Distribution of axial length and related factors in an adult population of Mexico City

Distribución de la longitud axial y factores relacionados en una población adulta de la Ciudad de México

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Abstract

Background: The aim of the study was to analyze the axial length (AL), anterior chamber depth (ACD), lens thickness (LT), and vitreous chamber depth (VCD) in an adult population from Mexico City and the surrounding area with a diagnosis of cataract. **Methods:** This was a retrospective and descriptive study. We reviewed the medical files of subjects undergoing an ultrasound examination as part of the pre-surgical routine evaluation during a period of 6 months (June 1, 2013-December 31, 2013). Biometric parameters were available for 865 eyes after applying the exclusion criteria. All measurements were made using the Ocuscan® RxP ultrasonic biometer (Alcon Laboratories, Fort Worth, Texas, USA). **Results:** The study included 430 eyes. Mean AL was 23.44 ± 1.71 mm (median: 23.15; range: 20.48-35.05 mm; 23.27-23.60, 95% confidence interval [CI]). Mean ACD was 3.12 ± 0.46 mm (median: 3.13 mm; range: 1.77-4.54 mm; 3.07-3.16, 95% CI). Mean LT was 4.47 ± 0.57 mm (median: 4.50 mm; range: 3.18-5.78; 4.41-4.52, 95% CI). Mean VCD was 15.81 ± 1.63 mm (median: 15.58 mm; range: 12.98-26.78; 15.66-15.97, 95% CI). Mean age of the patients was 70.03 ± 10.50 years (median 70 years, range 40-96 years). **Conclusion:** In a Mexican adult population from Mexico City, particularly in women, a lower AL and ACD were observed. Compared to other studies, the AL was found within an average range. Age and sex were significantly associated with the other parameters evaluated in this study.

Key words: Axial length. Anterior chamber depth. Lens thickness. Vitreous chamber depth.

Resumen

Objetivo: Analizar la longitud axial, profundidad de cámara anterior, grosor del cristalino y profundidad de cámara vítrea en una población adulta de la ciudad de México y alrededores con diagnóstico de catarata. **Métodos:** Estudio retrospectivo y descriptivo. Se revisaron los expedientes de un período de 6 meses (de 1 de junio de 2013 a 31 de diciembre de 2013) de sujetos sometidos a un examen ecográfico como parte de su rutina prequirúrgica. Los parámetros biométricos estaban disponibles para 865 ojos después de aplicar los criterios de exclusión. Todas las mediciones fueron realizadas utilizando

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el biómetro ultrasónico Ocuscan RxP (Alcon Laboratories, Fort Worth, Texas, EE.UU). **Resultados:** El estudio incluyó 430 ojos. La longitud axial media fue de 23.44 ± 1.71 mm (mediana: 23.15; rango: 20.48-35.05 mm; IC 95%: 23.27-23.60). La profundidad de cámara anterior media fue de 3.12 ± 0.46 mm (mediana: 3.13 mm; rango: 1.77-4.54 mm; IC 95%: 3.07-3.16). El grosor cristalino medio fue de 4.47 ± 0.57 mm (mediana: 4.50 mm; rango: 3.18-5.78; IC 95%: 4.41-4.52). La profundidad de cámara vítrea media fue de 15.81 ± 1.63 mm (mediana: 15.58 mm; rango: 12.98-26.78; IC 95%: 15.66-15.97). La edad media de los pacientes fue de 70.03 ± 10.50 años (mediana 70 años, rango 40-96 años). **Conclusiones:** En la población adulta mexicana de la Ciudad de México, particularmente en las mujeres, se encontró una menor longitud axial y profundidad de cámara anterior. Comparado con otros estudios, la longitud axial se encontró dentro de un rango promedio. La edad y el sexo estuvieron significativamente asociados con los demás parámetros evaluados en este estudio.

Palabras clave: Longitud axial. Profundidad de cámara anterior. Grosor cristalino. Profundidad de cámara vítrea.

Introduction

At the end of the 19th century, the British physicist and mathematician William Thompson Kelvin (1824-1907) said that "If you cannot measure it, you cannot improve it." Such is the case for axial length (AL) measurement, an important and necessary ophthalmic parameter for the calculation of intraocular lens power prior to cataract and refractive surgery¹, and useful for the early diagnosis of ocular conditions such as microphthalmos and/or nanophthalmos, staphyloma² and for the risk of retinal detachment³.

Several studies have shown the correlation between ocular biometrics, especially AL, with refractive errors. Hosny et al.⁴ found that corneal diameter, spherical equivalent, and anterior chamber depth (ACD) affect AL parameters. In a study conducted at the University of Shanghai by Wang et al.⁵ that measured the AL of 255 eyes, an AL of 23.63 mm (± 0.92) was observed in hyperopic subjects, 24.62 mm (± 0.38) in emmetropic subjects, and 26.68 mm (± 0.75) in myopic subjects. Since these parameters may be influenced by race, ethnicity, and genetics, their differences between different populations can probably explain refractive error variations.

Some Asian countries such as Taiwan, Myanmar, Singapore, and China⁶⁻⁹ have published population reports related to the distribution of ocular biometrics.

A review of several studies using different measurement techniques shows that AL measurement of the adult normal eye is of approximately 23.60 mm^{10,11}, taken from the corneal apex to the internal limiting membrane (ILM). However, most individuals are in the range of 22.00-24.50 mm.

Hoffer showed that the average ACD in phakic eyes is of 3.24 mm (± 0.44 mm)¹¹ and concluded, in a study of 7500 eyes, that the thickness of a cataractous lens (lens thickness [LT]) is of 4.63 mm¹⁰.

Objective

Our study shows the distribution of AL and its components, including ACD, LT, and vitreous chamber depth (VCD), in a Mexican population aged 40-99 years with a diagnosis of cataract.

Methods

All measurements were made with the Ocuscan RxP ultrasonic biometer (Alcon Laboratories, Fort Worth, Texas, USA) during the period from June to December 2013. The ultrasonic biometer measures from the cornea to the ILM. The measurements were recorded in automatic mode, with the immersion technique, to avoid corneal flattening and obtaining results comparable to optical biometrics.

AL is defined as the distance from the anterior aspect of the cornea to the ILM. ACD is defined as the distance from the anterior aspect of the cornea (corneal epithelium) to the anterior aspect of the lens, and LT is defined by its anterior and posterior aspects, and VCD is measured from the back of the lens to the ILM.

Each ocular biometrics index was defined by its mean and a 95% confidence interval (CI) by age and gender, and the normal range was calculated as the mean of ± 2 standard deviations. The 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles were estimated to show the distribution of these variables in more detail.

To assess distributions different from normal, they were plotted in histograms. Pearson's correlation coefficients were determined by examining the correlation between both eyes in terms of AL and its components.

In this report, only phakic eyes were included for analysis, and subjects with a history of eye surgery were excluded from the study. The correlation between the right and left eyes was high for the AL ($r = 0.997$), ACD ($r = 0.980$), LT ($r = 1.015$), and VCD ($r = 0.999$) indices; therefore, we present here only the results of the right eyes.

Table 1. Distribution of AL, ACD, LT, and VCD with means and 95% CI by age and gender

Age (years)	N	AL (mm) mean (95% CI)	ACD (mm) mean (95% CI)	LT (mm) mean (95% CI)	VCD (mm) mean (95% CI)
Male					
40-49	5	23.03 (22.66-23.41)	3.55 (3.02-3.42)	4.11 (3.62-4.60)	15.39 (15.15-15.62)
50-59	19	23.99 (23.66-24.32)	3.47 (3.27-3.66)	4.15 (3.93-4.37)	16.36 (16.04-16.68)
60-69	34	23.55 (23.02-24.08)	3.22 (3.02-3.42)	4.49 (4.27-4.71)	15.83 (15.33-16.33)
70-79	40	23.89 (23.48-24.30)	3.25 (3.10-3.40)	4.39 (4.20-4.58)	16.23 (15.84-16.62)
80+	31	23.67 (23.39-23.95)	3.17 (3.01-3.33)	4.60 (4.40-4.80)	15.89 (15.61-16.17)
Female					
40-49	9	24.36 (22.45-26.28)	3.50 (3.04-3.97)	4.02 (3.53-4.51)	16.83 (15.02-18.64)
50-59	43	23.56 (22.81-24.81)	3.16 (3.02-3.31)	4.21 (4.04-4.38)	16.16 (15.45-16.86)
60-69	85	23.41 (22.91-23.90)	3.10 (3.01-3.19)	4.47 (4.35-4.59)	15.83 (15.36-16.30)
70-79	113	23.26 (22.96-23.57)	3.02 (2.93-3.10)	4.55 (4.55-4.66)	15.59 (15.31-15.88)
80+	51	22.87 (22.71-23.04)	2.90 (2.79-3.00)	4.71 (4.56-4.87)	15.25 (15.06-15.45)
Total	430	23.44 (23.27-23.60)	3.12 (3.07-3.16)	4.47 (4.41-4.52)	15.81 (15.66-15.97)

AL: axial length; ACD: anterior chamber depth; LT: lens thickness; VCD: vitreous chamber depth; CI: confidence intervals.

Statistical analysis was performed using a commercially available statistical software package, Statistical Package for the Social Sciences version 19, Chicago, Illinois, USA.

The study was reviewed and approved by the Ethics Committee of the Conde de Valenciana Institute of Ophthalmology in Mexico City.

Results

Of a total of 565 patients, AL measurements and its associated parameters were available for 865 eyes (440 right and 405 left). Of the 440 right eyes studied, 10 were excluded due to a history of ocular surgery. Finally, a total of 430 eyes were included in the study. Mean patient age was 70.03 ± 10.50 years (median 70 years, range 40-96 years).

The results in terms of mean and 95% CI of the mean of AL, ACD, LT, and VCD studied by gender and age, the mean ± 2 SD of these variables by age and gender, and the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of these variables are summarized in Tables 1, 2, and 3, respectively. Figure 1 shows the distribution histogram of AL, ACD, LT, and VCD. Table 3 summarizes the asymmetry and kurtosis of the variables.

Mean AL was 23.44 ± 1.71 mm (median: 23.15; range: 20.48-35.05 mm; 95% CI 23.27-23.60).

Mean ACD was 3.12 ± 0.46 mm (median: 3.13 mm; range: 1.77-4.54 mm; 95% CI: 3.07-3.16).

Mean LT was 4.47 ± 0.57 mm (median: 4.50 mm; range: 3.18-5.78; 95% CI: 4.41-4.52). Mean VCD was 15.81 ± 1.63 mm (median: 15.58 mm; range: 12.98-26.78; 95% CI: 15.66-15.97).

Variations by gender were observed in all the parameters evaluated. Women had a lower AL, mainly explained

Table 2. Range (± 2 standard deviation) of AL, ACD, LT, and VCD by sex and age

Age (years)	AL (mm)	ACD (mm)	LT (mm)	VCD (mm)
Male				
40-49	22.73-23.38	2.89-3.88	3.66-4.61	15.23-15.67
50-59	22.69-25.23	2.85-4.07	3.41-4.97	15.49-18.00
60-69	21.17-29.56	2.32-4.54	3.46-5.66	13.42-21.19
70-79	22.31-28.15	1.77-4.11	3.23-5.38	14.65-20.72
80+	21.38-25.42	2.40-3.97	3.40-5.51	13.77-17.53
Female				
40-49	21.04-28.45	2.46-4.34	3.20-5.10	13.57-20.51
50-59	20.81-33.52	2.12-4.26	3.18-5.43	13.51-25.35
60-69	20.48-35.05	2.24-4.12	3.28-5.78	12.98-26.78
70-79	21.11-31.51	2.04-4.07	3.33-5.74	13.22-22.29
80+	21.84-24.75	2.40-3.97	3.54-5.73	13.57-17.48

AL: axial length; ACD: anterior chamber depth; LT: lens thickness; VCD: vitreous chamber depth.

by a lower ACD and a lower VCD. However, they showed a somewhat higher LT.

Subjects from 40 to 49 years of age, compared to subjects over 80 years of age, showed a higher AL (mean difference, 0.72 mm), a higher ACD (mean difference, 0.52 mm), and a higher VCD (mean difference, 0.82 mm). However, subjects over 80 years had a higher LT (mean difference, 0.62 mm). Among people aged 50-59, on average, a lower AL (mean difference, 0.20 mm) was observed compared to younger people (40-49). Older subjects showed a lower ACD (0.26 mm) and a lower VCD (0.09 mm), but a higher LT (0.14 mm).

When analyzed by decades, the parameters of AL, ACD, and VCD decreased at the expense of an increase in LT.

Discussion

Our study provides information on the ocular biometric components in Mexican adults over 40 years of age who live in and around Mexico City.

Figure 1. Axial length distribution (A), anterior chamber depth (B), lens thickness (C), vitreous chamber depth (D).

Table 3. Percentiles, asymmetry, kurtosis, and interquartile range of AL, ACD, LT, and VCD

	Percentiles							Normal distribution rates		
	5%	10%	25%	50%	75%	90%	95%	Asymmetry	Kurtosis	Interquartile range
AL	21.68	21.99	22.59	23.15	23.85	24.63	26.53	2.99	12.81	1.26
ACD	2.38	2.47	2.79	3.13	3.44	3.70	3.93	0.06	-0.40	0.65
Lens thickness	3.49	3.64	4.08	4.50	4.89	5.23	5.44	-0.08	-0.58	0.80
Vitreous chamber depth	13.99	14.42	15.01	15.58	16.25	16.90	18.31	2.90	12.41	1.24

AL: axial length; ACD: anterior chamber depth; LT: lens thickness; VCD: vitreous chamber depth.

The average AL in the Mexican population studied ($23.44 \text{ mm} \pm 1.71 \text{ mm}$) was higher than that previously reported in an adult Chinese population (The Tanjong Pagar Survey: $AL 23.23 \pm 1.17 \text{ mm}$)⁸ and in an Indian

adult population (The Central India Eye and Medical Study: $AL 22.6 \pm 0.91 \text{ mm}$)^{12,13}. In an Iranian population, Hashemi et al.¹⁴ reported an average AL of 23.14 mm. When analyzing the other factors, we also found lower

average values with respect to the population studied. However, all these studies were conducted in Asian populations.

The Los Angeles Latino Eye Study¹⁵ included 5588 Latinos over 40 years of age, finding an average AL value of 23.38 ± 1.01 mm, very similar to that of our population. These results support the assumption about ethnic importance in biometric values.

Villanueva-Pérez et al. (2009)¹⁶, in a comparative study in a Mexican population regarding ACD in 26 patients, found that the average ACD measured with immersion A-ultrasound biometry was of 3.29 ± 0.37 mm. We found that older people have a lower AL, a narrower ACD, and a smaller VCD, but a higher LT. These biometric data coincide with measurement patterns observed in the previous studies in different populations^{7,9}. While an increase in AL is expected from childhood to adolescence, it is difficult to explain the shortening of the eye after middle age. One of the disadvantages of our study is the lack of comparison of these variations through time. However, Gudmundsdottir et al.¹⁷ demonstrated, in a 5-year cohort study, that this could be due to many unknown causes, including ocular atrophy.

A decrease in ACD and an increase in LT with age are another finding in this and other studies. The increase of LT with age is attributed to the regular apposition of crystalline fibers throughout life, which causes a decrease in ACD¹⁸.

All the biometric data analyzed in this study were higher in men. All studies have shown higher AL and ACD values in men, but the results between LT and gender have been conflicting.

Conclusion

AL and its associated factors (ACD, LT, and VCD), compared to other studies conducted in Asian and American populations, showed average values. Except for LT, which increases with age, the rest of the values decreased with age. In addition, all biometric values were higher in men than in women.

Conflicts of interest

The authors declare no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

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