Original Article

Ocular biometry parameters in mobile cataract surgery camp: a large-scale report from Nigeria

Ernest N Ogbedo [1], Ugochukwu A Eze [1], Helen A Alen [1], Adedeji O Akinyemi [1] and Abiola A Salimonu [1]

[1] *Department of Ophthalmology, Federal Medical Centre, Asaba, Nigeria*

ABSTRACT

Background: Humanitarian missions and mobile camp surgeries have pivotal role in the uptake of cataract surgery in areas with limited resources. Ocular biometry is an important preoperative evaluation tool for cataract surgery candidates. Herein, we report the distributions of ocular biometric values among cataract surgery candidates in camp settings in southern Nigeria.

Methods: In this cross-sectional study, we retrieved data from consecutive patients scheduled for cataract surgery. All patients underwent a full ophthalmic examination using a slit-lamp biomicroscope. Age, sex, and preoperative biometric values, including anterior chamber depth (ACD), lens thickness (LT), vitreous chamber depth (VCD), and axial length (AL), together with intraocular lens (IOL) power, were documented. Biometric values were obtained using A-mode ultrasonography.

Results: Records of 567 patients with a mean (standard deviation) age of 66.0 (13.4) years revealed a male-to-female sex ratio of 1:1.24. Most participants were in the 66–70-year age group. Mean IOL power was significantly different between males and females ($P < 0.001$). However, the biometric values were comparable between sexes (all $P > 0.05$). There were significant differences in the mean IOL power ($P < 0.001$) and ACD ($P < 0.05$) between the age groups, indicating a decrease in ACD with age. However, the other biometric parameters were comparable between the age groups (all $P > 0.05$). ACD had a significant weak negative correlation with LT ($r = -0.16$; $P < 0.001$) and IOL power ($r = -0.22$; $P < 0.001$) and a positive correlation with AL ($r = +0.24$; $P < 0.001$). LT had a significant weak negative correlation with VCD ($r = -0.16$; $P < 0.001$) and a positive correlation with AL ($r = +0.09$; $P < 0.05$). VCD had significant moderate positive and negative correlations with AL ($r = +0.39$; $P < 0.001$) and IOL power ($r = -0.34$; $P < 0.001$), respectively. AL had a significant strong negative correlation with IOL power ($r = -0.78$; $P < 0.001$).

Conclusions: This study presents the mean distributions of ocular biometric parameters among cataract surgery candidates in camp settings in southern Nigeria. Age and sex were important determinants of IOL power and should be considered when planning eye camp supplies. AL had a strong inverse correlation with IOL power. Further multicenter national studies are required to verify these preliminary findings.

KEYWORDS

ocular biometry, cataract, axial length, anterior chamber depth, keratometry, lens thickness, age group, resource-limited setting.

Correspondence: Ugochukwu Anthony Eze, Department of Ophthalmology, Federal Medical Centre, Asaba, Nigeria. Email: ugochukwu.eze@npmcn.edu.ng. ORCID iD: https://orcid.org/0000-0001-5722-9429

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INTRODUCTION

Biometry is a fundamental preoperative assessment tool and an important determinant of refractive outcomes following intraocular lens (IOL) implantation in cataract surgery. The principle of biometry is that the refractive power of the human eye is a function of corneal power, crystalline lens power and position, and axial length (AL) [1-3]. Biometry consists of keratometry and AL determination; any error in the calculation of these parameters can cause postoperative refractive surprise [1-3]. The magnitude of the effect of AL measurement error on the IOL power calculation is greater than that of keratometry. Other biometric parameters are anterior chamber depth (ACD), lens thickness (LT), and vitreous chamber depth (VCD) [1-5].

Studies have reported mean values of these biometric parameters in individuals of different racial backgrounds [5-8]. LT values vary at different ages owing to the continuous addition of new lens fibers throughout life [9]. A report found a constant rate of LT increase per decade after the stabilization of globe length in the second decade of life [10], highlighting the effect of age on LT. Ocular biometry may vary based on age, sex, ethnic background, or refractive status of individuals [11-16].

Herein, we report the ocular biometric values among cataract surgery candidates in camp settings in different parts of Delta State, Nigeria, as reference values for eye camps in resource-constrained settings. Furthermore, we investigate possible correlations between these biometric parameters.

METHODS

This cross-sectional study retrieved data from consecutive patients who planned to undergo cataract surgery under the coverage of a nongovernmental organization (Restore Sight Africa Initiative) from January 2021 to January 2022 in Delta State, Nigeria. The study protocol was approved at the Department of Ophthalmology, Federal Medical Centre, Asaba, Nigeria. Consent was obtained from each patient prior to cataract surgery. We included patients with complete demographic and biometric data available on their medical charts. We randomly selected data from one eye of each patient.

All patients considered for cataract surgery underwent a full ophthalmic examination using slit-lamp biomicroscopy (Topcon, Livermore, CA, USA) for detailed anterior segment assessment and dilated fundus examination. Demographic data (age and sex), preoperative biometric values (ACD, LT, VCD, and AL), and power of the implanted IOL for each individual were retrieved from the medical records. An expert technician obtained biometric values using A-mode ultrasonography (CAS-2000C AB Scan; Nanjing Redsun Optical Co., Ltd., China). For IOL power calculation, a constant keratometry value of 43.00 D was considered because of unavailability of a keratometer [17]. The participants were allocated to one of 10 age subgroups as follows: ≤40, 41–45, 46–50, 51–55, 56–60, 61–65, 66–70, 71–75, 76–80, and > 80 years.

AL was recorded in millimeters and defined as the axial distance from the anterior corneal surface to the anterior retinal surface. The ACD was recorded in millimeters and defined as the axial distance between the anterior surface of the cornea and the anterior surface of the crystalline lens. LT was recorded in millimeters and defined as the axial distance from the anterior surface of the crystalline lens to the posterior surface of the crystalline lens [18]. The VCD was recorded in millimeters and defined as the axial distance between the posterior surface of the crystalline lens and the anterior retinal surface [19].

The data were analyzed using SPSS Statistics for Windows (version 22.0; IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the results as frequencies, percentages, means, and standard deviations (SDs), while inferential statistics were used to test for associations between dependent and independent variables. Pearson's product-moment correlation was used to determine possible correlations between the measured parameters. A P-value < 0.05 was considered to be statistically significant.

RESULTS

Records of 567 patients who underwent cataract surgery during a cataract outreach camp revealed a sex ratio of 1:1.24 (Table 1). The age range was 10–98 years, with a mean (SD) of 66.0 (13.4) years. Most participants were in the 66–70-year age group, representing 17.9% (n = 102) of the total sample. Table 1 lists the detailed age and sex frequencies of the participants with the mean (SD) ocular biometric parameters and IOL powers for all participants and for each age and sex group. The mean (SD) IOL power was significantly different between males and females (21.12 [4.00] D and 22.78 [5.59] D, respectively; $P < 0.001$). However, the mean (SD) biometric values were comparable between the sexes (all $P > 0.05$) (Table 1). The mean (SD) ACD was significantly different between the age groups ($P < 0.05$), showing a decrease with increasing age. The mean IOL power significantly differed between age groups ($P < 0.001$). Although the values did not follow any pattern, the age group with the highest IOL power was 51–55 years (Table 1). The IOL power with highest frequency was 23 D, which was obtained in 59 patients (10.4%). Other biometric parameters (LT, VCD, and AL) were comparable between the age groups (all $P > 0.05$) (Table 1).

Table 2 lists the correlations between ocular biometric parameters. ACD had significant negative correlations with LT (r = - 0.16; $P < 0.001$) and IOL power (r = - 0.22; $P < 0.001$) and a positive correlation with AL (r = + 0.24; $P < 0.001$), yet the strength of the relationship between these variables was weak. However, ACD had no significant correlation with VCD (r = - 0.48; $P > 0.05$). LT had a significant negative correlation with VCD (r = - 0.16; $P < 0.001$) and a positive correlation with AL (r = + 0.09; $P < 0.05$), yet the strength of the relationship between these variables was weak. However, LT had no significant correlation with IOL power (r = - 0.06; $P > 0.05$). VCD had a significant positive and negative correlation with AL (r = + 0.39; $P < 0.001$) and IOL power (r = - 0.34; $P < 0.001$), respectively. The strength of the relationship between these variables was moderate. AL had a significant strong negative correlation with IOL power (r = - 0.78; $P < 0.001$) (Table 2).

Table 1. Biometric parameters and IOL powers of participants in total and according to sex and age groups

Age Group	n (%)	ACD (mm), Mean ± SD	LT (mm), Mean ± SD	VCD (mm), Mean ± SD	AL (mm), Mean ± SD	IOL power (D), Mean ± SD
≤ 40	25 (4.4)	3.17 ± 3.15	3.49 ± 4.91	17.40 ± 10.63	24.07 ± 10.93	20.08 ± 22.96
41 – 45	17 (3.0)	3.34 ± 3.40	3.19 ± 5.53	16.61 ± 16.22	24.22 ± 11.84	19.29 ± 29.94
46 – 50	30 (5.3)	3.19 ± 2.85	3.49 ± 3.95	16.82 ± 12.45	23.56 ± 6.19	20.78 ± 16.40
51 – 55	42 (7.4)	2.99 ± 1.76	3.45 ± 3.09	16.31 ± 11.72	23.18 ± 4.13	23.02 ± 32.62
56 – 60	56 (9.9)	2.94 ± 1.21	3.28 ± 3.22	16.53 ± 9.11	23.25 ± 3.28	21.75 ± 8.99
61 – 65	74 (13.1)	3.07 ± 1.52	3.40 ± 2.55	16.82 ± 3.83	23.22 ± 3.40	21.96 ± 8.38
66 – 70	102 (17.9)	2.86 ± 1.21	3.58 ± 5.53	16.92 ± 3.83	23.25 ± 3.28	22.25 ± 5.65
71 – 75	88 (15.5)	2.88 ± 1.21	3.30 ± 2.31	16.68 ± 4.68	23.04 ± 2.25	22.41 ± 6.74
76 – 80	75 (13.2)	2.81 ± 1.15	3.57 ± 2.43	16.48 ± 3.46	22.85 ± 2.25	22.75 ± 6.19
> 80	58 (10.2)	2.83 ± 1.37	3.81 ± 2.67	16.42 ± 3.52	23.09 ± 2.85	22.10 ± 7.71
***P*-value**		**0.01**	0.09	0.75	0.06	**< 0.001**
Sex groups						
Male	253 (44.6)	3.01 ± 0.67	3.54 ± 1.76	16.99 ± 2.49	23.49 ± 1.70	21.12 ± 4.00
Female	314 (55.4)	2.89 ± 0.73	3.42 ± 1.52	16.49 ± 2.49	22.92 ± 1.46	22.78 ± 5.59
***P*-value**		0.10	0.49	0.54	0.20	**< 0.001**
Total	567 (100)	2.94 ± 0.5	3.48 ± 1.3	16.71 ± 1.8	23.17 ± 1.1	22.0 ± 3.7

Abbreviations: IOL, intraocular lens; n, number of participants; %, percentage; ACD, anterior chamber depth; mm, millimeters; SD, standard deviation; LT, lens thickness; VCD, vitreous chamber depth; AL, axial length; D, diopters. Note: *P*-values < 0.05 are shown in bold.

Table 2. Correlations between ocular biometric parameters

Variable		ACD (mm)	LT (mm)	VCD (mm)	AL (mm)	IOL power (D)
ACD (mm)	**Correlation Coefficient**		r = - 0.16	r = - 0.48	r = + 0.24	r = - 0.22
	***P*-value**		***P* < 0.001**	*P* = 0.253	***P* < 0.001**	***P* < 0.001**
LT (mm)	**Correlation Coefficient**	r =- 0.16		r = - 0.16	r = + 0.09	r = - 0.06
	***P*-value**	***P* < 0.001**		***P* < 0.001**	***P* = 0.040**	*P* = 0.152
VCD (mm)	**Correlation Coefficient**	r = - 0.48	r = - 0.16		r = + 0.39	r = - 0.34
	***P*-value**	*P* = 0.253	***P* < 0.001**		***P* < 0.001**	***P* < 0.001**
AL (mm)	**Correlation Coefficient**	r = + 0.24	r =+ 0.09	r = + 0.39		r = - 0.78
	***P*-value**	***P* < 0.001**	***P* = 0.040**	***P* < 0.001**		***P* < 0.001**
IOL power (D)	**Correlation Coefficient**	r =- 0.22	r = - 0.06	r = - 0.34	r = - 0.78	
	***P*-value**	***P* < 0.001**	*P* = 0.152	***P* < 0.001**	***P* < 0.001**	

Abbreviations: ACD, anterior chamber depth; mm, millimeters; LT, lens thickness; VCD, vitreous chamber depth; AL, axial length; IOL, intraocular lens; D, diopters. Note: *P*-values < 0.05 are shown in bold.

DISCUSSION

Data from 567 cataract surgery candidates aged 10–98 years in outreach camp settings revealed a female predominance. Most participants were in the 66–70-year age group (17.9%). Despite a significantly higher IOL power in females than in males, we found no significant difference in biometric values between the sexes. Although the ACD and IOL power differed significantly between the age groups, the other biometric parameters were comparable. We found a strong significant negative correlation between the IOL power and AL. However, the correlations between other parameters, if significant, were weak or moderate in strength.

Although some authors have reported that AL decreases with age, others have reported no decrease [12-15]. We found no significant difference in AL between the age groups. Furthermore, males have been shown to have greater AL, ACD, LT, and VCD [16, 20]. However, in the current study, the mean biometric parameters were statistically comparable between the two sexes but were numerically higher in males than in females.

In Port-Harcourt, Nigeria, Adio et al. [21] reported a mean AL, corneal power, and IOL power of 23.57 mm, 42.43 D, and 21.34 D, respectively, among individuals with no identified ocular pathology. Jagun et al. [22] reported normative mean values for corneal power, AL, ACD, LT, and VCD of 43.77 D, 23.31 mm, 3.13 mm, 4.15 mm, and 16.01 mm, respectively, in Southwest Nigeria [23]. In a chart review of patients evaluated for cataract surgery in Abak, Nigeria, the mean ACD, LT, VCD, and AL were 3.22 mm, 4.23 mm, 16.06 mm, and 23.51 mm, respectively [23]. In our study, the mean AL (23.17 mm) and VCD (16.71 mm) were similar to those observed in individuals from Nigeria [21-23]; however, the mean LT (3.48 mm) and ACD (2.94 mm) were different [21-23]. Age-related changes are mainly related to LT or ACD, rather than AL or VCD [24], later in life. Therefore, a possible justification for the observed discrepancies between the current and previous studies is that parameters such as LT and ACD are more affected by age, yet AL and VCD values remain fairly constant once they stabilize in adulthood. Further multicenter studies with similar age groups in our region are required to prove this hypothesis.

In the current study, more females (55.4%) than males benefited from the humanitarian surgical camps. This is probably because most males had more access to funds for eye care than females, as suggested by a study that assessed barriers to eye care utilization in some parts of Nigeria's Federal Capital Territory [25]. Lack of funds is a known source of social exclusion, which predominantly affects women, who are more vulnerable than men [26]. Therefore, the free eye camp provides a "catch-up" opportunity for women. Older age and vulnerability in women could be limiting factors in accessing effective healthcare because of the lack of social support for this particular cohort of individuals [26, 27].

In the present study, the mean ACD was 2.94 mm. This is lower than results in other studies from Nigeria [22, 23]. Although not statistically significant, males (3.01 mm) had higher numerical ACD values than females (2.89 mm). This difference was similar to that reported in Abak, Nigeria [23], but differed from that reported in Shagamu, Nigeria, where the difference between males and females was significant [22]. ACD in this study decreased with age, which was not unexpected, because the crystalline lens continuously increases in size throughout life because of the laying down of new lens fibers [20]. These new fibers cause a forward shift of the lens and a resultant shallowing of the ACD [22]. Moreover, with cataracts, which are common with increasing age, LT usually increases, further reducing ACD [28].

In the present study, changes in LT with age were inconsistent. Although the oldest age group (> 80 years) had the highest mean LT value (3.81 mm), the pattern of change in LT with age appeared sinusoidal when plotted on a graph. This is inconsistent with the findings of other studies that reported an increase in LT with age [18, 19]. Nuclear sclerosis cataracts are common with increasing age and are associated with increased formation of lens proteins and deposition of new lens fibers, which is continuous with increasing age. The age-related increase in LT in cataractous lenses has been attributed to this [11, 20, 29].

In older age groups, the mean VCD decreased with age; however, no statistically significant difference was found among the 10 age groups. Mean VCD was higher in males (16.99 mm) than females (16.49 mm), yet the difference was not significant. Conversely, Jagun et al. [22] reported significant differences in both parameters concerning patients' age and sex. They reported an initial increase in VCD from 18 to 40 years of age, after which there was a steady decrease [22].

The mean AL in the present study was 23.17 mm. This was similar to the 23.31 mm value reported in the Sagamu region by Jagun et al. [22]. In the current study, there was a steady reduction in AL with age, which was higher in males (23.49 mm) than females (22.92 mm). However, the difference noted was not significant between age and sex groups compared to that reported by Jagun et al. [22]. AL was found to change with age [30]. The AL values in this study were also similar to those previously obtained in Iran (24.14 mm) [20] and China (23.27 mm) [8]. The mean AL value obtained was comparable to that of studies in Nigeria [22].

The constant average keratometric value used in this study, owing to the lack of availability of keratometers [17]. However, some variations in corneal power would have possibly been noted if the actual real-time keratometric values were obtained. The mean IOL power in this study was 22.0 D, with significant differences observed between sex and age groups. This result is similar to that reported by Adio et al. [21]. They found a mean IOL power of 21.34 D, which is slightly lower than the 22.0 D value reported in all participants in this study. The mean IOL powers for females (22.78 D) and males (21.12 D) reported in this study differed significantly. Furthermore, the IOL power with the highest frequency in this study was 23.0 D. This is very plausible from our results, considering the range of IOL power for females and the fact that they accounted for 55.4% of patients who benefited from this camp. The IOL power among some individuals in this study ranged from 6 to 22 D or from 24 to 34 D, which could be justified by the lower mean values of the biometric parameters obtained compared to those of previous studies [22, 23]. Regardless of the IOL power, the age-related trends in the above parameters and sex differences obtained were comparable, to some extent, to those of previous studies in Nigeria [21-23].

Humanitarian missions play a pivotal role in performing a large number of cataract surgeries in a short time, particularly in areas with limited resources [17]. In this large-scale study of cataract surgery candidates with a wide age range, we reported the mean values for biometric parameters overall and in different age and sex groups, which could be considered as racial reference values for future studies. However, the study was limited in that actual patients' keratometric values were not used to calculate IOL power; instead, a constant average value of 43.0 D was used for all patients owing to limited resources in our region and the nature of the mobile camp. Further longitudinal studies focusing on preoperative biometric and keratometric values along with postoperative changes, including visual outcomes, effects of surgery on quality of life, and documentation of postoperative complications, are required.

CONCLUSIONS

This large-scale study presented the mean distributions of ocular biometric parameters in candidates for cataract surgery, and observed a significant correlation between them. The mean ACD, LT, VCD, AL, and IOL power were 2.94 mm, 3.48 mm, 16.71 mm, 23.27 mm, and 22.0 D, respectively. The most common IOL power was 23.0 D. Despite a strong significant negative correlation between IOL power and AL, the correlation between other parameters, if significant, had a weak or moderate strength. Age and sex are important determinants of IOL power and should be considered when stocking supplies for eye camps. However, further longitudinal investigations using keratometry and biometric assessments are required to verify these outcomes.

ETHICAL DECLARATIONS

Ethical approval: The study protocol was approved at the Department of Ophthalmology, Federal Medical Centre, Asaba, Nigeria. Consent was obtained from each patient prior to cataract surgery.

Conflict of interest: None.

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