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Anterior chamber parameters in cataract surgery candidates from middle China

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Abstract

To determine the distribution of the anterior chamber parameters and associated factors in cataractous adults from middle China. In this cross-sectional study, axial length, anterior chamber depth (ACD) and lens thickness (LT) were measured with IOLMaster 700. The Pentacam HR was designed to measure the anterior chamber volume (ACV) and anterior chamber angle (ACA). Patients' data were collected and analyzed between 2020 and 2022. A total of 157 eyes of 157 Chinese adults (mean age: 64.43 ± 12.16 years) with a cataract were enrolled in this study. The mean values measured were as follows: axial length, 24.10 ± 2.44mm; ACD, 2.99 ± 0.52 mm; LT, 4.51 ± 0.48 mm; ACV, 113.98 ± 45.12 mm3; ACA, 32.33 ± 7.66 degrees. The ACD and ACV were statistically significantly greater in men than in women and had a decrease trend as age and LT increased. In the simulated linear equation of age with ACD and LT the absolute slope coefficients of equations were the same; however, the directions were opposite. The mean ACV was <100 mm^3 when the patients were over 60 years. In the multivariate regression analysis of ACD, ACV and ACA there was a reasonable prediction with adjusted R^2 = 0.878, 0.847 and 0.564, respectively. This study may provide normative data for cataract patients. The profile of anterior chamber can help improve the knowledge of the risk of angle closure in cataract candidates.

Abbreviations: ACA = anterior chamber angle, ACD = anterior chamber depth, ACV = anterior chamber volume, AL = axial length, CD = cornea diameter, Km = keratometer mean value, LT = lens thickness, PACG = primary angle closure glaucoma, PD = pupil diameter.

Keywords: anterior chamber angle, anterior chamber depth, anterior chamber volume, cataract, primary angle closure glaucoma

1. Introduction

Glaucoma is the leading cause of global irreversible blindness. The number of people with glaucoma worldwide is expected to increase to 111.8 millions in 2040, and the prevalence of primary angle closure glaucoma (PACG) was highest in Asians.[1] The mean prevalence for PACG worldwide in the population over age 40 was 0.69%, while that was 1.26% in China.[2] The visual damages of PACG are more severe than of the other main subtypes of glaucoma, presenting an even greater public health challenge with a considerable social and economic impact.[2,3] Therefore, early screen and detection are significant to treatment.

Numerous risk factors play a role in the development of PACG, including increasing age, female gender, shallow anterior chamber, short axial length of the eye in hyperopia, small corneal diameter, steep corneal curvature, shallow limbal chamber depth, and thick, anteriorly positioned lenses.[4] In adult cataractous eyes, lens thickness (LT) was directly proportionate to age.[5] On the other hand, LT is the main factor that affects anterior chamber depth (ACD).[6] Therefore, we should pay more attention to the anterior chamber parameters of adult cataract patients and be alert to the PACG. In routine clinical use, gonioscopy is the most common method to evaluate the anterior chamber angle, which is subjective and highly dependent on the examiner's judgement and experience. ultrasound biomicroscopy visualizes the shape of the angle but provide no specific values of ACD, anterior chamber volume (ACV) and anterior chamber angle (ACA) which need to be measured by the examiner. In addition, the contact check may cause discomfort to the subject. The Pentacam is a noncontact, highly repeatable device that scans the anterior eye segment and provides measurements promptly via a rotating Scheimpflug camera.[7] As a swept-source OCT-based optical biometry device, the IOLMaster 700

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

The retrospective study was performed in accordance with the World Medical Association Declaration of Helsinki. It was approved by the Ethics Committee of Aier Eye Hospital, approval number [HS2021IRBKY05]. Due to the retrospective nature of the study, the need for informed consent was waived.

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provides OCT imaging of the macula and visualizes the measurement of the axial length (AL) of the eye. The repeatability and reproducibility of the swept source optical biometer is excellent and its agreement with a standard biometer is very high; better lens penetration ability and more accurate AL measurements are obtained with the swept source biometer than with the standard biometer.[8]

The purpose of the study was to review the anterior chamber parameters by using the Pentacam and the IOLMaster 700 in adult cataractous eyes to assess the distribution of anterior chamber parameters and the associated factors.

2. Methods

In this cross-sectional study, the medical records of patients scheduled for cataract surgery from Aier Eye Hospital of Wuhan University, Hubei, middle China between June 2020 and August 2022 were reviewed and analyzed. To avoid data duplication only the eye of each patient scheduled for surgery were included. All patients signed an informed consent form. The retrospective study was approved by the Ethics Committee of Aier Eye Hospital and was performed in accordance with the Declaration of Helsinki.

The inclusion criteria were as follows: patients diagnosed with cataracts; patients who were 30 years or older; patients with good quality measurements with the IOLMaster 700 (Carl Zeiss Meditec AG, Jena, Germany) and Pentacam HR (Oculus Inc, Wetzlar, Germany). The exclusion criteria were as follows: patients who had complications with other eye diseases including corneal diseases, retinal diseases, glaucoma or inflammatory eye diseases; patients who had a history of trauma or ocular surgery; patients who had used drugs that affected anterior chamber depth and pupil diameter, such as atropine or pilocarpine eye drops.

AL, ACD and LT were measured with a noncontact swept-source optical biometer IOLMaster 700. We controlled the quality of the measurements according to the manufacturer instructions. All patients were tested by experienced examiners. The compound values of AL, ACD and LT are derived from the average of the 6 measurements. We selected measurements with a standard deviation of < 20 microns.

The Pentacam HR was designed to measure the keratometry values, cornea diameter (CD), pupil diameter (PD), apex corneal thickness, ACV and ACA. Corneal power is measured in 2 meridians: the greatest and least radii of curvature (K1, K2). Mean keratometry (Km) is the average of K1 and K2. The scans with an examination quality specification of "OK" by the Pentacam were retained for analysis.

Data were processed with the SPSS software version 21.0 (IBM, US). Mean, standard deviation, 95% confidence interval were used to describe the data. We stratified the parameters according to sex and age groups. The Independent Samples *t* test was used to compare the ocular parameters between males and females. The study participants were classified into 5 groups based on age (≤ 49 years, 50 to 59 years, 60 to 69 years, 70 to 79 years, ≥ 80 years). We conducted the association between age and other ocular parameters using Spearman's correlation. The scatter plots between age and ACD, LT were made to assess their relations. Multiple linear regression models were used to evaluate ACD, ACV and ACA. All *P* values were 2-sided and considered statistically significant when the values were < .05.

3. Results

A total of 157 eyes of 157 Chinese adults (mean age: 64.43 ± 12.16 years) with a cataract were enrolled in this study. The subjects comprised 64 (40.8%) males and 93 (59.2%) females. The mean values measured were as follows: AL, 24.10 ± 2.44mm; ACD, 2.99 ± 0.52 mm; LT, 4.51 ± 0.48 mm; ACV, 113.98 ± 45.12 mm^3; ACA, 32.33 ± 7.66 degrees; Km, 44.19 ± 1.65 D; CD, 11.32 ± 0.43 mm; PD, 2.72 ± 0.70 mm; apex corneal thickness, 543.85 ± 33.67 μm. The details of age and ocular biometric parameters are shown in Table 1. In this study population, the ACD was significantly deeper in men than in women (3.11 mm vs 2.91 mm, $P < .05$). The ACV was larger in men than in women (125.39 mm^3 vs 106.13 mm^3, $P < .05$). The Km was flatter in men than in women (43.66 D vs 44.55 D, $P < .05$). The CD was significantly wider in men than in women (11.46 mm vs 11.22 mm, $P < .05$).

According to Table 2, ACD, ACV and ACA decreased in a linear fashion with age before the age of 80 years. LT increased in a linear fashion with age after the age of 50 years. Figure 1 shows the trend of ACD and LT with increasing age. The slope coefficient of the simulated linear equation for ACD and age is 0.02. The slope coefficient of the simulated linear equation for LT and age is 0.02.

Pearson correlation analysis revealed that ACD, ACV and ACA were all significantly correlated with each other ($P < .001$). ACD correlated positively with AL ($R = 0.482$, $P < .001$), ACV ($R = 0.890$, $P < .001$), ACA ($R = 0.729$, $P < .001$), but negatively with age ($r = -0.401$, $P < .001$) and LT ($r = -0.722$, $P < .001$). ACV correlated positively with AL ($R = 0.586$, $P < .001$), ACD ($R = 0.890$, $P < .001$), ACA ($R = 0.678$, $P < .001$), but negatively with age ($r = -0.510$, $P < .001$) and LT ($r = -0.577$, $P < .001$). ACA correlated positively with AL ($R = 0.355$, $P < .001$), ACD ($R = 0.729$, $P < .001$), ACV ($R = 0.678$, $P < .001$), but negatively

Table 1

Age and ocular biometric parameters of the study sample.

	Total (n = 157)		Male (n = 64)		Female (n = 93)		*t* Test
Parameters	Mean	SD	Mean	SD	Mean	SD	*P*
Age (y)	64.43	12.16	63.43	12.72	65.10	11.79	.412
AL (mm)	24.10	2.44	24.47	2.32	23.84	2.49	.107
ACD (mm)	2.99	0.52	3.11	0.53	2.91	0.51	.021*
LT (mm)	4.51	0.48	4.52	0.52	4.51	0.44	.907
ACV (mm^3)	113.98	45.12	125.39	47.08	106.13	42.20	.008*
ACA (deg.)	32.33	7.66	33.26	7.84	31.68	7.51	.205
Km (D)	44.19	1.65	43.66	1.46	44.55	1.68	.001*
CD (mm)	11.32	0.43	11.46	0.40	11.22	0.42	<.001*
PD (mm)	2.72	0.70	2.65	0.50	2.77	0.80	.293
Apex CT (μm)	543.85	33.67	544.09	33.09	543.69	34.24	.941

Independent samples *t* test was used to investigate the difference between males and females.

ACA = anterior chamber angle, ACD = anterior chamber depth, ACV = anterior chamber volume, AL = axial length, Apex CT = apex corneal thickness, CD = cornea diameter, IOP = intraocular pressure, Km = keratometer mean value, LT = lens thickness, PD = pupil diameter.

Table 2

Mean and 95% confidence interval (CI) of anterior chamber parameters in different age groups.

		ACD (mm)		ACV (mm³)		ACA (deg.)		LT (mm)	
Age group (yr)	N	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
≤ 49	20	3.39	3.15–3.63	157.55	133.75–181.35	35.31	31.22–39.40	4.28	4.08–4.48
50–59	31	3.24	3.05–3.42	136.94	120.87–153.00	34.35	31.65–37.05	4.26	4.10–4.41
60–69	46	2.91	2.76–3.07	107.57	96.10–119.03	30.94	28.82–33.06	4.51	4.39–4.64
70–79	42	2.74	2.60–2.88	91.33	80.76–101.90	30.56	28.10–33.01	4.69	4.53–4.85
≥80	18	2.89	2.73–3.05	95.28	81.71–108.85	32.20	29.99–36.41	4.78	4.62–4.94

ACA = anterior chamber angle, ACD = anterior chamber depth, ACV = anterior chamber volume, CI = confidence interval, LT = lens thickness.

with age ($r = –0.186$, $P < .05$) and LT ($r = –0.520$, $P < .001$). The complete matrix of the correlation was presented in Table 3. We used a multiple linear regression model to evaluate the association of ACD, ACV and ACA with related parameters respectively. In the final model of ACD, which included ACV, LT, ACA and Km, there was a reasonable prediction with adjusted $R^2 = 0.878$ (shown in Table 4). In the final model of ACV, which included ACD, AL, age, LT and ACA, there was a reasonable prediction with adjusted $R^2 = 0.847$ (shown in Table 4). In the final model of ACA, which included ACD, PD and age, there was a reasonable prediction with adjusted $R^2 = 0.564$ (shown in Table 4).

4. Discussion

This study reported the 3 parameters of anterior chamber, ACD, ACV and ACA, in the adult cataract population in middle China by using the Pentacam and the IOLMaster 700 and analyzing the association factors. We created the multiple linear regression model to predict the 3 anterior chamber parameters. The results may be helpful for recognizing the risk of PAC in adult cataract patients.

In our study, the mean ACD was 2.99 ± 0.52 mm, which is almost identical to the published data from central China[9] (3.15 ± 0.48 mm), western China[10] (3.08 ± 0.47 mm) and southern China[11] (3.01 ± 0.57 mm). A closer look at Wang's[12] study shows that the ACD of Whites (3.28 ± 0.42 mm) is deeper than Asians (3.08 ± 0.43 mm) and Hispanics (3.06 ± 0.39 mm). These findings may have relevance as to the higher prevalence of PACG in Asia (1.09%) and Latin America (0.85%) than in Europe (0.42%) and North America (0.26%).[1] The ACD showed a trend of decrease with age, while the LT tended to be thicker with age in adult cataract patients (shown in Table 2). This is consistent with findings from other studies.[5,13] According to the simulated linear equation of age with ACD and LT, we found that the absolute slope coefficients of equations were the same; however, the directions were opposite (shown in Fig. 1). This result suggests that the magnitude of ACD and LT changes with age is similar, which may be explained by the lens thickening shifting the iris forward, making the anterior chamber shallower. Therefore, we assume that the anterior portion of lens increase contributes to the lens thickening. It is reported that the lens vault (LV), which represents the anterior portion of the lens, is a novel parameter independently associated with angle closure.[14] Eyes with angle closure have thicker lenses with greater LV compared with normal eyes.[15] These studies further confirmed the correlation between ACD and LT. In addition, the results of ACD correlation analysis suggest that women and patients with the shorter AL tend to have shallower ACD (shown in Table 1, 3), which is consist with findings in other studies.[10,11]

The mean ACV was 113.98 mm³ and it was larger in male subjects than in female subjects in the present study. Since there were few ACV data of adult cataract patients from Pentacam, it was difficult to compare with other data. In the Shahroud Eye Cohort Study the mean ACV was 139 mm³ which selected individuals from 40 to 64 years old without the ocular trauma and surgery.[16] Yang et al[17] reported that the mean ACV was 78 mm³ selecting clinical data of cataract patients with axial lengths between 22 mm and 24 mm and anterior chamber depths < 2.2 mm from Peking University International Hospital. In the cross-sectional study of normal Chinese children aged 6 to 18 years, the mean ACV was 194.89 mm³.[18] The ACV is a stereoscopic parameter to describe the anterior chamber which is from the 3-dimensional model using Pentacam. It was reported that eyes with ACV ≤ 100 mm³, ACD ≤ 2.1 mm, ACA ≤ 26 degrees may be considered at high risk for developing acute angle closure.[19] Thomas et al[20] has found that without treatment, 22% of primary angle closure suspect (PACS) eyes progress to primary angle closure (PAC) over a period of 5 years. Additionally, the 5-year incidence for progression from PAC to PACG was shown to be 28.5%.[21] In our study, the mean ACV was < 100 mm³ when the patients were over 60 years. Therefore, we should be alert to the possibility of angle closure in cataract patients over 60 years.

The mean ACA was 32.33 degrees in our study and 34.3 degrees in the north Iran, which was on a 40 to 64-year-old population-based study.[22] In another cross-sectional study from Beijing the ACA was 38.31 degrees which was measured by OCT.[23] Different participants and measurement devices may be the reasons for the data differences. Compared with gonioscopy, Pentacam as an noncontact morphometry with anterior chamber tomography has high accuracy in measuring the ACV and ACA, with a sensitivity of more than 50% and a specificity of 100%,[24] which can help to classify the potential risk for angle closure glaucoma.[25] The mean ACA were greater in men than in women, but there was no statistically significant difference. We found a significant relationship between ACD, ACV and ACA. Therefore, the factors such as the age, AL and LT related to ACD are similar to those related to ACV and ACA (shown in Table 3).

Our study has limitations. First, the records drawn from the cataract candidates in our hospital do not completely represent the ocular anterior chamber characteristics of general population in middle China. Second, the number of cases in each age group is relatively small. Moreover, we should collect more cases and analyze the data by dividing the subjects into different AL groups.

In summary, our study is the first study exploring ACD, ACV and ACA of adult cataract candidates using the Pentacam and IOLMaster 700. The results showed the ACD, ACV and ACA decrease with age and LT increasing. The amplitudes of ACD and LT changes with age are the same, but the directions are opposite. It is statistically significant that men have greater ACD and ACV than women. The mean ACV was < 100 mm³ when the patients were over 60 years. The profile of anterior chamber in cataract candidates can help improve the knowledge of the risk of angle closure.

Author contributions

Conceptualization: Yiqiao Xing.
Data curation: Qiong Lei, Danmin Cao, Jun Hu, Wanping Zhang.

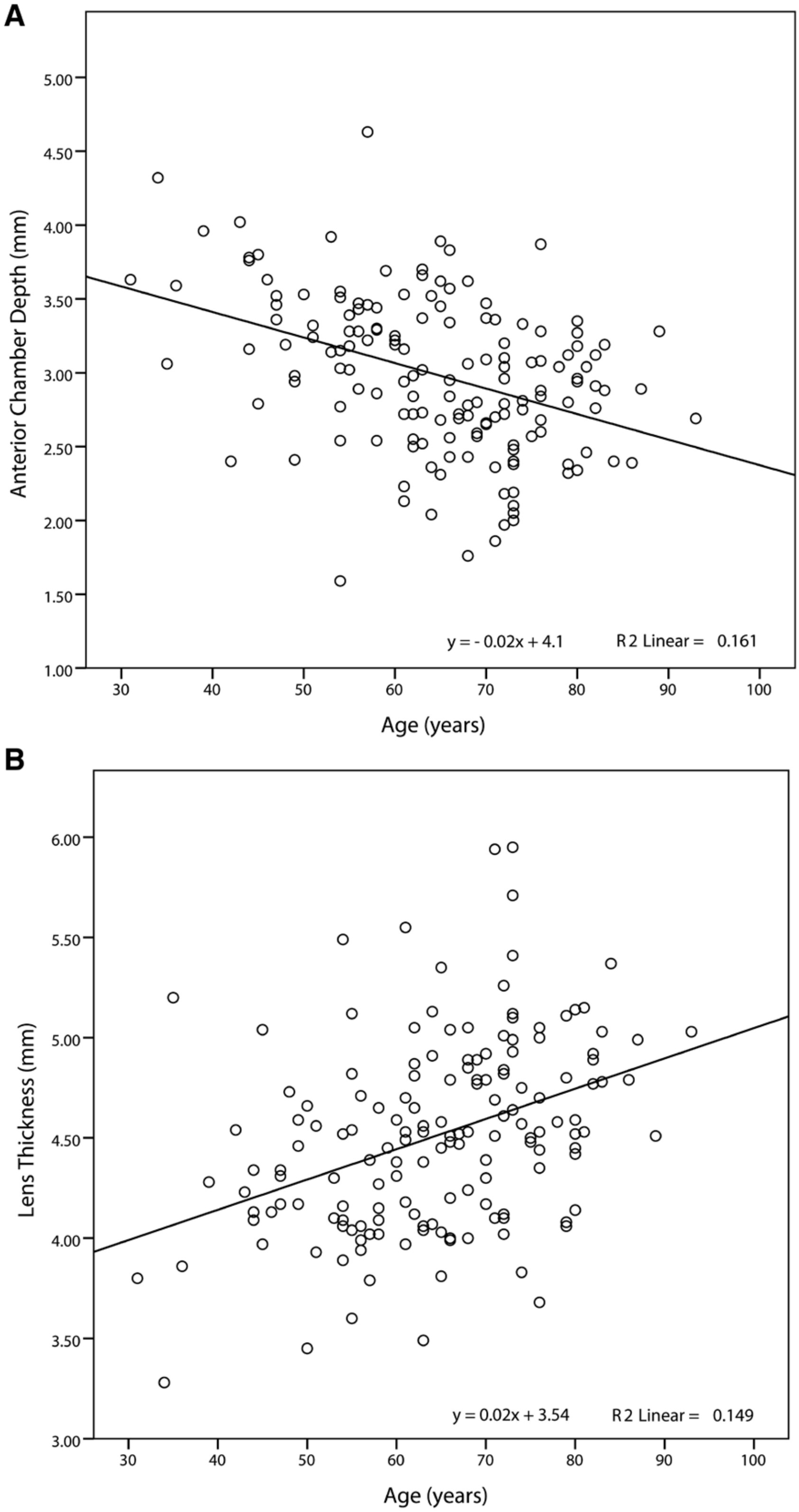

Figure 1. Correlation of age with anterior chamber depth or lens thickness. (A) Anterior chamber depth decreased with age. The slope coefficient of the simulated linear equation is 0.02. (B) Lens thickness increased with age. The slope coefficient of the simulated linear equation is 0.02.

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Writing – original draft: Qiong Lei.
Writing – review & editing: Yong Wang, Hezheng Zhou, Yiqiao Xing.

Table 3

Correlation between ACD, ACV, ACA and other parameters.

Pearson correlation		Age	AL	ACD	ACV	ACA	LT	Km
ACD	*r*	–0.401**	0.482**	1	0.890**	0.729**	–0.722**	–0.017
	P	<.001	<.001		<.001	<.001	<.001	.830
ACV	*r*	–0.510**	0.586**	0.890**	1	0.678**	–0.577**	–0.154
	P	<.001	<.001	<.001		<.001	<.001	.054
ACA	*r*	–0.186*	0.355**	0.729**	0.678**	1	–0.520**	0.006
	P	.020	<.001	<.001	<.001		<.001	.944

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
ACA = anterior chamber angle, ACD = anterior chamber depth, ACV = anterior chamber volume, AL = axial length, Km = keratometer mean value, LT = lens thickness.

Table 4

Multiple linear regression analysis of the associations between ACD, ACV, ACA and Its determinants.

Parameters	Factors	Unstandardized coefficients	Standardized coefficients	*P*	Adjusted R^2
ACD	(Constant)	1.870		<.001	0.878
	ACV	0.008	0.693	<.001	
	LT	–0.316	–0.288	<.001	
	ACA	0.008	0.124	.003	
	Km	0.026	0.080	.006	
	Age	0.003	0.080	.021	
ACV	(Constant)	–171.361		<.001	0.847
	ACD	65.995	0.766	<.001	
	AL	2.519	0.136	.001	
	Age	–0.674	–0.182	<.001	
	LT	11.483	0.121	.014	
	ACA	0.589	0.100	.033	
ACA	(Constant)	–10.817		.013	0.564
	ACD	10.920	0.747	<.001	
	PD	1.851	0.168	.002	
	Age	0.085	0.135	.021	

ACA = anterior chamber angle, ACD = anterior chamber depth, ACV = anterior chamber volume, AL = axial length, Km = keratometer mean value, LT = lens thickness, PD = pupil diameter.

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