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The Axial Length and Anterior Chamber Depth in Patients with Cataracts: A Study of Hungarian, Kosovan, and Brazilian Populations

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Abstract

Background: Two crucial parameters to consider when calculating the intra-ocular lens are the axial length (AL) and anterior chamber depth (ACD). This study aims to compare the AL and ACD between Hungarian, Kosovan, and Brazilian patients with cataracts and to predict the possible factors that play a role in these differences.

Methods and Results: This comparative cross-sectional observational study included pre-operative biometric parameters, AL and ACD, measured with LenStar900 in patients from Hungary, Kosovo, and Brazil who were scheduled to undergo cataract surgery. We performed biometric measurements of 2043 eyes of patients with cataracts. There was a statistically significant weak negative correlation between age and both biometric parameters (AL and ACD) in Hungarian subjects (P=0.000), while in Kosovar subjects, a statistically significant weak negative correlation was observed only between age and ACD. Unfortunately, this type of analysis was not conducted among Brazilian subjects.

A one-way ANOVA with Tukey HSD test showed a statistically significant difference in AL between the Hungarian and Kosovan patients (P=0.0000) and Hungarian and Brazilian patients (P=0.0002); however, no statistically significant difference was found in AL between the Kosovan and Brazilian patients (P=0.7284). There was no statistically significant difference in ACD values between all three groups (P=0.5064).

Conclusion: There are statistically significant differences in the AL biometric parameter between the three groups of patients, which could be attributed to demographic and social factors specific to each group. Furthermore, this is the first study to include patients from these three countries.(**International Journal of Biomedicine. 2025;15(1):101-107.**)

Keywords: Intra-ocular lens • axial length • anterior chamber depth • biometry • cataracts • LenStar 900

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Introduction

The eye is an optical system that, explained in a simplified way, consists of the cornea, crystalline lens, and vitreous body; therefore, any change in the components of this optical system causes an alteration in the eye's refractive power.[1] Among other contributing factors, demographic features such as age and age-related diseases, such as cataracts, play a major role in the alteration of the biometric factors of the eye, and other socioeconomic factors should also be considered.

Cataracts are accountable for visual impairment and blindness worldwide.[2-4] Blindness rates due to cataracts vary by country; however, 90% of the total disability-adjusted life years in developing countries is attributed to cataracts.[5]

Despite the ongoing advances in science, cataracts remain the leading cause of vision loss in middle- and low-income countries, causing 50% of blindness cases and 5% in developed countries.[6] Cataract is the ocular pathology with the highest prevalence in people over 65 and is considered a leading cause of preventable blindness worldwide;[7] cataract

extraction with intra-ocular lens (IOL) implantation is perhaps the most effective surgical procedure. Currently, considering the advances in cataract treatment, patients expect more than just removing the opacified crystalline lens. Therefore, for better post-operative refractive outcomes, it is crucial to analyze and assess the parameters of the anterior segment of the eye thoroughly and precisely. One of the most important biometric parameters of the eye is the axial length (AL), which represents the length of the eyeball from front to back and changes with age. A newborn's eye has an AL of 16 mm, and it increases to up to 24–25 mm;[8,9] a normal AL is in the range of 22 mm–25 mm.[10]

Although AL is a crucial measurement when investigating eye growth and development, advances in ocular biometry have added valuable supplementary measures that provide a more comprehensive point of view. Research into ocular biometry has shed light on the relationship between AL and other biometry parameters in myopic eyes.[11,12]

Different refractive error variations in older adults aged 50 years or above are mostly influenced by variations in AL and crystalline lens refractive power, followed by variations in corneal refractive power and, to a minor degree, by variations in lens thickness and anterior chamber depth (ACD).[13,14] Calculating an intraocular lens (IOL) with an appropriate power lowers the degree of post-operative refractive error; thus, IOL planning requires high-precision measurements of biometric parameters. As ophthalmology advances, the need for precise ocular parameters increases. One crucial biometric parameter of the eye is the AL, which is commonly needed for intra-ocular lens power calculation before cataract and refractive surgery.[15,16] An accurate evaluation of ACD (ACD—the measurement from the anterior surface of the cornea to the anterior surface of the crystalline lens) is also critical when planning procedures utilizing either a phakic or pseudophakic intra-ocular lens (IOL).[17] The anterior chamber (ACD) is an important parameter in intra-ocular lens (IOL) power formulas to predict the appropriate IOL power. It is also critically important for the Haigis formula, which only uses AL and ACD to predict the effective lens position (ELP).[18-20] Furthermore, the pre-operative ACD is considered a crucial component in the IOL calculation process since an increase in the AL causes the ACD to increase accordingly.[21]

In search of higher precision and better post-operative refractive outcomes, cataract surgeons choose to work with modern biometric devices. Certain modern biometric devices have become the preferred choice among cataract surgeons because they can produce high-precision measurements and due to the possibility of capturing multiple biometric dimensions of the eye. The Lenstar LS 900 (Haag–Streit AG, Köeniz, Switzerland) is used by many surgeons since it is an optical low-coherence refractometry instrument that captures the AL, white-to-white (WTW) distance, central corneal thickness (CCT), aqueous depth (AD; the distance between the corneal endothelium and anterior lens capsule), ACD (the distance between the corneal epithelium and anterior lens capsule), crystalline lens thickness, and keratometric values (K) in a single measurement.[22,23]

However, even with modern biometry and continuous improvements in surgical techniques, intra-ocular lenses (IOLs), and IOL power formulas, the refractive outcomes in approximately 5% of eyes remain more than 1.0 diopter (D) from the intended target.[24,25] Furthermore, the surge in refractive surgery in recent years has led to the discovery of many patients with a shallow ACD at a younger age.[26] Studies have shown that the biometric parameters of the eye, such as AL and ACD, can be influenced by many demographic and socioeconomic factors such as race, ethnicity, and lifestyle. Therefore, the differences in biometric parameters among different populations could probably explain the differences in refractive errors in each population.

This study aims to compare the AL and ACD between Hungarian, Kosovan, and Brazilian patients with cataracts and to predict the possible factors that play a role in these differences.

Materials and Methods

This comparative cross-sectional observational study included consecutive patients with cataracts from three countries (Hungary, Kosovo, and Brazil) who were scheduled to undergo cataract surgery between 2020 and 2023. Patients' biometric data were collected using the biometry reports of patients appointed for cataract surgery in the Department of Ophthalmology of Semmelweis University in Budapest, Hungary; the Department of Ophthalmology of the University Clinical Center of Kosovo in Prishtina, Republic of Kosovo; and the Department of Ophthalmology of the Faculty of Medicine of Ribeirão Preto, Sao Paulo, Brazil.

Data Collection

Data were collected from the Patient Data Management System in each clinic and consisted of the biometry measurements performed using a Haag-Streit LenStar 900 (Haag-Streit, Köniz, Switzerland) biometer. These measurements were performed by a skilled and well-trained resident before cataract surgery to calculate the intra-ocular lens (IOL), while the standard deviation (SD) was automatically computed in the device. Patients with a standard deviation (SD) higher than SD > 0.2 mm for the AL and SD > 0.13 mm for the ACD were not included in this study. We selected all patients whose data were measured by the same resident and who were scheduled to be operated on by the same surgeon. This study included all patients diagnosed with cataracts in one or both eyes who were scheduled to undergo cataract surgery in 2020–2023. Only measurements of patients with a healthy corneal surface were included in this study, while patients with corneal disorders were excluded. However, patients with other comorbidities, such as pseudo-exfoliation syndrome (PEX), proliferative diabetic retinopathy, non-proliferative diabetic retinopathy, and exudative and non-exudative age-related macular degeneration (AMD), which did not influence the corneal surface nor the accuracy of the measurement of the biometric factors (AL and ACD, respectively), were included in this study. We complied with the inclusion and exclusion criteria by analyzing all patients' pre-operative medical reports registered in the Patient Data Management System, and we only included patients who were not diagnosed with any type of corneal disorder. The definitive diagnosis was given by the operating surgeon.

The biometry parameters were taken from the biometry reports that fulfilled the inclusion criteria and that were registered in the optical biometer patient database. Each biometry report represented five consecutive biometric measurements performed for all patients, and the SD of <0.2 mm for AL and SD of <0.13 mm for ACD were strictly applied. All biometric data were measured using the same equipment, the Haag-Streit LenStar 900 biometer, in all three centers.

All the data of eligible patients were collected and inserted in a separate database for analysis by the same person appointed in each center who was a part of this study group. We collected the biometry measurements of patients assigned to undergo cataract surgery with the standard procedure of phacoemulsification by the same surgeon with 10 years of experience or more in cataract surgery using this method in each center. Phacoemulsification, as a standard type of procedure for cataract surgery, was performed under local anesthesia, which was either subconjunctival or retrobulbar based on the surgeon's choice.

Statistical Analysis

STATA 18 and SPSS 27.0 were used for the statistical analysis and graphic presentation of the collected data results. Baseline characteristics were summarized as mean and standard deviation (SD). Multiple comparisons were performed with one-way ANOVA and a Post Hoc Tukey HSD test. Pearson's correlation coefficient (r) was used to determine the strength of the relationship between the two continuous variables. All values of $P<0.05$ were considered significant.

Results

In this study, we analyzed the biometric data obtained using a LenStar 900 optical biometer, and we used biometry reports from measurements performed before cataract surgery, which were inserted in the LenStar 900 database and Patient Data Management System. We extracted and analyzed the biometric data of 2043 eyes of patients with cataracts who were scheduled to undergo phacoemulsification cataract surgery in one or both eyes in one of three different centers in three countries: Hungary, Kosovo, and Brazil.

We included the data on AL and ACD of 998 eyes of patients from Hungary, 630 eyes of patients from Brazil, and 415 eyes of patients from Kosovo. We compared the AL and ACD of patients scheduled for cataract surgery in three different countries' centers.

Using Pearson's correlation coefficient, we also assessed the correlation between the patients' age and AL and ACD.

Table 1 shows the general results of the descriptive statistics; the mean age of subjects in Kosovo was 70.4±9.23, while the mean age of subjects in Hungary was 68.9±12.35.

The mean AL in Kosovan patients was 23.23±0.98 mm, and a similar AL was found in Brazilian patients (23.3±0.954 mm); however, AL in Hungarian patients (23.60±1.84 mm) differs compared to that of patients from Kosovo and Brazil. The mean ACD was the lowest in the Kosovan patients (3.12±0.42 mm) and the highest in the Brazilian patients (3.15±0.417 mm).

Table 1.

Descriptive statistics.

Variables	Kosovars		Hungarians		Brazilians	
	Mean	SD	Mean	SD	Mean	SD
Age, yrs	70.4	9.23	68.97	12.35	-	-
AL, mm	23.23	0.98	23.6	1.84	23.3	0.954
ACD, mm	3.12	0.42	3.14	0.45	3.152	0.417

Table 2 presents the results of the correlation analysis between the age of Hungarian patients, AL and ACD. There was a statistically significant (P=0.000) negative weak correlation between age and both evaluated parameters, AL (r=-0.116) and ACD (r=-0.250), indicating that AL and ACD decreased with patient age.

Table 2.

The results of the correlation analysis between the age, AL, and ACD of Hungarian patients.

		Age	AL	ACD
Age	r	1	−0.116	−0.250
	P-value		0.000	0.000
	n	993	990	900
AL	r	−0.116	1	0.351
	P-value	0.000		0.000
	n	990	998	908
ACD	r	−0.250	0.351	1
	P-value	0.000	0.000	
	n	900	908	908

According to the results in Table 3, there was also a negative weak correlation between age and AL (r=-0.048) and ACD (r=-0.188) in Kosovan subjects. The correlation between age and ACD was statistically significant (P=0.000); however, there was no statistically significant correlation between age and AL (P=0.330). Unfortunately, this type of analysis was not conducted among Brazilian subjects.

Table 3.

The results of the correlation analysis between the age, AL, and ACD of Kosovan patients.

		Age	AL	ACD
Age	r	1	−0.048	−0.188
	P-value		0.330	0.000
	n	416	415	392
AL	r	−0.048	1	0.289
	P-value	0.330		0.000
	n	415	415	392
ACD	r	−0.188	0.289	1
	P-value	0.000	0.000	
	n	392	392	392

A one-way ANOVA with Tukey HSD test showed a statistically significant difference in AL between the Hungarian and Kosovan patients (P=0.0000) and Hungarian and Brazilian patients (P=0.0002); however, no statistically significant difference was found in AL between the Kosovan and Brazilian patients (P=0.7284) (Table 4, Figure 1). There was no statistically significant difference in ACD values between all three groups (P=0.5064) (Table 4, Figure 2).

Table 4.

One-way ANOVA and Tukey HSD for pairwise comparisons.

Parameter	Hungarian patients (n=998)	Brazilian patients (n=630)	Kosovan patients (n=415)	One-way ANOVA and Tukey HSD
	[1]	[2]	[3]	F=13.1629, P=0.0000
AL, mm	23.6±1.84	23.3±0.954	23.23±0.98	P_{1-2}=0.0002, P_{1-3}=0.0000 P_{2-3}=0.7284
ACD, mm	3.14±0.45	3.152±0.417	3.12±0.42	F=0.6807, P=0.5064

In Figures 1 and 2, the asterisks indicate extreme outliers, values greater than three times the interquartile range from the upper or lower quartiles.

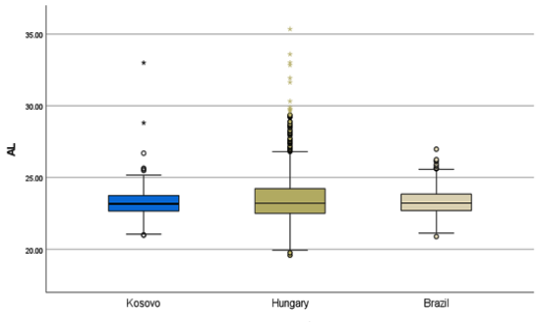

Fig. 1. *Comparison of the mean axial length between study groups.*

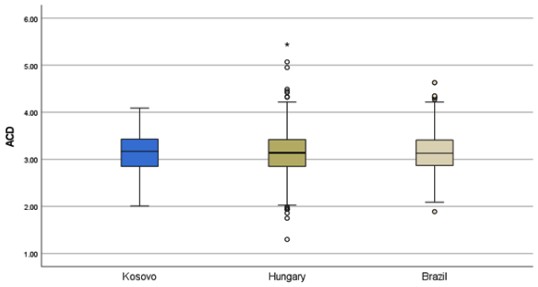

Fig. 2. *Comparison of the mean anterior chamber depth between study groups.*

Discussion

This study compared the axial length (AL) and anterior chamber depth (ACD) between Hungarian, Kosovan, and Brazilian populations; the pre-operative biometric data of patients with cataracts who were scheduled to undergo phacoemulsification cataract surgery were analyzed. Socioeconomic and demographic factors, such as race, ethnicity, and lifestyle, impact biometric parameters such as AL, ACD, and lens thickness; these factors can also explain differences in refractive errors between populations.

Guo Yin et al.[13] in the Beijing Eye Study found that the axial length was significantly associated with the systemic parameters of a higher age (P<0.001), higher body height (P=0.003), higher level of education (P<0.001), and an urban region of habitation (P<0.001). These findings align with our results because we also found a statistically significant negative correlation (P=0.000) between age and biometric parameters (AL and ACL) in Hungarian patients. We found that there was also a statistically significant negative correlation between age and the anterior chamber depth in the Kosovan patients (P=0.000).

The correlation between age and the axial length and anterior chamber depth found in our study also aligns with another survey of the distribution of the axial length and ocular biometry, measured using partial coherence laser interferometry (IOL Master) in an older white population conducted by Fotedar et al.,[27] who also found that there was a mean reduction in the axial length with age.

Our findings are also supported by Mingguang He et al.,[28] as in their longitudinal population study of Chinese adults, the mean axial length was greater for younger persons than the older persons included in the study.

Lowe's findings[29] show that lens growth and lens thickening are associated with shallowing of approximately 0.35–0.50 mm in the anterior chamber with increasing age, particularly over 50.[30]

The results of the study conducted by Arad et al.[31] on the biometric factors in Caucasian patients with cataracts show that the AL, ACD, lens thickness (LT), keratometry, and white-to-white distance (W-W) are negatively correlated with age but positively correlated with each other.

However, in his research on the age-related paraxial schematic emmetropic eye, D. Atchison[32] argued that with increasing age, in the schematic eye, there are some changes such as a decreased anterior chamber depth, increased lens thickness, decreased vitreous length, increased axial length, decreased anterior lens radius of curvature, and increased lens equivalent refractive index. Differently from the age-related schematic eye, our results present a negative correlation between age and AL and ACD, which shows that not only the ACD but also the AL decreases with age. The results of our research show a statistically significant correlation between age and the AL in the Hungarian population.

Regarding the effect of socioeconomic differences on the biometric parameters in populations, the results of the Beijing Eye Study[13] correspond to our results showing a statistically significant difference in AL between the Hungarian patients

and Kosovan and Brazilian patients based on socioeconomic differences in these populations, especially those between Hungary and other two countries, Kosovo and Brazil.

Lam et al.[33] reported that ACD was significantly shorter in Hispanic patients compared to non-Hispanic patients. A study comparing the anterior segment biometry between Chinese and Caucasian patients showed that ACD was smaller in Chinese patients; however, there were no significant differences in AL between the two groups.[34] A study on a Caucasian population showed that there are statistically significant differences in the ACD and lens thickness (LT), which are correlated with patients' ages such that elderly patients had a lower ACD and higher LT;[35] this is similar to the results of our study.

In a study titled "Racial and Ethnic Differences in the Roles of Myopia and Ocular Biometrics as Risk Factors for Primary Open-Angle Glaucoma," based on the data used from the Los Angeles Latino Eye Study (LALES) and the Chinese American Eye Study (CHES), Zhou et al.[36] found out that although the POAG risk conferred by myopic refractive error (RE) and a longer AL is similar between Latino and Chinese Americans, the difference in POAG prevalence between the two groups is narrowed by higher myopia prevalence among Chinese Americans.

Many population studies have reported the association between biometric factors, particularly the axial length, and sociodemographic and economic factors, mainly those conducted in Asia. In their cross-sectional survey study analyzing education, socioeconomic status, and ocular dimensions in Chinese adults, Wong et al.[37] concluded a statistically significant correlation between socioeconomic factors and AL. They concluded that subjects with a high level of education, higher incomes, and work-related occupations had a longer axial length (0.60 mm; 95% confidence interval (CI)).

The study by Nangia et al.[38] supports the findings of our study and those of previous studies because they concluded that the mean axial length in a rural population in India was shorter than that in other populations; thus, a higher axial length is related to higher socioeconomic standards.

Our study found a statistically significant difference in the axial length between the Hungarian subjects and the subjects from Kosovo and Brazil. However, no statistical significance was found between the axial length of subjects from Kosovo and Brazil.

According to many studies, an increase in axial length and higher myopia in an urban population, especially younger ones, is attributed to the fast-developing economy and more stringent educational systems.[39,40] The results of the EPIC—Norfolk Eye Study show that the AL was strongly related to education level,[41] whereas, similar to our findings apart from the correlation between the ACD and age, there was no other significant finding regarding the ACD.

Many studies that were conducted to determine the differences in the biometric parameters of the anterior segment of the eye between different groups and populations support the results of our research, showing that genetic, social, and environmental factors play key roles in the differences in these parameters.

Conclusion

In our comparative study of patients with cataracts from Hungary, Kosovo, and Brazil, we found statistically significant differences in the axial length between the Hungarian patients and the other two groups of patients; however, there was no statistically significant difference in the anterior chamber depth between the countries. In terms of demographics, the results of our study show a statistically significant negative correlation between age and the biometric parameters studied, namely the axial length and the anterior chamber depth. Our study shows a decrease in the axial length and anterior chamber depth with increasing age. With many studies already conducted in several countries in Asia in addition to England and the United States of America, including Caucasian, non-Caucasian, Hispanic, and non-Hispanic subjects, we consider the novelty of our research to be the findings obtained by analyzing the biometric data of subjects from the three countries that we included in this study. Furthermore, this is the first study comparing the biometric data of adult Hungarian, Kosovan, and Brazilian patients with cataracts before surgery.

Institutional Review Board Statement

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Kosovo Chamber of Doctors (No. 49/2022; 12 April 2022), the Regional Institutional Scientific and Research Ethics Committee at Semmelweis University (SE RKEB 82/2024; 14 May 2024), and the National Commission of Research Ethics at the University of Sao Paulo—Ribeirão Preto, Brazil (CAAE:79011223.2.0000.5440; 26 August 2024).

Competing Interests

The authors declare that they have no competing interests.

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