Original Article

The Distribution of Ocular Biometrics among Patients Undergoing Cataract Surgery

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Abstract

Background: Ocular biometry is essential in many clinical and research applications; for example, axial length is essential in intraocular lens power calculation prior to cataract and refractive surgeries, making diagnosis of staphyloma, etc. Various factors affect their values. We intend to study the distribution of ocular biometrics among cataract patients in our environment. **Materials and Methods:** This is a cross-sectional observational study. One hundred fifty-one patients with bilateral cataract scheduled for cataract surgery during the 1-year study period (July 2016–June 2017) were consecutively recruited for the study. Medical records including age and gender were collected. Ocular biometric data including axial length (AL), anterior chamber depth (ACD), cataractous lens thickness (LT), and vitreous chamber depth (VCD) values were measured for both eyes before cataract operation for either eye, using an optical biometer (ophthalmic A/B ultrasound system: CAS-2000BER, England). All the metric data were observed by the same experienced ophthalmic technician to avoid interobserver error. **Result:** The mean AL was 23.51 [95% confidence interval (CI), 23.33–23.64], mean ACD was 3.22 mm (95% CI, 3.12–3.30), mean LT was 4.23 mm (95% CI, 4.17–4.29), and the mean VCD was 16.06 mm (95% CI, 15.89–16.20). AL was longer among those ages less than 30 years, ACD was decreasing with increasing age, and the mean LT was higher for ages 30 years and above. The median ACD was decreasing with increasing age up to ≥50 years, whereas the median LT increased with increasing age. The male–female variation in mean AL and mean VCD were statistically significant ($P < 0.001$ by Mann–Whitney *U* test); however, the mean ACD and mean LT were not statistically significant ($P =$ 0.110 and 0.496, respectively, by Mann–Whitney *U* test). The median AL was higher in males than females (24.00 vs 23.00), with an interquartile range (IQR) of 23.50 to 24.00 mm in males, and for females was 22.50 to 24.00 mm. The median ACD was a little higher in males than females (3.30 vs 3.10 mm), with IQR was 2.90 to 3.50 mm in males, and for females was 2.80 to 3.40 mm. **Conclusion:** Age and sex should always be considered in making inferences from biometric data in ophthalmic practice.

Keywords: Anterior chamber depth, axial length, biometry, intraocular lens, lens thickness, vitreous chamber depth

Introduction

Axial ocular dimensions include axial ocular length, anterior chamber depth (ACD), lens thickness (LT), and vitreous chamber depth (VCD). The ability to obtain accurate measurement of ocular biometric dimensions, such as axial length (AL), ACD, and crystalline LT, is essential for many clinical and research applications. AL is used clinically for intraocular lens (IOL) power calculation prior to cataract and refractive surgeries[1] and to diagnose ocular conditions such as staphyloma,[2] to evaluate the risk of retinal detachment,[3] as well as to measure the structural and dimensional components in myopia.[4] The standard value of the AL of the eyeball is taken to be 24 mm internationally, in an adult, irrespective of the sex, race, and other body measurements.[5] Mean ACD is considered to be 3.11 mm.[6] The VCD varies from 14.42 to 16 mm.[7]

With increase in life expectancy, there has been a progressive increase in the volume of cataract and cataract surgeries worldwide. Good postoperative visual outcome is paramount in patients' expectations. Accurate ocular biometric measurements are therefore essential. Knowledge of these measures is fundamental for obtaining precise IOL

Access this article online

Quick Response Code:

Website: www.nigerianjournalofophthalmology.com

DOI: 10.4103/njo.njo_7_18

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How to cite this article: Chinawa EN, Ezeh EI. The distribution of ocular biometrics among patients undergoing cataract surgery. Niger J Ophthalmol 2018;26:40-5.

power calculation, which is primarily based on formulas derived from normative ocular biometric parameters.

Various factors affect ocular biometry. These include age, gender, ethnicity, and refractive error.[8-17] These factors have been studied by various researchers with varying results. Some studies have reported age-related decreases in AL.[8,9] However, other studies have reported no age-related decrease in AL.[10-12] Several studies suggest that ACD decreases with increasing age.[11-15] LT has been known to increase with age due to age-related nuclear sclerosis.[18]

The AL of the eyeball and the vitreous chamber of the globe have been reported to be larger in males than females.[19,20] The studied biometrics (AL, ACD, LT, and VCD) were all higher in men compared to women in a study done in the population of Shahroud in the north of Iran.[20]

Many published studies on ocular biometrics, to the best of our knowledge, have been among Caucasians, Hispanics, and Asians. A study by Jagun *et al.*[21] on normative ocular biometric dimension and its variation in Nigerian population showed that the mean AL, ACD, LT, VCD, and cornea power were 23.31 ± 0.91, 3.13 ± 0.40, 4.15 ± 0.46, 16.01 ± 0.91 mm and 43.77 ± 1.33 D, respectively. A similar study in southern Nigeria by Adio *et al.*[22] showed that mean AL in males and females were, respectively, 23.86 and 23.27 mm, whereas the overall average was 23.57 mm.

Bearing in mind the vital role of ocular biometrics in diagnostic and therapeutic eye care, we intend to study the ocular biometric parameters and their associations in cataract patients seen at a Nigerian eye care centre in Akwa Ibom State, Nigeria.

Materials and Methods

This is a cross-sectional observational study. One hundred fifty-one patients with bilateral cataract were scheduled for cataract surgery during the 1-year study period (July 2016–June 2017), in Mercy Hospital, Abak, Akwa Ibom State, Nigeria, were consecutively recruited for the study. A total of 521 cataract patients were seen at the hospital within the study period, 183 with bilateral cataract and 338 with unilateral cataract. Bilateral cataract patients with history of ocular trauma or surgery, complicated cataract in either eye, secondary causes of cataract such as diabetes mellitus, uveitis were excluded from the study. Permission from the Hospital Ethical Committee was obtained. Medical records including age and gender were collected. Ocular biometric data including AL, ACD, LT, and VCD values were measured for both eyes before cataract operation for either eye, using an optical biometer Ophthalmic Ultrasound A/B Scan [ChongQing KangHua S & T Co., Ltd, CAS-2000BER (MODEL A), China]. AL was measured as the distance from the anterior corneal vertex to the retinal pigment epithelium (RPE) along fixation, automatically adjusted for the distance between the inner limiting membrane and RPE.[23] ACD was measured as the distance from the anterior corneal vertex to the anterior cataractous lens surface by image analysis of an optical section.[23] LT was measured as the distance from the anterior cataractous lens surface to the posterior cataractous lens surface by image analysis of an optical section. VCD was measured as the distance from the posterior cataractous lens surface to the RPE along fixation, automatically adjusted for the distance between the inner limiting membrane and RPE.[23] All the metric data were observed by the same ophthalmic technician to avoid interobserver error.

Result

There were 151 participants. The age range was 12 to 88 years, with a mean age of 57.73 ± 14.87 years [95% confidence interval (CI), 54.70–59.90]. The mean age of males and females was 57.31 and 57.16 years, respectively, and their difference was not statistically significant (P = 0.910). Of the 151 participants, 77 (51.0%) were males and 74 (49.0%) were females. The male-to-female ratio is approximately 1:1 [Table 1].

Spearman rho correlation coefficients were determined to examine the correlation between two eyes in terms of AL and its components. There exists a moderate positive correlation between left and right eyes in case of the indices of AL (r = 0.370), ACD (r = 0.447), LT (r = 0.297), and VCD (r = 0.334), and thus, only results from right eyes are presented here [Table 2].

Table 3 shows the distribution of AL, ACD, LT, and VCD as mean, and 95% CIs of mean by age group. In the studied sample, mean AL was 23.51 mm (95% CI, 23.33–23.64), mean ACD was 3.22 mm (95% CI, 3.12–3.30), mean LT was 4.23 mm (95% CI, 4.17–4.29), and the mean VCD was 16.06 mm (95% CI, 15.89–16.20). AL was longer among those ages less than 30 years, ACD was decreasing with increasing age, and the mean LT was higher for age 30 to 69

Table 1: Age and sex distribution of study participants

		Sex		Total	*P* value
		Male	Female		
Mean age ± SD (years)	57.73 ± 14.87	57.31 ± 15.84	58.16 ± 13.88		0.910
Age group (years)	<30	4	2	6	
	30–49	14	16	30	
	50–69	41	38	79	
	70–89	18	18	36	
Total		77	74	151	

years and less for <30 years and above 69 years. Statistically, by Kruskal–Wallis test, there were no significant differences across the age group in terms of mean biometric indices of AL ($P = 0.446$), ACD ($P = 0.076$), LT ($P = 0.119$), and VCD ($P = 0.094$).

Table 4 shows the distribution of AL, ACD, LT, and VCD as mean, and 95% CIs of mean by sex. The male–female variation in mean AL and mean VCD were statistically significant ($P < 0.001$ by Mann–Whitney *U* test); however, the mean ACD and mean LT were not statistically significant ($P = 0.110$ and 0.496, respectively, by Mann–Whitney *U* test).

There was a steep decrease in median AL from age less than 30 years to age 30 years and above; however, the median AL remains essentially same from age 30 years and above. The interquartile range (IQR) was similar across the age groups [Figure 1].

The median ACD was decreasing with increasing age up to ≥50 years. The IQR was widening with increasing age [Figure 2].

The median LT increased with increasing age. The IQR was similar across the age groups. Those <30 years were below the 75th percentile [Figure 3].

Table 2: Correlation between OD and OS

Variable	Correlation coefficient (*r*)	*P* value
AL	0.370	<0.001*
ACD	0.447	<0.001*
LT	0.297	<0.001*
VCD	0.334	<0.001*

*Statistically significant.

The median VCD decreased with increasing age. The IQR was similar across the age groups [Figure 4].

The median AL was higher in males than females (24.00 vs 23.00). The IQR was 23.50 to 24.00 mm in males, and for females was 22.50 to 24.00 mm [Figure 5].

The median ACD was a little higher in males than females (3.30 vs 3.10 mm). The IQR was 2.90 to 3.50 mm in males, and for females was 2.80 to 3.40 mm [Figure 6].

The median LT was same in males than females (4.20 vs 4.20 mm). The IQR was 3.80 to 4.60 mm in males, and for females was 4.00 to 4.50 mm [Figure 7].

The median VCD was higher in males than females (16.40 vs 15.60 mm). The IQR was 15.70 to 17.00 mm in males, and for females was 15.20 to 16.20 mm [Figure 8].

Discussion

The mean AL in this study of 23.51 mm is quite similar to that (23.57 mm) obtained in another Nigerian study in the same region[22] but slightly higher than that obtained in a study in Western Nigeria (23.31 mm).[21] AL in our study is longer than the one reported in the Iranian[20] and Chinese populations,[24] with a difference in mean values of about 0.4 and 0.5 mm, respectively. It is shorter than that reported in a Portuguese population,[25] with a difference in mean values of about 0.4 mm. However, it is closer to that reported among Caucasians in the USA[6,26,27] and other European Caucasians,[28,29-33] with a difference in mean values of about 0.04 mm. The mean differences observed are relevant, as it may suggest an ethnic and racial variation in AL. As an 1-mm error in AL results in a residual postoperative refractive error of about 3.00 D in a 23.5-mm eye, about 2.00 D in a 30.00-mm eye, and about 4.00 D in a 20.00-mm eye,[34] it is

Table 3: Distribution of axial length (AL), anterior chamber depth (ACD), lens thickness (LT), and vitreous chamber depth (VCD) as mean, and 95% confidence intervals of mean (CI) by age

Age (years)	*N*	AL (mm)Mean (95% CI)	ACD (mm)Mean (95% CI)	LT (mm)Mean (95% CI)	VCD (mm)Mean (95% CI)
<30	6	24.41 (23.36–25.95)	3.50 (3.12–3.91)	3.85 (3.52–4.29)	17.06 (16.37–17.92)
30–49	30	23.47 (23.17–23.75)	3.31 (3.12–3.54)	4.25 (4.10–4.39)	15.90 (15.64–16.23)
50–69	79	23.44 (23.27–23.62)	3.20 (3.05–3.28)	4.26 (4.20–4.35)	16.02 (15.78–16.23)
70–89	36	23.54 (23.26–23.85)	3.22 (3.12–3.42)	4.21 (4.10–4.33)	16.11 (15.85–16.42)
P value		0.446	0.076	0.119	0.094
Total	151	23.51 (23.33–23.64)	3.22 (3.12–3.30)	4.23 (4.17–4.29)	16.06 (15.89–16.20)

Table 4: Distribution of axial length (AL), anterior chamber depth (ACD), lens thickness (LT), and vitreous chamber depth (VCD) as mean and 95% confidence intervals of mean (CI) by sex

	n	AL (mm)Mean (95% CI)	ACD (mm)Mean (95% CI)	LT (mm)Mean (95% CI)	VCD (mm)Mean (95% CI)
Male	77	23.84 (23.64–24.03)	3.28 (3.18–3.39)	4.21 (4.12–4.30)	16.35 (16.18–16.55)
Female	74	23.16 (23.02–23.39)	3.15 (3.07–3.31)	4.25 (4.17–4.32)	15.76 (15.58–16.00)
P value		<0.001*	0.110	0.496	<0.001*
Total	151	23.51 (23.37–23.66)	3.22 (3.16–3.31)	4.23 (4.17–4.29)	16.06 (15.94–16.21)

*Statistically significant.

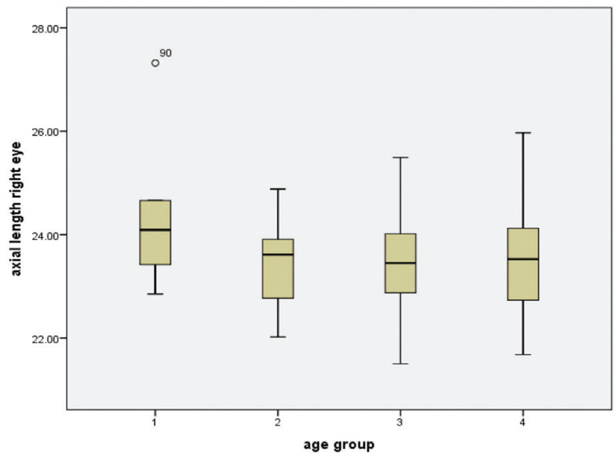

Figure 1: Boxplot of Axial length by age (<30 years = 1; 30–49 years = 2; 50–69 years = 3; ≥70 years = 4)

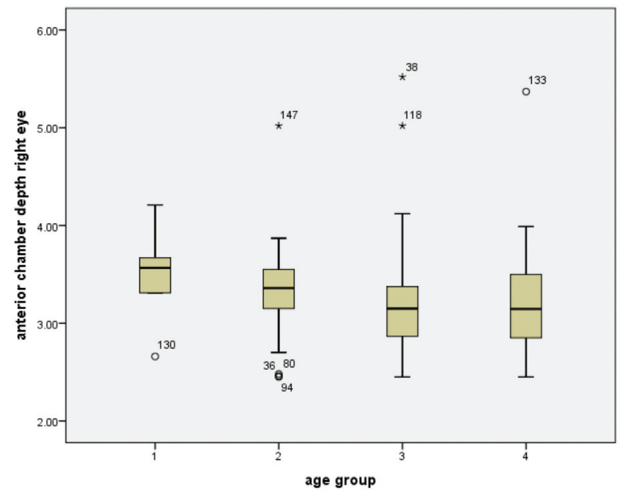

Figure 2: Boxplot of Anterior chamber depth by age (<30 years = 1; 30–49 years = 2; 50–69 years = 3; ≥70 years = 4)

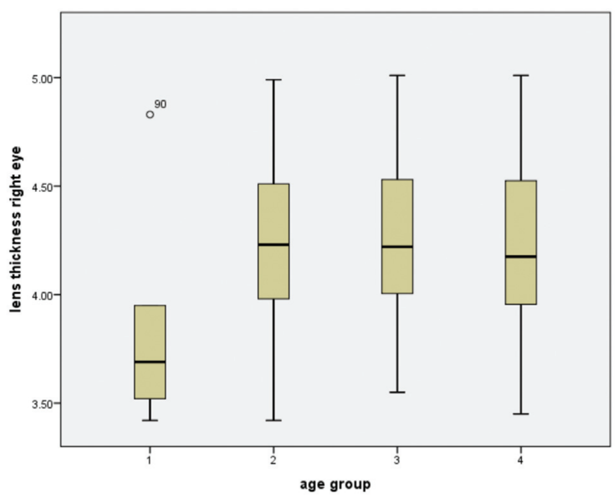

Figure 3: Boxplot of Lens thickness by age (<30 years = 1; 30–49 years = 2; 50–69 years = 3; ≥70 years = 4)

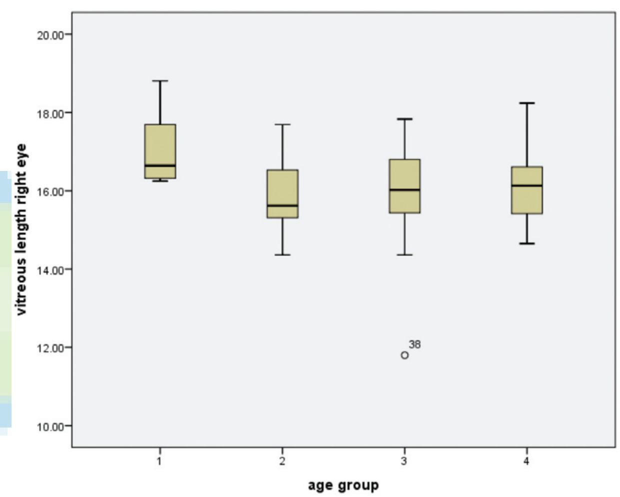

Figure 4: Boxplot of Vitreous chamber depth by age (<30 years = 1; 30–49 years = 2; 50–69 years = 3; ≥70 years = 4)

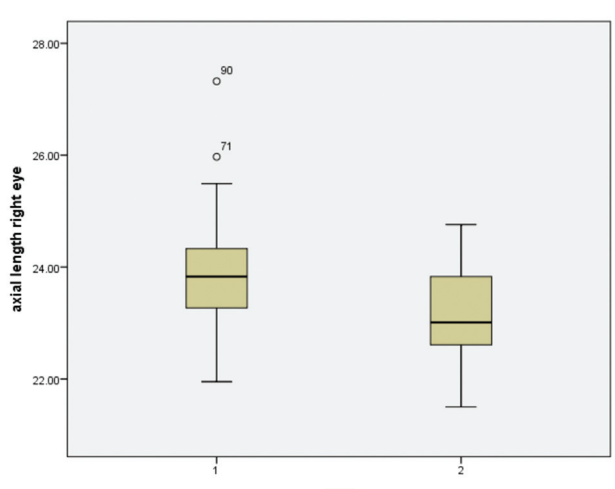

Figure 5: Boxplot of Axial length by sex (male = 1, female = 2)

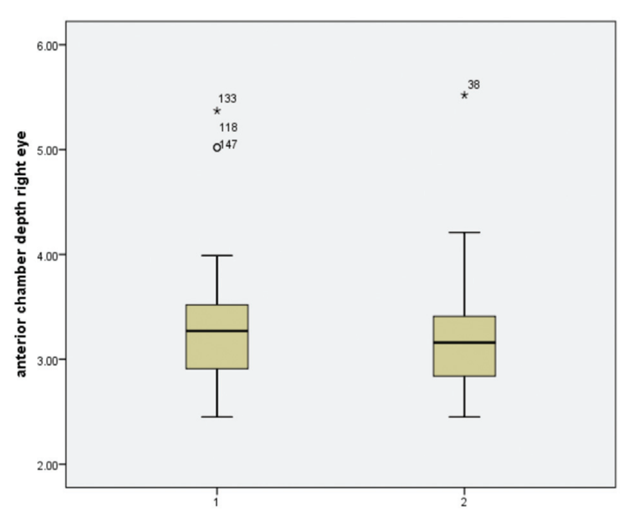

Figure 6: Boxplot of Anterior Chamber Depth by sex (male = 1, female = 2)

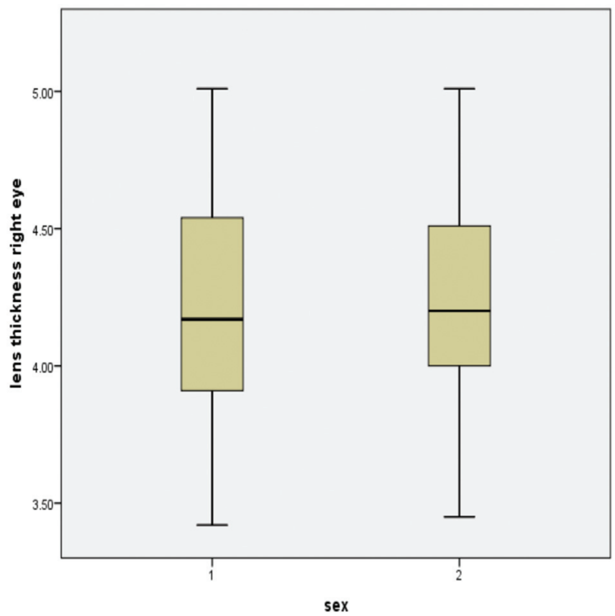

Figure 7: Boxplot of Lens thickness by sex (male = 1, female = 2)

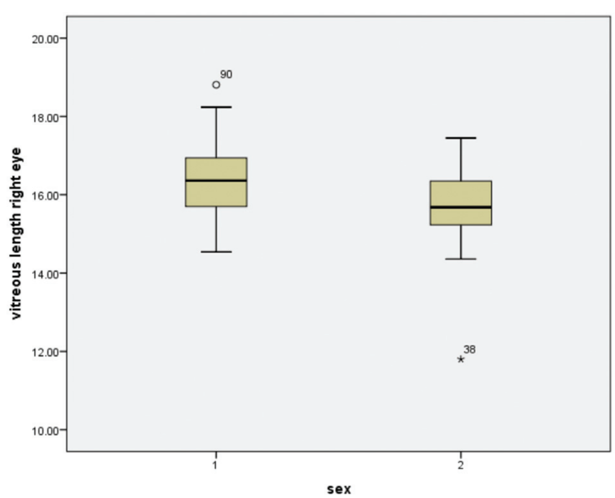

Figure 8: Boxplot of Vitreous chamber depth by sex (male = 1, female = 2)

therefore pertinent to consider the influence of ethnicity in the determination of biometric parameters in cataract patients. The effect of age on AL was not statistically significant in this study; however, a steep decrease in both the mean and median AL from age less than 30 years to age 30 years and above was observed. Grosvenor[35] proposed that age-related reduction in AL occurs as an emmetropization mechanism, compensating for the increase in the refractive power caused by the change of the crystalline lens. However, Wong *et al.*[8] stated that the decrease in AL in older persons may be due to a cohort effect such that older persons may have smaller eyes. According to him, this may be due to poor nutrition and health status in the aged. Hassan *et al.*[20] had postulated that the decrease in AL with age may be due to some unknown changes, especially ocular atrophy.

The mean ACD of 3.22 mm observed in this study is similar to that (3.13 mm) reported by Jagun *et al.*[21] in a Southwestern Nigerian population. ACD was noted to decrease with age. The reduction in ACD is understandable because the crystalline lens has been documented to continuously increase in size throughout life due to lying down of lens fibers, thus causing gradual progressive shallowing of the anterior chamber.[20] LT has been shown to increase with presence of cataract, thus shallowing the anterior chamber in cataract patients.[21] The shallower ACD with age have also been reported to be due to forward shift of the lens with the lying down of lens fibers.[31]

The increase in LT with age, which was noted in this study, will largely explain the progressive reduction in ACD noted. An increase in LT with age has been observed in other studies.[28,36-38] Age related nuclear sclerosis, increase in protein fiber layers forming under the capsule as well as continuously lying down of lens fibers with increasing age, have been reported as being the reasons for increase in LT in cataractous lens with advancing age.[8,12,20,36]

All of the assessed biometrics in this study were greater in males, except the LT. Consistent with this study, Hashemi *et al.*[20] and He *et al.*[37] had reported that except for LT with contradicting results, of being greater in women, other biometrics were higher in men. These results are in accordance with other studies in populations from Nigeria,[21,22,36] Germany,[30] Australia,[28] USA,[6,26] and Iceland.[29] Scientifically, larger ocular biometrics in male can be well explained by the normal biological feminine and masculine difference of facial and body features on the bases of sexual dimorphism in anthropometric measurements.[28,36,39,40] Based on these findings, intergender differences in ocular refractive state are expected. Giving that the AL and ACD were the significantly higher metrics found in this study between both genders, they may play a more prominent role in the intergender difference in ocular refractive state compared to other ocular biometrics. It is interesting to note that a large difference of 0.68 mm in the mean values in AL between genders was observed in our study. Other studies had reported a mean value difference in AL of 0.5[27] and 0.31 mm[25] between genders. Gender is therefore an important determinant of ocular biometric parameters that need to be considered in the calculation of the IOL power for cataract surgeries, as shown by the appearance of the fifth-generation formula, the Hoffer-H-5, which uses the same basic structure as the Holladay 2 formula but considers gender and ethnicity to reduce the error associated with the use of generalized population regression factors.[25]

Conclusion

Age and sex are important factors influencing ocular biometrics. It may be important to consider them and potential biometric refinements made, in the calculation of IOL power for cataract surgeries as well as in corneal refractive surgeries.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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