Distribution of Anterior Chamber Angle Width and Correlation With Age, Refraction, and Anterior Chamber Depth—The Gutenberg Health Study

Alexander K. Schuster,[1] Norbert Pfeiffer,[1] Stefan Nickels,[1] Andreas Schulz,[2] René Höhn,[1,3] Philipp S. Wild,[2,4,5] Harald Binder,[6] Thomas Münzel,[5,7] Manfred E. Beutel,[8] and Urs Vossmerbaeumer[1]

[1]Department of Ophthalmology, University Medical Center Mainz, Mainz, Germany
[2]Preventive Cardiology and Preventive Medicine, Center for Cardiology, University Medical Center of the Johannes Gutenberg-University Mainz, Mainz, Germany
[3]Department of Ophthalmology, University Hospital of Bern, Bern, Switzerland
[4]Center for Thrombosis and Hemostasis, University Medical Center of the Johannes Gutenberg-University Mainz, Mainz, Germany
[5]DZHK (German Center for Cardiovascular Research), Partner Site Rhine-Main, Mainz, Germany
[6]Department of Biomedical Statistics, University Medical Center of the Johannes Gutenberg-University Mainz, Mainz, Germany
[7]Center for Cardiology, University Medical Center of the Johannes Gutenberg-University Mainz, Mainz, Germany
[8]Department of Psychosomatic Medicine and Psychotherapy, University Medical Center Mainz, Mainz, Germany

Correspondence: Alexander K. Schuster, Department of Ophthalmology, University Medical Center Mainz, Langenbeckstr. 1, 55131 Mainz, Germany; alexander.k.schuster@gmx.de.

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Purpose. Scheimpflug imaging allows quantitative analysis of the width of the anterior chamber angle. We report the population-based distribution of the anterior chamber angle width using this noncontact imaging technique and investigate associated factors.

Methods. A population-based cross-sectional study was carried out in Germany. A comprehensive ophthalmologic examination including refraction, biometry, and Scheimpflug imaging was performed. Automated measurement of the anterior chamber angle was performed in each anterior chamber quadrant. Exclusion criteria were previous ocular surgery or inadequate image quality. Association analyses were carried out to determine independently associated systemic and ocular factors for anterior chamber angle width using a generalized estimating equation model.

Results. A total of 3014 subjects (48% female) with a mean age of 58.6 ± 10.4 years were included in this study. The mean anterior chamber angle width was 32.6° ± 5.5°. Statistical analysis revealed an independent association between a smaller anterior chamber angle and female sex, higher age, and more hyperopic refraction. When including biometric parameters, shallow anterior chamber depth, shorter axial length, higher central corneal thickness, and lower corneal power were independently associated with a narrower mean anterior chamber angle width.

Conclusions. These parameters are considered risk factors for angle-closure glaucoma.

Keywords: Scheimpflug photography, epidemiology, anterior chamber angle, refraction, anterior chamber depth

Anterior chamber angle and depth have been identified as an important risk factor for angle-closure glaucoma[1] and progression of open-angle glaucoma.[2] For almost a century, gonioscopy has been used to semiquantitatively analyze anterior chamber angle width.[3–5] More recently, quantitative imaging modalities including ultrasound biomicroscopy, optical coherence tomography, and Scheimpflug imaging have been developed.[6–8] In contrast to ultrasound biomicroscopy, optical coherence tomography and Scheimpflug imaging offer noncontact imaging of the anterior segment and make these methods attractive for patients and doctors alike.[9]

To interpret measurements from Scheimpflug imaging and to integrate the results into a clinical context, it is important to know the distribution of anterior chamber angle width and to understand associations with clinical factors. The underlying idea is that a narrower anterior chamber angle width is associated with clinically suspicious risk factors for acute angle closure, namely female sex, older age, hyperopic refraction, shorter axial length, and thicker crystalline lens.

Hence, the focus of this study is to derive normative values of the anterior chamber angle width. Using Scheimpflug imaging we investigate, for the first time, correlations between anterior chamber angle width and systemic and ocular parameters in a very large population-based setting.

Materials and Methods

The Gutenberg Health Study (GHS) is a prospective, population-based, observational cohort study conducted in the Rhine-Main region in midwestern Germany. A study sample of 15,000 intended participants was drawn in waves of equal stratification to meet a standardized recruiting and to allow defined subsample

analyses after inclusion of 5000 participants. More details of the study design have been described by Höhn et al.[10] For each participant a comprehensive ophthalmologic workup was conducted. Objective refraction (Humphrey Automated Refractor/Keratometer [HARK] 599; Carl Zeiss Meditec AG, Jena, Germany), biometry (Lenstar LS900; Haag-Streit Diagnostics, Koeniz, Switzerland), and anterior segment Scheimpflug imaging (Pentacam; Oculus, Wetzlar, Germany) took place under mesopic light conditions. Examinations were performed by experienced study nurses in accordance with standardized operation procedures. Noncontact tonometry (Nidek NT-2000; Nidek Co, Gamagori, Japan) was performed and repeated three times.

This study was approved by the ethics committee (Ethics Commission of the State Chamber of Physicians of Rhineland-Palatinate). In accordance with the tenets of the Declaration of Helsinki, written informed consent was obtained from all participants prior to entering the study. The GHS is a joint project of internal medicine, ophthalmology, and epidemiology at the Johannes Gutenberg-University Mainz, Germany.

Study Sample

This study sample was recruited from the 5-year follow-up of the GHS cohort including subjects with an age of 40 to 79 years at the time of examination. A total of 4181 subjects came for the follow-up examination of the first third of the total study population. The characteristics of the study sample have been described in detail elsewhere.[10]

Exclusion Criteria

Participants with previous ocular surgery were excluded from this study analysis. We included all other eyes.

Data and Statistical Analysis

Anterior chamber angle (ACA) was automatically measured using the integrated software of the Scheimpflug imaging device (Pentacam, v1.20r41; Oculus) for each quadrant and the mean of the quadrant measurements. Only Scheimpflug images with high quality (Pentacam quality status 0 or 1) were included; all other Scheimpflug measurements were excluded. A plausibility check was performed for all extreme values (ACA $< 15°$ and ACA $> 60°$). Additionally, centration of the Scheimpflug imaging on the central cornea and opening of the eyelids were checked. Central corneal thickness, corneal power, anterior chamber depth, lens thickness, and axial length were measured with Lenstar LS900 (Haag-Streit Diagnostics). Refraction (Humphrey Automated Refractor/Keratometer [HARK] 599) was included as spherical equivalent in the analysis.

Data were processed by statistical analysis software (version 3.1.1; http://www.R-project.org/, provide in the public domain by R Core Team, Vienna, Austria.) Median, interquantile range, minimum, and maximum were calculated for all variables. Variables found to be within normal distribution mean and standard deviation were computed. Spearman rank correlation coefficients were computed comparing right to left eyes with all primary and secondary variables.

Distribution of the ACA width was evaluated using an age- and sex-weighted calculation for the Rhine-Main region in southwestern Germany. To prevent oversampling of older subjects, our study population was drawn equally from males and females and stratified into 10-year age groups. Associated factors were evaluated using a generalized estimating equation model with consideration of the correlation structure between both eyes of the subjects.

We performed a three-step analysis. In the first model we examined associations with anthropometric parameters and evaluated general associations without specific consideration of ocular biometry. In the second model, sex, age, height, weight, smoking, spherical equivalent, and intraocular pressure were included as independent variables; and in the third model, biometric characteristics of the eye and the intraocular pressure were included as well. The independent variables in this model were sex, age, height, weight, smoking, central corneal thickness, intraocular pressure, corneal power of the steep meridian, anterior chamber depth, lens thickness, and axial length. Variation inflation factors (VIF) were calculated to investigate multicollinearity in our model.

Correlation analysis (Pearson) was conducted to investigate associations between anterior chamber depth, lens thickness, and age as possible interacting parameters.

This study was performed as an explorative study to analyze distribution and associations with ACA width. All P values should be regarded as a continuous parameter that reflects the level of evidence and are therefore reported exactly.

Results

We included 5744 eyes of 3014 subjects with a mean age of 58.6 ± 10.4 years (range, 40–79 years) after excluding 570 eyes of 285 subjects due to prior intraocular surgery and 498 eyes of 447 subjects due to inadequate image quality as defined above. Details of the systemic and ocular characteristics of the study population are shown in Table 1.

Measurement of the ACA width was possible in 5519 eyes for the temporal quadrant, 5743 for the inferior quadrant, and 5682 for the nasal quadrant. In the superior quadrant measurements could be performed in only 5102 eyes, mainly because the upper lid covered the cornea. Mean ACA was 32.6° ± 5.5° with a range from 15.0° to 52.8° (Fig.). There was no eye with an angle closure when Scheimpflug images were analyzed.

Correlation analysis revealed highly significant correlations between the different quadrants with correlation coefficients between 0.45 and 0.50 comparing the upper quadrant with the other quadrants ($P < 0.001$) and 0.75 and 0.85 between the other quadrants ($P < 0.001$). Comparing right to left eyes ACA width was highly significantly correlated in all measurement positions ($P < 0.001$), showing a correlation coefficient of 0.60 in the superior, 0.83 in the nasal, 0.82 in the temporal, and 0.76 in the inferior quadrant.

Associated factors with the ACA width were examined by a generalized estimating equation model. The first model using sex, age, height, weight, and smoking status as independent variables showed sex, age, and smoking status as associated factors. The measurement of the angle revealed a 1° smaller ACA in women compared to men. Older and shorter persons had a slightly narrower ACA. Each decade of age was associated with a 1° narrower ACA. Smoking was associated with a narrower chamber angle, too (Table 2).

The second analysis model, including anthropometric characteristics and general ocular characteristics, namely, intraocular pressure and refraction (spherical equivalent), showed the same associated factors as in model 1. Additionally, a more hyperopic refraction was associated with a narrower ACA (Table 3).

The third analysis also included biometrics of the eye. It revealed that a deeper anterior chamber depth, longer axial length, higher corneal power, and intraocular pressure were associated with a wider ACA. A thicker central cornea, female sex, and older age were associated with a narrower angle. There was no common association with body height, body weight, smoking status, and crystalline lens thickness in this multivariable model (Table 4). Variation inflation factors for all

Table 1. Characteristics of the Study Sample, Mean ± Standard Deviation, Total Cohort and Separated by Sex; Corneal Astigmatism Described as Median and 25%/75% Quantiles

Variable	All, 3014	Men, 1554	Women, 1460
Sex, women	48.4%		
Age, y	58.6 ± 10.4	59.1 ± 10.5	58.1 ± 10.3
Smoking, yes	16.0%	16.3%	15.7%
Body mass index, kg/m^2	27.6 ± 4.8	28.0 ± 4.2	27.0 ± 5.4
Height, m	1.71 ± 0.10	1.77 ± 0.07	1.64 ± 0.07
Weight, kg	80.3 ± 16.3	87.8 ± 14.2	72.2 ± 14.5
Systemic medication			
Antihypertensives, ATC C02	1.0%	1.2%	0.8%
Diuretics, ATC C03	5.4%	6.1%	4.6%
Beta-blockers, ATC C07	17.9%	18.8%	16.9%
Calcium channel blocker, ATC C08	9.1%	11.3%	6.7%
ACE inhibitors, ATC C09	29.2%	33.1%	25.0%
Lipid-modifying agents, ATC C10	15.0%	17.0%	12.9%
Ophthalmology			
Diseases, % of eyes			
Glaucoma*	3.5	3.0	4.0
Age-related macular degeneration*	1.5	1.6	1.4
Corneal disease†	3.8	5.1	2.5
Pseudoexfoliation†	0.4	0.3	0.5
Cataract†	18.2	18.7	17.7
Eye medication			
Sympathomimetics, ATC S01EA	0.4%	0.2%	0.5%
Parasympathomimetics, ATC S01EB	0.1%	0.1%	0.1%
Carbonic anhydrase inhibitors, ATC S01EC	0.2%	0.1%	0.4%
Beta-blocking agents, ATC S01ED	1.3%	1.1%	1.6%
Prostaglandin analogues, ATC S01EE	0.9%	0.9%	0.8%
Ocular parameters			
Right eyes			
Intraocular pressure, mm Hg	14.9 ± 2.92	14.5 ± 2.98	14.8 ± 2.86
Central corneal thickness, μm	549 ± 34	552 ± 34	546 ± 35
Spherical equivalent, dpt	−0.42 ± 2.54	−0.45 ± 2.58	−0.38 ± 2.49
Sphere, dpt	−0.12 ± 2.50	−0.13 ± 2.56	−0.12 ± 2.44
Astigmatism, dpt	−0.59 ± 0.65	−0.64 ± 0.71	−0.53 ± 0.57
Anterior chamber depth, mm	2.72 ± 0.39	2.77 ± 0.39	2.66 ± 0.38
Axial length, mm	23.7 ± 1.3	24.0 ± 1.2	23.4 ± 1.2
Lens thickness, mm	4.37 ± 0.36	4.38 ± 0.38	4.36 ± 0.35
Corneal power, dpt	44.0 ± 1.6	43.6 ± 1.6	44.4 ± 1.5
Corneal astigmatism, dpt	−0.74 (−1.13/−0.44)	−0.67 (−1.06/−0.41)	−0.81 (−1.21/−0.48)
Left eyes			
Intraocular pressure, mm Hg	15.0 ± 2.96	15.2 ± 2.96	14.9 ± 2.94
Central corneal thickness, μm	550 ± 34	552 ± 34	547 ± 34
Spherical equivalent, dpt	−0.43 ± 2.57	−0.48 ± 2.60	−0.37 ± 2.55
Sphere, dpt	−0.14 ± 2.53	−0.17 ± 2.56	−0.11 ± 2.50
Astigmatism, dpt	−0.57 ± 0.60	−0.62 ± 0.64	−0.52 ± 0.56
Anterior chamber depth, mm	2.71 ± 0.41	2.76 ± 0.41	2.66 ± 0.40
Axial length, mm	23.7 ± 1.3	24.0 ± 1.3	23.4 ± 1.2
Lens thickness, mm	4.42 ± 0.36	4.44 ± 0.37	4.41 ± 0.34
Corneal power, dpt	44.0 ± 1.6	43.6 ± 1.6	44.4 ± 1.5
Corneal astigmatism, dpt	−0.74 (−1.12/−0.44)	−0.69 (−1.00/−0.44)	−0.80 (−1.20/−0.48)
Anterior chamber angle, ACA, °			
Right eyes			
ACA superior	28.0 ± 7.3	28.3 ± 7.1	27.7 ± 7.5
ACA inferior	31.9 ± 5.9	32.2 ± 5.8	31.5 ± 6.0
ACA nasal	35.8 ± 6.8	36.5 ± 6.8	35.0 ± 6.7
ACA temporal	34.1 ± 6.9	34.9 ± 6.8	33.2 ± 6.8
ACA mean	32.4 ± 5.5	33.0 ± 5.4	31.8 ± 5.6

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Table 1. Continued

Variable	All, 3014	Men, 1554	Women, 1460
Left eyes			
ACA superior	28.8 ± 7.9	28.9 ± 7.4	28.7 ± 8.4
ACA inferior	31.8 ± 5.8	32.2 ± 5.8	31.4 ± 5.7
ACA nasal	36.1 ± 7.0	36.7 ± 7.0	35.3 ± 6.9
ACA temporal	33.5 ± 6.8	34.4 ± 6.8	32.6 ± 6.7
ACA mean	32.5 ± 5.6	33.1 ± 5.4	31.9 ± 5.6

* Self-reported.
† As examined by slit-lamp examination; systemic and local medication is reported according to the ATC code of its components.

variables were below 3, indicating that there is no clear evidence for multicollinearity.

Correlation analysis revealed that anterior chamber depth was highly correlated with lens thickness ($r = -0.54$, $P < 0.001$), while correlation with age was low (Pearson correlation coefficient $r = -0.16$, $P < 0.05$). Lens thickness was highly correlated with age ($r = 0.50$, $P < 0.001$).

Statistical analysis of the ACA width in each quadrant showed associations similar to those reported for the mean width of the ACA for model 1 and model 2, while in model 3 there were some differences with respect to the quadrant being analyzed (Table 5).

Discussion

This is the first study to analyze the distribution of the ACA width in a population-based setting and to evaluate systemic and ocular associations. We found a mean ACA width as measured with Scheimpflug imaging of 32.6° with a range from 15.0° to 52.8°. Previous studies reported similar values for the ACA width using Scheimpflug imaging in a smaller cohort[11] and optical coherence tomography.[8,11,12]

When analyzing anthropometric and ocular parameters (refraction, intraocular pressure), the model showed female sex, higher age, and smoking as independent factors associated with a narrower ACA width. Myopic refraction was associated with a wider ACA. Findings for age and sex were concordant with the literature, showing a narrower ACA in women[7] and in persons of higher age.[6,13] Likewise, hyperopic refraction has been described as a risk factor for angle-closure glaucoma.[14,15] However, several other studies incorporating ocular parameters (e.g., axial length) in their statistical models were not able to confirm this association.[16–20] Nevertheless, the goodness of fit for our model was low, and its measurement corresponds to $r^2 = 0.13$ in the unilateral analysis, meaning that only 13% of the variance of ACA width is explained by these factors.

In the third analytical model, associations of biometric parameters of the eye were independently assessed. The ACA was independently associated with a shallower anterior chamber, as previously reported by other groups.[21,22] This was similar to observations in patients with angle-closure glaucoma, who tend to have a shallower anterior chamber and a thicker crystalline lens.[23] It should be kept in mind that what is termed anterior chamber depth is in fact the measurement of a single point measurement of the optical axis. Interestingly, lens thickness was not associated with ACA when anterior chamber depth was included in our statistical model. Therefore a thicker lens seems not to have an effect on ACA width independently of the reduction of anterior chamber depth. Further univariable investigations showed that lens thickness is correlated with age and inversely with anterior chamber depth, while anterior chamber depth was marginally associated with age. Sensitivity analysis revealed that the correlation of anterior chamber depth and lens thickness was age independent and there was no evidence for effect modification by age. This indicates that an age-related increase of lens thickness leads to a shallower anterior chamber and consequently to a narrower ACA.

Additionally, a shorter axial length was independently associated with a narrower ACA, but the decrease of 1 mm of axial length was related to only a 0.1° narrower ACA. This finding is consistent with the reported relationship between shorter axial length and angle-closure glaucoma.[14,17,20]

Corneal shape was also linked to ACA width. A flatter cornea was associated with a narrower ACA, as expected, since the peripheral cornea forms the anterior part of the angle. Second, a thicker central cornea was associated with a narrower ACA. This is in concordance with a report in Chinese showing an independent negative association with the ACA and central corneal thickness.[12]

In the unilateral analysis of the third model, which included the biometric parameters, there was an excellent correlation with an $r^2 = 0.58$. This means that 58% of the variance was explained by this model. The main factor was anterior chamber depth.

Table 2. Associations of Mean Anterior Chamber Angle and Anthropometric Characteristics in the Gutenberg Health Study Calculated With a Generalized Estimating Equations Model to Control for Correlations Between Right and Left Eyes

	Estimate	95% CI	*P* Value
Sex, female	−0.96	−1.43, −0.48	<0.0001
Age, y	−0.10	−0.12, −0.08	<0.0001
Height, m	3.01	0.35, 5.67	0.027
Weight, kg	0.00	−0.01, 0.01	0.96
Smoking	−1.06	−1.48, −0.63	<0.0001

CI, confidence interval.

Table 3. Associations of Mean Anterior Chamber Angle and Anthropometric Characteristics and Intraocular Pressure (IOP) and Refraction in the Gutenberg Health Study Using a Generalized Estimating Equations Model to Incorporate Correlations Between Right and Left Eyes

	Estimate	95% CI	*P* Value
Sex, female	−1.03	−1.50, −0.56	<0.0001
Age, y	−0.06	−0.08, −0.04	<0.0001
Height, m	1.79	−0.84, 4.44	0.18
Weight, kg	0.00	−0.01, 0.01	0.95
Smoking	−0.97	−1.38, −0.56	<0.0001
IOP, mm Hg	−0.06	−0.11, 0.00	0.051
Spherical equivalent, dpt	−0.63	−0.71, −0.55	<0.0001

CI, confidence interval; dpt, diopters.

Table 4. Associations of Mean Anterior Chamber Angle and Anthropometric and Ocular Characteristics Including Ocular Geometric Parameters in the Gutenberg Health Study; We Used a Generalized Estimating Equations Model to Consider Correlations Between Right and Left Eyes in Our Statistical Model

	Estimate	95% CI	*P* Value
Sex	−0.39	−0.70, −0.08	0.014
Age, y	−0.05	−0.07, −0.04	<0.0001
Height, m	−0.39	−2.18, 1.40	0.67
Weight, kg	0.00	−0.01, 0.01	0.98
Smoking	−0.24	−0.53, 0.05	0.11
IOP, mm Hg	0.05	0.00, 0.09	0.039
Anterior chamber depth, mm	10.6	10.2, 11.1	<0.0001
Axial length, mm	0.15	0.03, 0.28	0.014
Lens thickness, mm	0.19	−0.23, 0.60	0.37
Corneal power, dpt	0.30	0.21, 0.39	<0.0001
CCT, μm	−0.009	−0.013, −0.005	<0.0001

CI, confidence interval; dpt, diopters; CCT, central corneal thickness.

Presumably, genetic variations between Caucasians and Asians contribute to different ocular geometry and its relation to angle-closure glaucoma.[24] In Asians, almost one-quarter of angle-closure patients are myopic,[25] while in a multiethnic population, patients with angle-closure were far more hyperopic.[15]

There are methodological limitations to the study: Imaging the ACA using Scheimpflug imaging technology did not allow the visualization of the superior ACA because the lid covered the superior cornea in approximately 15% of the cases. To make up for this limitation we performed a sensitivity analysis for all quadrants separately and found some differences. Especially for intraocular pressure, the results varied and only the nasal sector showed moderate evidence for an association, while the other sectors showed low (inferior) to none (superior and temporal). In addition, intraocular pressure did not show clear evidence of an association to ACA width when biometric factors were not taken into account. For all quadrants, associations of ACA width with age, anterior chamber depth, and corneal power were similar and showed strong evidence for an association. Central corneal thickness was not associated in the superior quadrant, but otherwise strong evidence was present for an association. We performed a sensitivity analysis to assess the effect of corneal diseases, glaucoma, and cataract on ACA width. None of these diseases were associated with ACA width independently of the variables in model 3. Also, we were not able to adjust for the potential influence of the pupil diameter on the ACA width under different lighting conditions. Imaging of the anterior segment was performed under mesopic lighting conditions without dilation of the pupil. Furthermore, we did not measure objective refraction under cycloplegic conditions; therefore findings regarding hyperopia might be underestimated. Also, accommodation might have influenced our results on lens thickness. However, our study cohort had an age range from 40 to 79 years. In the older age groups, accommodation is limited. Also, we reported a cross-sectional analysis of associations with ACA and did not refer to actual changes over time. A critical look should always be taken at the measurement method for the determination of the ACA width. We used the built-in measurement tool and performed a plausibility check for inappropriate values. The built-in measurement tool reliably measures the ACA,[26] but coefficient of repeatability was reported to be ±5.45°.[27] This means that 95% of the repeated measures were within a difference of

Table 5. Sensitivity Analysis: Associations of Anterior Chamber Angle in Each Quadrant and Anthropometric and Ocular Characteristics Including Ocular Geometric Parameters in the Gutenberg Health Study; We Used a Generalized Estimating Equations Model to Consider Correlations Between Right and Left Eyes in Our Statistical Model

	Superior			Temporal			Inferior			Nasal		
	Estimate	95% CI	*P* Value	Estimate	95% CI	*P* Value	Estimate	95% CI	*P* Value	Estimate	95% CI	*P* Value
Sex	−0.10	−0.75, 0.56	0.77	−0.78	−1.16, −0.40	<0.0001	−0.07	−0.43, 0.30	0.72	−0.37	−0.75, 0.01	0.057
Age, y	−0.03	−0.05, 0.00	0.023	−0.07	−0.09, −0.06	<0.0001	−0.02	−0.03, 0.00	0.035	−0.08	−0.09, −0.06	<0.0001
Height, m	−3.79	−7.44, −0.14	0.042	1.21	−1.02, 3.44	0.29	0.58	−1.51, 2.67	0.59	0.24	−1.96, 2.43	0.83
Weight, kg	0.01	−0.01, 0.03	0.20	−0.01	−0.01, 0.00	0.30	0.00	−0.01, 0.01	0.69	−0.01	−0.02, 0.00	0.18
Smoking	−0.44	−1.04, 0.15	0.14	−0.07	−0.44, 0.29	0.70	−0.21	−0.56, 0.14	0.24	−0.27	−0.64, 0.10	0.15
IOP, mm Hg	−0.03	−0.11, 0.05	0.50	0.03	−0.02, 0.09	0.21	0.06	0.01, 0.11	0.014	0.09	0.03, 0.14	0.001
Anterior chamber depth, mm	7.57	6.67, 8.46	<0.0001	12.5	12.0, 13.1	<0.0001	9.77	9.26, 10.3	<0.0001	12.6	12.0, 13.1	<0.0001
Axial length, mm	0.19	−0.05, 0.44	0.12	0.19	0.04, 0.35	0.013	−0.07	−0.22, 0.07	0.32	0.41	0.24, 0.57	<0.0001
Lens thickness, mm	0.27	−0.56, 1.10	0.52	−0.28	−0.77, 0.21	0.26	−0.08	−0.55, 0.40	0.75	0.62	0.12, 1.12	0.015
Corneal power, dpt	0.29	0.13, 0.45	0.00031	0.36	0.25, 0.46	<0.0001	0.27	0.16, 0.37	<0.0001	0.32	0.21, 0.43	<0.0001
CCT, μm	−0.005	−0.012, 0.002	0.21	−0.008	−0.012, −0.003	0.0012	−0.009	−0.013, −0.005	<0.0001	−0.007	−0.011, −0.002	0.0015

CI, confidence interval; dpt, diopters; CCT, central cornal thickness.

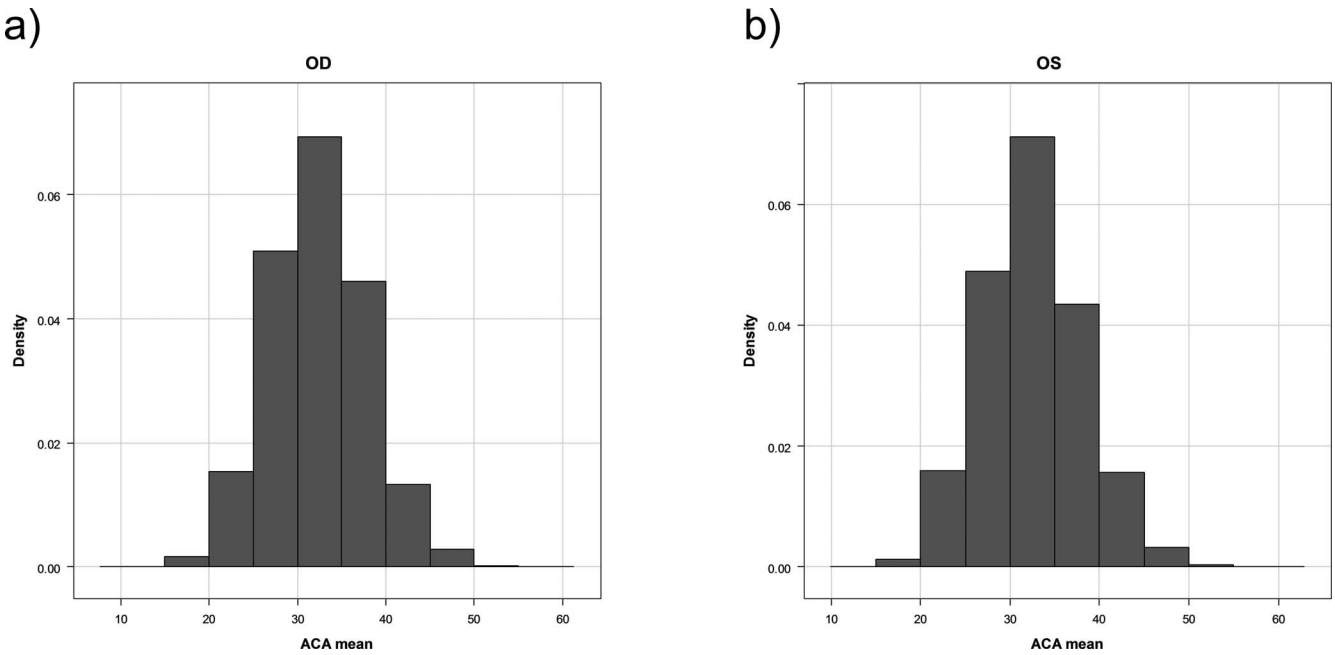

FIGURE. Distribution of the anterior chamber angle (ACA in degrees) in the study sample. The mean ACA was calculated as the arithmetic mean of the ACA in the four quadrants. (**a**) Right eyes (OD); (**b**) left eyes (OS).

5.45°. This broad interval indicates that a 1° difference has to be interpreted with caution.

Other parameters such as angle opening distance (AOD) or trabecular–iris space area (TISA) were not included in the software as measurement parameters and therefore were not a subject of this study. In addition, we did not perform gonioscopy and therefore cannot compare our results to gonioscopic findings.

As most of our study participants were Caucasians, our conclusions should be regarded as valid for this ethnicity only. They cannot be generally applied to other ethic and genetic backgrounds.

In 1969 Van Herick et al.[28] described a method for the estimation of the ACA width by flashlight and by slit lamp. Furthermore they elaborated the dependency of the ACA width on its position and reported that the ACA is narrowest superior and widest inferior. In our work we found similar results: The ACA width was narrowest superior, but was followed by inferior and was largest in the temporal and nasal position.

In summary, we are the first to report the distribution of the ACA width using Scheimpflug imaging in a population-based study. A narrower ACA was independently associated with female sex, older age, shallow anterior chamber, shorter axial length, lower corneal power, and a thicker central cornea. These factors explain two-thirds of the variance of ACA width, mainly driven by anterior chamber depth. The combination of these parameters may be used as an estimator for ACA width when no direct examination is clinically possible.

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