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Ocular biometry in children and adolescent from age 4 to 17 years with intraocular lens power calculation in Sulaymaniyah city

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Abstract

Background and objectives: Ocular biometry is an essential method to measures the anatomical dimensions of the eye in adult and children. The objective is to detect the ocular biometric changes and intraocular lens power calculation in children and teenagers (4 to 17) years.

Methods: This hospital-based observational study included 208 participants (109 females and 99 males) distributed across three age groups (4 to 8, 9 to 12, 13 to 17) years, visiting Shahid Dr. Aso Teaching Eye Hospital in Sulaymaniyah governorate from November 2022 to July 2023. Information on axial length, anterior chamber depth, mean keratometry value, central corneal thickness, and intraocular lens power was collected and evaluated by the IOL Master 700 and Haigis formula.

Results: The average age was 10.52 with a standard deviation of ± 3.31. In the three age groups, AL changed from 22.83 mm to 23.28 mm. Mean keratometry values ranged from 43.46 D to 43.20 D, and IOL power varied from 22.27 D to 21.33 D. Despite gender differences, only AL and IOL power changes were statistically significant (p values: 0.025 for AL, 0.00 for IOL).

Conclusion: The optical ocular elements consistently align with changes in axial length, showing an increase as the child ages. This is accompanied by a decline in mean keratometry values, particularly between the ages of 4 to 8 years and a decrease in intraocular lens power. As the child matures, the variations in these parameters diminish.

Keywords: Adolescent, Biometry, Child, Intraocular

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Introduction

The evaluation of ocular biometry has gained significance in the pediatric demographic for the purpose of examining the refractive condition of the eyes in children and teenagers. Accurate information regarding ocular biometry throughout the eye's development is crucial for comprehending emmetropization and characterizing the progression of refractive issues like myopia.[1] The significant increase in the growth rate at the initial years of life is widely recognized, such as the deepening of the anterior chamber and elongation of the eye's axis occur in tandem with the flattening of the cornea and a reduction in the crystalline lens refractive power. These changes aim to lessen the average level of hyperopia and minimize the variability in early refractive errors. Subsequently, refractive errors tend to stabilize, even as the eye continues to grow, until later in childhood and early adolescence, when myopia reaches its highest occurrence. [2] The IOL power calculation formula has evolved over time, with P (IOL power) being determined by the variables A (a constant), K (average keratometry value), and AL (axial length in mm), as follows: $P = A - 0.9K - 2.5AL$.[2] The assessment of corneal strength, while not entirely precise, relies on the curvature of the cornea.[3] Measurement inaccuracies lead to power errors ranging from 0.8 to 1.3 diopters in both adults and children.[4] Axial length refers to the distance from the front of the cornea to the retinal pigment epithelium. Erroneous measurements of axial length can result in a discrepancy of 3 to 4 diopters for every millimeter difference in intraocular lens (IOL) power.[4] Traditional A-scan ultrasonography was the standard for measuring axial length but had drawbacks, requiring an expert person, general anesthesia, and dealing with corneal indentation.[5] Non-contact optical techniques offer consistently reproducible measurements, which represent a significant benefit when evaluating ocular biometric elements in pediatric cases.[6] Partial coherence interferometry gained popularity because of its non-invasive characteristics and enhanced precision. This technology allows for the measurement of intraocular distances not only along the visual axis but also at various oblique angles.[7] As the use of intraocular lens (IOL) implantation in children becomes more common, choosing the correct IOL power is crucial for various reasons. Pediatric eyes exhibit distinct characteristics compared to adult eyes, such as shorter axial lengths, steeper corneas, and shallower anterior chambers. These factors significantly impact the calculation of IOL power.[8] Pediatric ophthalmologists often aim for under correction, expecting the child's eye to keep growing after cataract surgery. The goal is for the eye to approach emmetropia as it matures, rather than becoming highly myopic.[9] Among advocates of the under-correction approach, there is a guideline called the "rule of 7." According to this rule, the sum of the postoperative refractive target and the child's age equals 7, and the target refraction is determined accordingly: +6D for a 1-year-old, +5D for a 2-year-old, +4D for a 3-year-old, +3D for a 4-year-old, +2D for a 5-year-old, +1D for a 6-year-old, emmetropia for a 7-year-old, and -1 to -2D for patients older than 8 years.[10] The aim of our study is to investigate normal ocular biometric data in children and enabling analysis for ocular growth.

Patients and methods

This hospital based cross-sectional study occurred at Shahid Dr. Aso Eye Teaching Hospital from November 2022 to July 2023. It included 208 randomly selected cases aged 4-17 years. Inclusion criteria comprised individuals with clear corneas and proper ocular alignment. Exclusion criteria were chronic illnesses or ocular syndromes, previous trauma, previous intraocular surgery and drug usage. Informed consent from their guardians taken. The study examined ocular parameters with the IOL-Master 700, a novel non-invasive optical biometer, this device utilizes swept-source optical coherence tomography (SS-OCT) with a 1050 nm wavelength, enabling fast acquisition of three-dimensional anterior segment data with high lateral and axial resolution.[11] Variables assessed were axial length (AL) in mm, anterior chamber depth (ACD) in mm, mean keratometry value from anterior and posterior corneal curvature in diopter, intraocular lens power (IOL) in diopter and central corneal thickness (CCT)in µm of the right eye. The Haigis formula was employed to calculate intraocular lens (IOL) power, with a notable emphasis on its incorporation of preoperative anterior chamber depth measurements.[12] For analysis, participants were categorized into three age groups: group one (4-8 years), group two (9-12 years), and group three (13-17 years). Statistical Package of Social Science SPSS V. 25 used for finding the correlation between biometric measurements, age and genders using one way ANOVA test with significant level of p-value of <0.05 and One Sample T test and 95% confidence level interval. The study protocol was approved by ethical committee of Kurdistan Higher Council of Medical Specialties.

Results:

Among cases 52.4% were female and 47.6% were male, mean age was 10.52 with ± 3.31. Age group distribution divided into group 1(4 to 8 years), group 2(9 to 12 years) and group 3(13 to 17 years). Mean AL in the first group was 22.83 mm then increased to 23.28 mm in comparison to the third group. Mean K values ranged from 43.46 D at age 4 to 8 years to 43.20 D at age 13 to 17 years. The first group exhibited a higher mean IOL power data, whereas the third group showed a comparatively lower value, with readings of 22.27 D and 21.33 D, respectively. The mean ACD data changed from 3.50 mm to 3.58 mm, and the mean CCT ranged from 561.10 µm to 549.63 µm across the mentioned groups, all are displayed in Table (1). The mean biometric changes by age group, revealing a significant increase in axial length with advancing age among children, as indicated by a p-value of 0.025, which is statistically significant p-value < 0.05. Additionally, the mean K value showed variations across mentioned age groups and the mean IOL power decreased as the child ages increased. The statistical significance was observed in the case of the IOL change, with a p-value of 0.00, in which p <0.05. However, there was no significant difference found for the mean K value, the mean CCT, and the mean ACD, with p-values of 0.905, 0.101, and 0.141, respectively. All are illustrated in Table (2). A multiple linear regression was performed to examine the relationship between the age of the participants and changes in axial length (AL) and intraocular lens (IOL) power. The analysis revealed that as the age of child increases, the axial length increased and the IOL power decreased. These findings are depicted in Figure (1) and Figure (2). Table (3) represents the mean changes in ocular biometric measurements from the age 4 to 17 years in both males and females. Specifically, there are a significant increase in the mean axial length from 21.93 mm at age 4 to 23.12 mm at the age 9 in both genders. Subsequently, there are alterations AL beyond age 9, albeit in a more modest magnitude. The mean intraocular lens (IOL) power exhibited notable variations across different age points, recording 25.53 D at age 4 and declining to 20.65 D by the age of 17 years.

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Table (1): Mean biometric parameters according to age groups and their significance

age group			Mean AL mm	Mean ACD	mean keratometry value in diopter	Mean IOL power in diopter	Mean CCT in mm
1	N	Valid 70					
	Mean		22.8366	3.5036	43.4629	22.7541	561.10
2	N	Valid 87					
	Mean		23.2726	3.6157	43.2956	21.4786	550.08
3	N	Valid 51					
	Mean		23.2837	3.5367	43.2041	21.3339	549.63
	Sig.	P value <0.05	0.025	0.141	0.905	0.00	0.101

*1 (4 to 8 years) *2 (9 to 12 years) *3 (13 to 17 years)
* Significance done by One Way ANOVA test

Table (2): Significance of ocular biometric variables between genders

Gender		Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper
Male	AL	0.00	23.34712	23.1789	23.5154
	ACD	0.00	3.59914	3.5451	3.6532
	K mean	0.00	42.91611	42.5617	43.2706
	IOL	0.00	21.61328	21.1879	22.0387
	CCT	0.00	560.551	553.67	567.43
Female	AL	0.00	22.92060	22.7629	23.0783
	ACD	0.00	3.51225	3.4627	3.5618
	K mean	0.00	43.69537	43.4179	43.9728
	IOL	0.00	22.09821	21.6379	22.5585
	CCT	0.00	547.426	540.68	554.17

*One-sample Test and 95% confidence interval

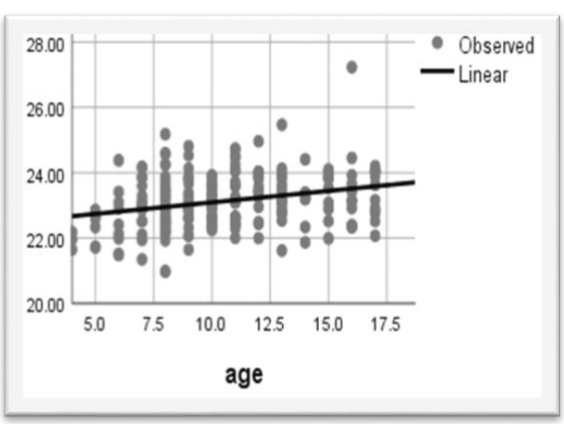

Figure (1): linear regression between age and AL

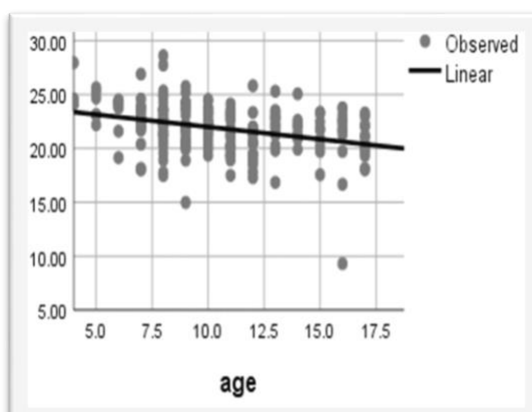

Figure (2): Linear regression between age and IOL power

Table (3): mean biometric parameter between both genders from age 4 to 17 years old

gender			Axial length in mm	anterior chamber depth in mm	intra ocular power in diopter	keratometry value in diopter	CCT
male	4	Mean	21.6500	3.4900	24.0600	45.9000	565.00
	5	Mean	22.0300	3.3800	24.9800	43.9750	548.00
	6	Mean	23.1560	3.4480	22.6920	42.5720	547.20
	7	Mean	23.2814	3.4857	22.7143	42.2000	568.00
	8	Mean	23.1665	3.5609	22.0043	43.1561	567.17
	9	Mean	23.3450	3.5921	21.1364	43.3129	563.71
	10	Mean	23.2440	3.5910	22.3770	42.9210	543.70
	11	Mean	23.3643	3.6743	21.1243	43.3386	542.71
	12	Mean	23.9163	3.8575	19.9838	42.8100	570.50
	13	Mean	23.7213	3.5538	21.4563	41.2975	574.13
	14	Mean	23.3500	3.4000	22.0000	42.5100	602.00
	15	Mean	23.0800	3.5900	21.7600	43.5200	594.00
	16	Mean	24.4500	3.5900	19.7200	41.5500	591.00
	17	Mean	24.0550	3.8775	19.3025	42.9300	551.50
female	4	Mean	22.0700	3.4200	26.2650	42.8750	565.50
	5	Mean	22.4600	3.6125	23.5000	43.9900	550.50
	6	Mean	21.8825	3.3725	24.1250	45.0625	539.00
	7	Mean	22.8278	3.5156	22.0567	44.0522	565.56
	8	Mean	22.5673	3.4191	23.4445	43.6182	563.09
	9	Mean	22.8464	3.5555	22.7673	43.4091	542.27
	10	Mean	22.8764	3.5964	22.0873	43.8427	559.45
	11	Mean	23.3278	3.5611	21.0100	43.4111	526.89
	12	Mean	23.0275	3.5288	21.3000	43.9938	538.50
	13	Mean	22.7700	3.5250	22.6067	43.7217	569.00
	14	Mean	23.0683	3.4717	22.0100	43.3533	535.17
	15	Mean	23.3388	3.6413	21.1600	43.3050	543.13
	16	Mean	23.3527	3.3873	20.7891	43.5764	537.91
	17	Mean	23.1056	3.5589	21.2522	43.8289	537.89

Frequency table and mean value of data according to age and gender

Discussion:

It's important to consider that when comparing the descriptive results and the distribution of variables in children and adolescents, significant variations can arise due to the use of different instruments for measuring biometric components. As illustrated in Table (2), males had longer mean axial lengths than females which was 23.34 mm and 22.92 mm in both genders individually. The same was observed by Rauscher et al.[13] boys exhibit on average higher axial length than girls which was 23.06 mm and 22.54 mm in both genders independently. In our study, the noticeable variation in mean axial length in boys predominantly occurred between the ages of

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4 to 9 years, which are increasing from 21.65 mm to 23.34 mm, while in the girls changes in mean AL were happened at the age 4 to 11 years which means girls had a lag of 2 years in maturation of axial length which is ranging from 22.07 mm to 23.32 mm separately. This finding aligns with the results found by Rauscher et al.[13] who similarly observed a substantial change in mean AL between the ages of 4 to 9 years in boys, with an increase of AL from 22.21 mm to 23.03 mm, In the girls changes in the mean AL occurred from the age 4 to 13 years ranging from 21.58 mm to 23.29 mm with a lag of 4 years of maturation in AL. In our dataset, the average keratometry value from Table (2) indicates that males had corneas with a flatter curvature in which mean K was 42.91 D in comparison to females in which they had steeper cornea with the mean K was 43.69 D. in contrast to a study done by Weiqin Liu et al.[14] found that boys had higher corneal curvature than girls. Concerning the mean anterior chamber depth, a distinction was noted between the two genders, with males exhibiting deeper anterior chamber depths, as indicated in Table (2). This observation aligns with the findings of Hashemi et al.[15] who reported a male anterior chamber depth of 3.07 mm compared to 2.94 mm in females. We observed that the mean intraocular lens (IOL) power at the age of 4 to 8 years was 22.75 D, at the age of 9 to 12 years it was 21.47 D and at the age 13 to 17 years it was 21.33 D. BenEzra et al.[16]found that for the majority of youngsters older than two years, implanting a typical adult IOL of 21.00 D will be suitable in any situation. Regarding the CCT we found that male's central corneal thickness was higher than the females CCT and getting decreased with advance of age which was statistically significant as seen in Table (1). This change was compatible with the study done by Rauscher et al.[13]girls have statistically significantly thinner (10μm) corneas compared with boys.

Conclusion:

The existing dataset illustrates ocular biometric characteristics in pediatric individuals and their changes based on age and gender throughout a significant period of eye development.

Conflicts of interest:

The author reports no conflicts of interest.

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