 (dioptres) of study subjects between group A, B and C.

K_2 (dioptres)	Mean±SD	Median (25th-75th percentile)	Range	P value	Test performed
K_2 (group A)	42.38±1.88	42.5 (40.812-43.188)	38.25-46.75	<0.0001	Repeated measure ANOVA
K_2 (group B)	45±1.66	45.07 (43.838-45.76)	41.41-49.41		
K_2 (group C)	45±1.65	45.07 (43.838-45.76)	41.41-49.41		

Table 4: Comparison of axial length of study subjects between group A, B and C.

Axial length(mm)	Mean±SD	Median (25th-75th percentile)	Range	P value	Test performed
Axial length (group A)	22.86±0.85	22.83 (22.442-23.32)	20.99-24.6	0.0004	Repeated measure ANOVA
Axial length (group B)	22.92±0.85	22.59 (22.4-23.672)	21.5-24.9		
Axial length (group C)	23.1±0.93	23.09 (22.6-23.73)	20-25.08		

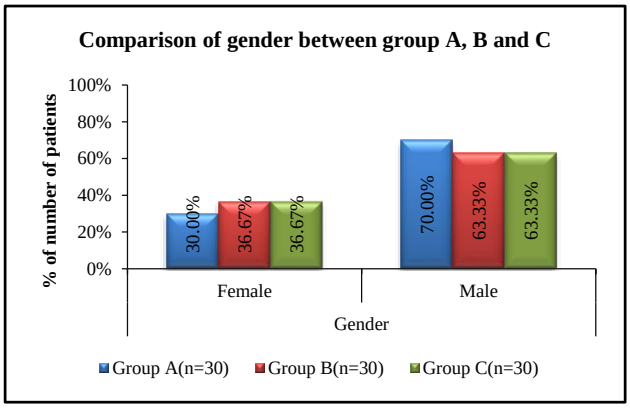

Figure 1: Comparison of gender between groups A, B and C.

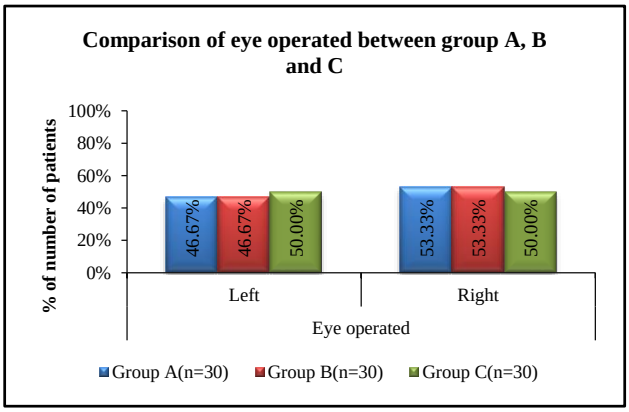

Figure 2: Comparison of eye operated between groups A, B and C.

The mean k1 reading in group A was 42.78±1.54D and in group B and C was 43.98±1.76 D (Table 1). The mean k2 reading in Group A was 42.38±1.88 D and in group B and group C was 45±1.65 D. There was a statistically significant difference between applanation A-scan and optical biometer regarding corneal powers- k1 and k2 (p value <0.0001) (Table 2). Mean axial length in group A measured by applanation A-scan was 22.86±0.85 mm which ranged from 20.99-24.6 mm and axial length measured by immersion technique in group B ranged from 21.5-24.9 mm with a mean AL of 22.92±0.85 mm. AL measured by non-contact method in group C ranged from 20-25.08 mm with a mean AL of 23.1±0.93 mm (Table 3). There was a statistically significant difference between all the three techniques regarding the measured AL (p=0.0004) (Figure 1).

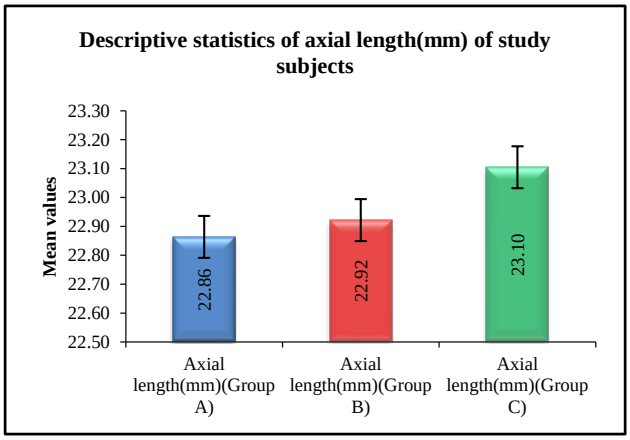

Figure 3: Comparison of axial length of study subjects between group A, B and C.

DISCUSSION

The precision of IOL calculation is influenced by several factors including the corneal curvature (vertical and horizontal), the axial length and the IOL type. The three groups in this study did not differ significantly in terms of age, sex, laterality and preoperative visual acuity. All the patients of the study were older than 48 years. Accurate biometric data are essential for achieving good surgical outcomes and patient satisfaction after cataract and refractive surgery. The mean κ reading values found in the present study are in conformity to the value given by various authors.

The axial length with applanation a-scan ranged from 20.99-24.6 mm with mean AL of 22.86±0.85 mm. The axial length in group B as measured with immersion A-scan ranged from 21.5-24.9 mm with a mean AL of 22.92±0.85 mm. The mean AL with immersion and contact technique in a study done by Ademola-Popoola et al were 26.60±1.36 mm and 23.46 mm.[7] Their study found statistically significant difference between the AL measured by the two techniques. Shammas et al revealed that the axial length measurements obtained with the contact technique were shorter compared to the immersion technique by an average of 0.24 mm.[8]

In present study, there was a statistically significant difference between the AL measured by the contact and immersion technique. The mean AL with optical biometer in our study was comparable to the mean AL found in study done by Nakhli et al.[9] In another study done by Gaballa et al, the mean AL measured by IOL-M was higher (26.18±2.92 mm) that with A-scan (26.02±2.99 mm) with a mean difference of 0.2±0.44 mm (p=0.07).[10] The mean AL found in the study done by Kongsap et al comprising 102 eyes was 23.12±1.34 mm with OLCR biometer and 23.18±1.08 mm with standard PCI biometer.[11]

However, this study is limited by the relatively small number of patients and short duration of follow-up and this study may be a seedbed for future research.

CONCLUSION

The refractive outcome of the cataract surgery has improved considerably in the last five decades due to the innovations in the methods of biometry, intraocular lens power prediction formula and surgical techniques. The outcome depends on the accurate prediction of the preoperative biometry data. The most important step for an accurate calculation of the IOL power is the preoperative measurement of the ocular axial length. This study concludes that the optical biometry has greater accuracy than ultrasound biometry as it measures the ocular axial length along the visual axis whereas during ultrasound biometry a misalignment between the measured axis and the visual axis may occur. Furthermore, with applanation A-scan, there may be variable corneal compression that can lead to an error in AL calculation, the chance of which is eliminated by non-contact optical biometry. Measurement of AL in dense cataract and posterior subcapsular cataract is difficult with optical biometer and can be measured by ultrasound biometry.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Arora C, Gupta S. Evaluation of axial length measurements obtained using three different techniques- applanation A-scan, immersion A-scan and optical biometer. Int J Res Med Sci 2023;11:1234-8.