ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

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The Assessment of Age-Related Changes in Anterior Segment Parameters Measured by Dual Scheimpflug Analyzer

Yaşla Beraber Ön Segment Parametrelerindeki Değişimin Dual Scheimpflug Topografi ile Değerlendirilmesi

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This study was presented as a poster at WOC 2018, World Ophthalmology Congress®, 16-19 June 2018, Barselona, Spain.

ABSTRACT Objective: The aim of this study was to investigate the changes according to age in anterior segment parameters measured by Galilei Dual Scheimpflug Analyzer. **Material and Methods:** Healthy subjects were recruited and classified into seven groups according to age. Group 1 consisted of subjects whose ages ranged between 5 and 10 years. Group 2, 3, 4, 5, 6, 7 consisted of subjects who were in their second, third, forth, fifth, sixth and seventh decades, respectively. After a detailed examination, anterior segment parameters were assessed by using Galilei Dual Scheimpflug Analyzer. The following parameters were obtained from topographic and pachymetric maps for analysis: anterior chamber angle (ACA), anterior chamber depth (ACD), anterior chamber volume (ACV), central corneal thickness (CCT), pupil diameter (PD) and corneal horizontal diameter (CHD). Statistical analysis was performed by using SPSS for Windows version 23.0. **Results:** The age of subjects ranged between 5 and 67 years. Of 229 subjects, 152 (66.4%) were female and 77 (33.6%) were male. The decrease in CCT, CHD, PD, ACD and ACA with age was statistically significant and a negative correlation was present (p=0.000). Except Group 1, the decline in ACV by increasing age was statistically significant and a negative correlation was present [r (458) =-0.34. p=0.000]. **Conclusion:** All anterior segment parameters except mean ACV measured by Galilei Dual Scheimpflug Analyzer were found to decline with age and mean ACD achieved to adult size till the beginning of the second decade.

Keywords: Dual scheimpflug analyzer; anterior segment parameters; age

ÖZET Amaç: Yaşla beraber ön segment parametrelerindeki değişimin Galilei Dual Scheimpflug Topografi ile değerlendirilmesi. **Gereç ve Yöntemler:** Çalışmaya sağlıklı denekler alınarak yaşlarına göre 7 gruba ayrıldı. Grup 1'deki deneklerin yaşları 5 ile 10 arasında idi. Grup 2, 3, 4, 5, 6 ve 7 ise yaşları sırasıyla ikinci, üçüncü, dördüncü, beşinci, altıncı ve yedinci on yıllarında olan deneklerden oluşturuldu. Detaylı göz muayenesinden sonra Galilei Dual Scheimpflug Topografi ile ön segment parametreleri değerlendirildi. Ön kamara açısı (ÖKA), ön kamara derinliği (ÖKD), ön kamara hacmi (ÖKH), merkezi kornea kalınlığı (MKK), pupilla çapı (PÇ) ve horizontal kornea çapı (KÇ) değerleri topografik ve pakimetrik haritalar incelenerek değerlendirildi. İstatistiksel analiz SPSS 23,0 programı ile yapıldı. **Bulgular:** Çalışmaya katılan 229 deneğin yaşları 5 ile 67 arasında değişmekte ve 152'si (%66,4) kadın, 77'si (%33,6) ise erkekti. Analiz sonucunda MKK, KÇ, PÇ, ÖKD ve ÖKA yaşla beraber azalmakta ve yaş ile bu değerler arasında istatistiksel olarak negatif korelasyon mevcuttu (p=0,000). ÖKH'de ise Grup 1 hariç diğer gruplar arasında yaşla beraber düşme olduğu gözlenmiş ve istatistiksel olarak negatif korelasyon bulunmuştur [r (458) =-0,34. p=0,000]. **Sonuç:** Galilei Dual Scheimpflug topografi ile ortalama ÖKH hariç tüm ön segment parametreleri yaşla birlikte azalmıştır. ÖKD'nin ikinci on yıldan itibaren erişkin boyutuna ulaştığı gözlenmiştir.

Anahtar Kelimeler: Dual scheimpflug topografi; ön segment parametreleri; yaş

Measurements of anterior segment parameters are very important clinical findings in diagnosis and assessment of corneal disease, contact lens evaluation, refractive status and glaucoma types. Simply, we know that mean central corneal thickness (CCT) affects intraocular pressure reading measured by Goldmann applanation tonometry. Anterior chamber angle (ACA) assessment is essential for the diagnosis of angle closure glaucoma. Besides, anterior chamber volume (ACV) and anterior chamber depth

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(ACD) are also essential findings for evaluation of glaucoma types and for cataract surgery.[1-5] Because of their importance, the measurements must be accurate.

Measurements of CCT, ACV and ACD can be done by using ultrasonic methods but these methods are cornea contact and may lead to superficial corneal lesions and transmission of infections.[6] Non-contact methods such as optical coherence tomography (OCT), Scheimpflug topography systems and slit scanning technologies have been used widely.[7-9] The Galilei Dual Scheimpflug Analyzer is one of the Scheimpflug topography system which is based on a revolving dual- channel Scheimpflug camera and a Placido disk. This device combines the advantages of two technologies: Placido imaging furnishes high-accuracy curvature data and Scheimpflug imaging is responsible for capturing precise elevation data. Galilei provides repeatable measurements of corneal curvature and of other anterior segment anatomical parameters such as topographic pachymetry, anterior chamber depth, volume and anterior segment diameter (angle-to-angle distance).[10]

Anterior segment parameters including CCT, ACV, ACD, ACA and CHD might be altered by age. This alteration can be important for evaluation of anterior segment diseases.[11] While, Hashmani et al. found decline with age in CCT measured by Scheimpflug Analyzer, Atchinson et al. did not find any alteration.[12,13] These studies did not include subjects under the age of 10 and the refractive status was variable.

The aim of this study was to investigate changes according to age in anterior segment parameters measured by Galilei Dual Scheimpflug Analyzer. While searching these changes, the earliest age group (5-10 years), standardized refractive state (<1 diopter spheric equivalent and < 1 diopter astigmatism) and relatively large sample sizes of subjects were the novelties of our study.

MATERIAL AND METHODS

This study was conducted at the Sakarya University, Department of Ophthalmology. Prior to the study, ethics committee approval was obtained from the Institutional Review Board of Sakarya University, no: 71522473/050.01.04/216) and written informed consent was obtained from each subject. The study was performed in adherence to the Declaration of Helsinki.

SUBJECTS

Subjects who were examined at Sakarya University, Ophthalmology Department and had minimal refractive error (<1 diopter spheric equivalent and < 1 diopter astigmatism) were recruited and classified into seven groups according to their ages. Two eyes of every subject were studied. Group 1 consisted of the subjects whose ages ranged between 5 and 10 years. Group 2, 3, 4, 5, 6, 7 consisted of the subjects who were in the second, third, forth, fifth, sixth and seventh decades, respectively. Subjects were chosen randomly. Detailed ophthalmologic examination including best corrected visual acuity measurement with a Snellen chart, intraocular pressure measurement by Goldmann Applanation tonometry, slit-lamp biomicroscopy and fundus observation by +90 diopter lens was performed for all patients. Subjects with any ocular diseases affecting the ocular surface, history of contact lens use within three months and any ocular surgery were not included in this study.

ANTERIOR SEGMENT EVALUATION

Anterior segment parameters were assessed by using the Galilei Dual Scheimpflug Analyzer (GALILEI Dual Scheimpflug Analyzer, Zeimer, Switzerland). Measurements were performed with undilated pupils under scotopic conditions by the same ophthalmologist (N.Ö.A.). Measurements were performed after ophthalmic examination except applanation tonometry. Intraocular pressure was measured after topography. Measurements with poor quality were excluded. The Galilei Dual Scheimpflug Analyzer specifies the quality of measurements. The measurements which met the quality check criteria of Galilei G4, were included in this study. The recommended values of criteria were; 85% motion compliance, 85% placido, 90% Scheimplug quality, 70% motion distance. The mean values of three measurements were used for statistical analysis. The following parameters were obtained from the topographic and pachymetric maps for analysis: anterior chamber angle, anterior chamber depth, anterior chamber volume, central corneal thickness, pupil diameter and corneal horizontal diameter.

STATISTICAL ANALYSIS

Statistical analysis was performed by using SPSS for Windows version 23.0 (SPSS Inc., Chicago, IL, USA). All data are reported as mean ± standard deviation. Normality distribution of variables was determined by the Kolmogorov-Smirnov test. Pearson test was used to detect the relationship between the variables.

Dependent variables were the meaning of anterior segment parameters CCT, CHD, ACV, ACD, PD, ACA. Anterior segment parameters in the age group effect were analyzed by using a one way ANOVA. Bonferroni corrected comparisons were used for multiple comparisons.

RESULTS

DEMOGRAPHIC CHARACTERISTICS OF THE SUBJECTS

This study included 458 eyes of 229 subjects. The age of subjects ranged between 5 and 67 years. Of 229 subjects, 152 (66.4%) were female and 77 (33.6%) were male. The mean ages of groups and gender distribution are presented in Table 1. Data were conformed with normal distribution according to Kolmogorov-Smirnov test. Table 1 revealed anterior segment parameters in all groups.

CORRELATION RESULTS OF ANTERIOR SEGMENT PARAMETERS

The highest mean central corneal thickness was 588.1±31.3 µ in Group 1 (age range 5-10 years). The decrease in central corneal thickness with increasing age was statistically significant and a negative correlation was present [r (458)=-0.21. p=0.000].

The mean corneal horizontal diameter decreased with age among groups. The decrease was statistically significant and a negative correlation was seen between age and mean corneal horizontal diameter [r (458)=-0.30, p=0.000].

The lowest mean pupil diameter was 2.6±0.4 mm in Group 7 (age range 61-67 years). The decline with increasing age was statistically significant and a negative correlation was present [r(458)=-0.18, p=0.000].

The mean anterior chamber volume of Group 7 (age range 61-67 years) was lowest between groups (93.6±21.3 mm^3). Except Group 1, the decline with increasing age in anterior chamber volume was statistically significant and a negative correlation was present [r (458)=-0.34, p=0.000].

The lowest mean anterior chamber depth was measured in Group 7 (2.5±0.2 mm) and the decrease with increasing age was statistically significant and a negative correlation was revealed [r (458)=-0.68, p=0.000].

The mean anterior chamber angle was found to be decreased with increasing age and a negative correlation was revealed [r (458)=-0.60, p=0.000].

Correlations are presented in Table 2.

ONE-WAY ANOVA TEST RESULTS OF ANTERIOR SEGMENT PARAMETERS

There were significant effects of age group on CCT (F (6, 451)=13.070, p<0.001, η^2=0.15) (Figure 1), on CHD (F (6, 451)=8.627, p<0.001, η^2=0.103) (Figure 2), on PD (F (6, 451)=22.709, p<0.001, η^2=0.23) (Figure 3), on ACV (F(6, 451)=23.757, p < 0.001, η^2 = 0.24) (Figure 4), on ACD (F (6, 451)=77.544, p < 0.001, η^2=0.51) (Figure 5) and on ACA (F (6, 450) = 57.111, p<0.001, η^2=0.432) (Figure 6).

DISCUSSION

In this study, the number of subjects in each group was similar and the subjects were chosen randomly as mentioned in the Method section. All data were in accordance with normal distribution due to Kolmogorov-Smirnov test. Furthermore, all measurements were performed by one ophthalmologist and under the same conditions.

The first parameter was mean central corneal thickness and a significant decrease with increasing age was found [r (458)=-0.21. p=0.000]. Hashmani et al. investigated this item by using Scheimpflug topography and also found the decline in central corneal thickness with age. The negative correlation was weak with a r-value of -0.058. Sample sizes of subjects in first, sixth and seventh decade were so small and could not be evaluated.[12] On the other hand, Atchison et al. found no significant correlation between central corneal thickness and age by using Scheimpflug topography.[13] In these studies, the age

TABLE 1: Demographic characteristics and distribution of anterior segment parameters of patients according to their ages.

Age (year)	Subjects (n)	Gender (n) Female/Male	CCT min-max	CHD min-max	PD min-max	ACV min-max	ACD min-max	ACA min-max
5-10 (Group 1)	30 (%13.1)	13/17	588.1±31.3 (531-658)	12.2±0.3 (11.7-12.9)	3.4±0.7 (2.5-4.9)	110.2±31.1 (67-180)	3.1±0.2 (2.7-3.5)	37.7±2.1 (33.7-43)
11-20 (Group 2)	36 (%15.7)	24/12	570.9±30.1 (488-622)	12±0.4 11.2-13.6)	3.5±0.6 (2.4-5.3)	133.9±21.8 (81-174)	3.2±0.2 (2.4-3.8)	37.2±2.9 (29.2-44.6)
21-30 (Group 3)	30 (%13.1)	23/7	549.8±31.2 (497-621)	12.2±0.4 11.1-13.2)	3.1±0.5 (2.4-4.6)	132.5±26.2 (90-190)	3.1±0.2 (2.6-3.7)	35.5±2.6 (31.1-41.9)
31-40 (Group 4)	30 (%13.1)	23/7	559±30.9 (492-608)	12.2±0.4 (11.2-13.3)	3.2±0.4 (2.5-4.2)	128.7±25.4 (72-179)	3±0.3 (2.3-3.5)	34.6±3.5 (27.5-40.6)
41-50 (Group 5)	41 (%17.9)	32/9	558.7±37.6 (488-650)	12±0.3 (10.8-13.3)	2.8±0.4 (2-4.2)	119.8±21.5 (71-162)	2.8±0.2 (2.1-3.5)	32.6±2.8 (25.8-38.3)
51-60 (Group 6)	33 (%14.4)	21/12	543.7±23.3 (494-615)	11.9±0.3 (11.2-12.6)	2.7±0.4 (2.1-3.7)	105.6±18.5 (71-144)	2.6±0.2 (1.9-3.3)	31±2.6 (26.6-37.8)
61-67 (Group 7)	29 (%12.7)	16/13	569.9±41.2 (492-642)	11.8±0.4 (11.1-13.3)	2.6±0.4 (2-4.7)	93.6±21.3 (68-135)	2.5±0.2 (2.1-3)	30.4±2.3 (24.8-35.4)
Total	229 (%100)	152/77	562.6±35.5 (488-658)	12±0.4 (10.8-13.3)	3±0.6 (2-5.3)	118.2±27.2 (67-190)	2.9±0.3 (1.9-3.8)	34.1±3.8 (24.8-44.6)

CCT: Central Corneal Thickness; CHD: Corneal Horizontal Diameter; PD: Pupil Diameter; ACV: Anterior Chamber Volume; ACA: Anterior Chamber Angle; ACD: Anterior Chamber Depth.

ranged between 10, 20 years and 70 years and refractive status was variable. In our study, subjects whose age ranged between 5-10 years were also evaluated and refractive status was limited. Hashmani et al. found that the astigmatic refractive error affected central corneal thickness.[12] The cylinder values were found to have a positive correlation with CCT, with a r-value of 0.154.

Studies carried out by using ultrasonic pachymetry were performed in the past.[14-16] In one of them, Prasad et al. also did not find any correlation with age.[14] The mean CCT was found to be 544±34 μ and the r- value was 0.00645. Altınok et al. found a slight negative correlation between age and CCT only in male subjects.[15]

In this study, a significant decrease of the mean corneal horizontal diameter with increasing age was found [r (458)=-0.30, p=0.000]. Jonnson et al. found no correlation between age and mean corneal horizontal diameter.[11] The mean corneal horizontal diameter was measured by slit-scan topography and some of the subjects had cataract, some of them had refractive errors and the range of age was between 22 and 85 years in that study.[11] According to this study; corneal horizontal diameter was found to be an important parameter especially in contact lens use and detailed studies should be done about the change in mean corneal horizontal diameter with age.

Age was found to be a factor affecting the pupil diameter [r (458)=-0.18, p=0.000]. Predictably, in older ages pupil diameter was found to be smaller in this study. Guillon et al. and Pi-Song Yan et al. also found this type of correlation in their studies.[17,18] But Guillon et al. found significant differences only in pre-presbyopes and established presbyopes (p=0.017).[17] Pupil diameter has an important role in visual performance in older ages. Therefore, especially in multifocal contact lens use for presbyopia, the change in pupil diameter with increasing age should be kept in mind.

The mean anterior chamber depth and anterior chamber volume were found to decline with age in this study. Jonnson et al., Atchinson et al. and Pi-Song Yan et al. found a similar decline, too.[11,13,18] In addition to these studies, we found lower mean anterior chamber depth values in subjects whose ages ranged between 5 and 10 years. In the second half of the first decade, mean anterior chamber depth tended to be lower and from the beginning of second decade, the mean anterior chamber depth was found to achieve adult sizes and then the decline started. These results might be important while a refractive surgery which includes phakic intraocular lens (pIOLs) implantation is performed for high ametropia. Advances in surgi-

TABLE 2: Pearson correlation test results of anterior segment parameters of groups.

	CCT		CHD		PD		ACV		ACD		ACA	
	r(458)	p	r(458)	p	r(458)	p	r(458)	p	r(458)	p	r(458)	p
Increase in age	-0.21	**0.000**	-0.30	**0.000**	-0.18	**0.000**	-0.34	**0.000**	-0.68	**0.000**	-0.60	**0.000**

CCT: Central Corneal Thickness; CHD: Corneal Horizontal Diameter; PD: Pupil Diameter; ACV: Anterior Chamber Volume; ACD: Anterior Chamber Depth; ACA: Anterior Chamber Angle.

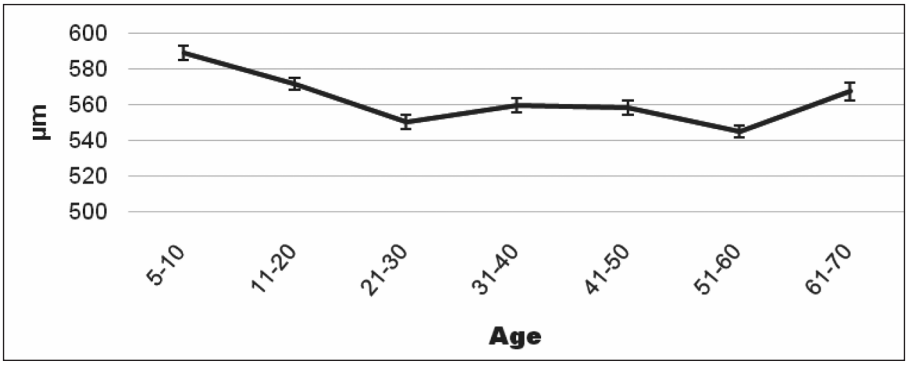

FIGURE 1: Relationship between Age and CCT (Central Corneal Thickness).

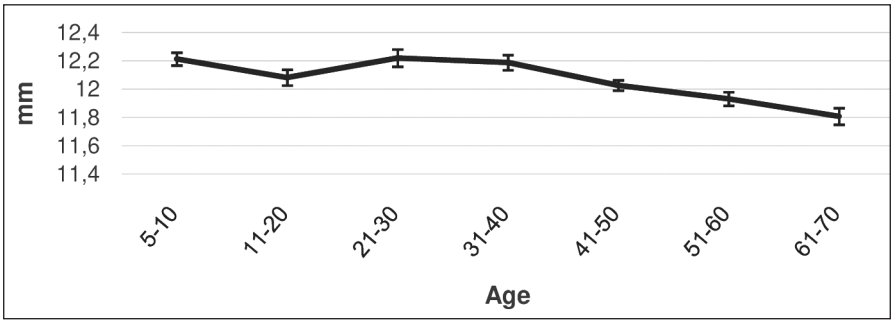

FIGURE 2: Relationship between Age and CHD (Corneal Horizontal Diameter).

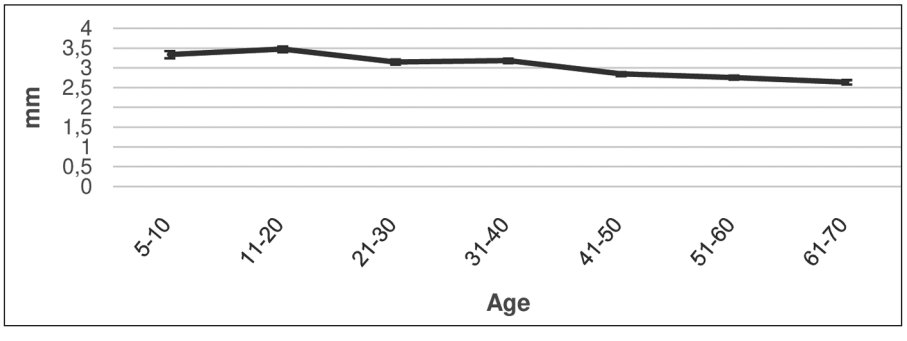

FIGURE 3: Relationship between Age and PD (Pupil Diameter).

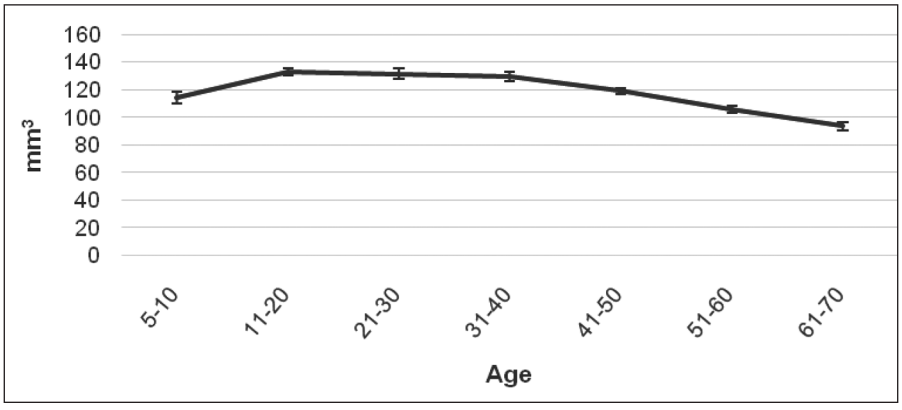

FIGURE 4: Relationship between Age and ACV (Anterior Chamber Volume).

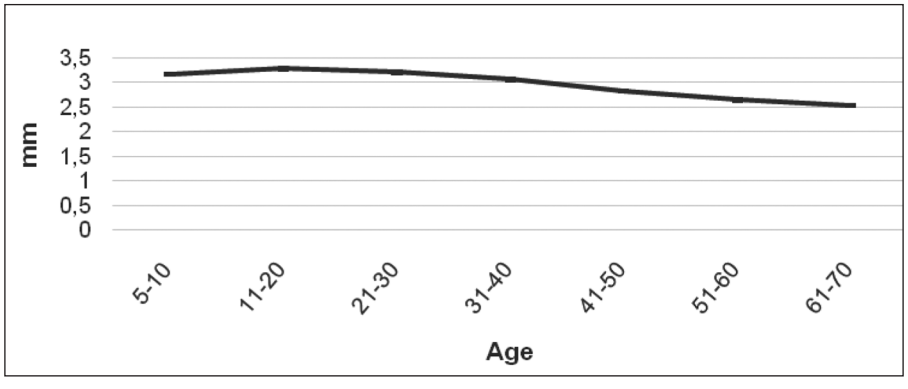

FIGURE 5: Relationship between Age and ACD (Anterior Chamber Depth).

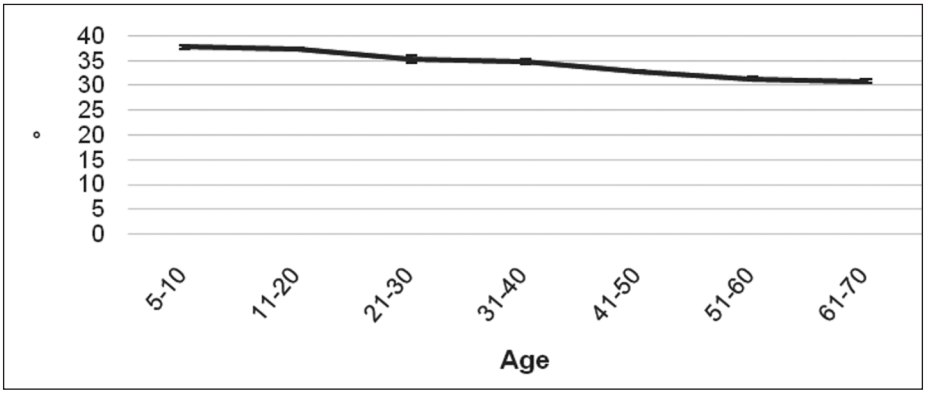

FIGURE 6: Relationship between Age and ACA (Anterior Chamber Angle).

cal techniques, fast visual recovery, preservation of accommodation and reversibility are the benefits of pIOLs implantation. Also, posterior chamber pIOLs have been accepted widely in recent years.[19-21] However, these changes with age should also be taken into consideration while performing cataract surgery.

Increasing risk of angle closure glaucoma with age has been already known. In this study, the decline in the mean anterior chamber angle of age was found [r (458) =-0.60, p=0.000]. Dalal et al. found that both nasal and temporal anterior chamber angles measured by anterior segment OCT decreased with age.[22] Oruçoğlu et al. also revealed narrower anterior chamber angle in older ages.[23] Both in glaucoma and in cataract surgery, decrease in the anterior chamber angle is important and can be measured totally by Galilei Dual Scheimpflug Analyzer.

The limitations of this study were distinct refractive states which did not allow to evaluate cylindrical changes with age and absence of peripheral corneal thickness values.

CONCLUSION

According to statistical Pearson correlation analysis, mean central corneal thickness, anterior chamber depth, anterior chamber angle, pupil diameter and corneal horizontal diameter were found to decline with age and mean anterior chamber depth achieved adult size by the beginning of the second decade of life. The Galilei Dual Scheimpflug Analyzer is non-invasive and a user-friendly instrument to evaluate the anterior segment and especially useful for quantitative examinations of the anterior chamber.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

***Idea/Concept:** Nilgün Özkan Aksoy; **Design:** Nilgün Özkan Aksoy, Burçin Çakır; **Control/Supervision:** Sedat Özmen, Gürsoy Alagöz; **Data Collection and/or Processing:** Nilgün Özkan Aksoy, Burçin Çakır, Sedat Özmen; **Analysis and/or Interpretation:** Nilgün Özkan Aksoy, Burçin Çakır; **Literature Review:** Burçin Çakır, Gürsoy Alagöz; **Writing the Article:** Nilgün Özkan Aksoy, Burçin Çakır; **Critical Review:** Gürsoy Alagöz; **References and Fundings:** Gürsoy Alalgöz.*

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