Lens Position and Age: The Central India Eye and Medical Study

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Purpose. We assessed changes in the position of the lens with aging in a general population.

Methods. The population-based Central India Eye and Medical Study included 4711 subjects. As part of an ophthalmic examination, anterior segment length (ASL) was measured sonographically and calculated as anterior chamber depth plus lens thickness. Subjects with nuclear cataract grades 5 or more (43.9% of the sample) were excluded.

Results. The study included 2468 subjects (1176 [47.6%] men) with a mean age of 41.2 ± 8.5 years (range, 30–78 years) and mean axial length of 22.68 ± 0.81 mm (range, 19.89–31.02 mm). In multivariate analysis, longer ASL was associated with older age ($P = 0.04$; correlation coefficient B, 0.002; 95% confidence interval [CI], 0.000, 0.005) after adjusting for male sex ($P < 0.001$), longer axial length ($P < 0.001$), higher degree of nuclear cataract ($P = 0.001$), and higher body mass index ($P = 0.02$). Greater lens thickness was associated with older age ($P < 0.001$; B, 0.009; 95% CI, 0.007, 0.0011) after adjusting for male sex ($P < 0.001$), shallower anterior chamber depth ($P < 0.001$), and higher degree of nuclear cataract ($P < 0.001$). Deeper anterior chamber depth was associated with younger age ($P < 0.001$; B, −0.007; 95% CI, −0.008, −0.005) after adjusting for male sex ($P < 0.001$), thinner lens thickness ($P < 0.001$), and longer axial length ($P < 0.001$). Combining both analyses revealed that for each year increase in age, lens thickness increased by 0.009 mm, anterior chamber depth decreased by 0.007 mm, the posterior lens pole moved backward by 0.002 mm, and the lens center moved forward by 0.0025 mm.

Conclusions. Increasing age before the development of cataract is associated with a slight forward movement of the lens center, adding to the lens paradox.

Keywords: anterior segment length, aging, cataract, lens thickness

The length of the anterior ocular segment, defined as the distance between the corneal apex and the posterior pole of the lens, is of high importance for the optical system of the eye. Together with the lens thickness, the anterior segment length (ASL) defines the axial position of the lens nucleus. Any change in the ASL and in the axial position of the lens influences the optical properties of the eye and image quality on the fovea. The two components of the ASL, anterior chamber depth and lens thickness, change with aging.[1-7] Studies have shown an age-related shallowing of the anterior chamber and an age-related increase in lens thickness, while the development of age-related cataract was associated with a thinning of the lens.[1–7] Previous investigations addressing age-related changes in ASL showed conflicting results. Examining 90 subjects with Scheimpflug photography, Dubbelman et al.[8] reported an increase in ASL with older age and concluded that the posterior lens pole moved backward in elderly individuals. On the contrary, Koretz et al.[9] studied a similar number of subjects with Scheimpflug photography and magnetic resonance imaging of the eye, and found that the ASL did not change with age. This study indicated that the age-related decrease in anterior chamber depth was fully equivalent to a lens thickening with older age. It implicated an anterior shift of the lens nucleus with older age, leading to an increased refractive power of the system in older individuals. Since the ASL depends on several potentially confounding parameters which should be taken into account in a multivariable analysis, and since the preceding studies included only a relatively small number of study participants not allowing a detailed statistical analysis, we conducted the present investigation to examine whether the ASL, and indirectly the axial position of the lens, is dependent on age. The answer to the questions may be of importance for the exploration of the properties of the optical system of the eye in the aging individual, it may be of interest for cataract surgery, since the position of the crystalline lens influences the position of an eventually implanted artificial intraocular lens, and it may be of interest for the discussion of the pathogenesis of primary angle-closure glaucoma.

Methods

The Central India Eye and Medical Study (CIEMS) is a population-based cross-sectional study that was performed in the rural region of Central India.[10] The Medical Ethics Committee of the Medical Faculty Mannheim of the Ruprecht-

Table 1. Ocular Biometric Measurements in the Population of the CIEMS (Nuclear Degree $\leq$4)

Age Groups	*n*	Anterior Chamber Depth, mm	Lens Thickness, mm	ASL, mm	ASL/Axial Length	Axial Length, mm	Refractive Error, Diopters	Nuclear Cataract Degree, 04
Men								
30–39 y	452	3.39 ± 0.25	3.86 ± 0.30	7.25 ± 0.33	0.32 ± 0.02	23.00 ± 0.78	−0.37 ± 1.23	3.56 ± 0.59
40–49 y	497	3.28 ± 0.31	4.04 ± 0.38	7.32 ± 0.47	0.32 ± 0.02	22.96 ± 0.80	0.07 ± 1.16	3.77 ± 0.43
50–59 y	169	3.27 ± 0.34	4.13 ± 0.46	7.40 ± 0.53	0.32 ± 0.02	23.00 ± 0.71	0.47 ± 1.26	3.92 ± 0.27
60–69 y	47	3.17 ± 0.27	4.20 ± 0.41	7.37 ± 0.45	0.32 ± 0.02	22.73 ± 0.63	0.27 ± 1.12	3.91 ± 0.28
70–79 y	11	3.15 ± 0.28	4.15 ± 0.65	7.30 ± 0.80	0.31 ± 0.04	23.5 ± 0.91	0.28 ± 1.44	3.91 ± 0.30
Women								
30–39 y	560	3.31 ± 0.27	3.80 ± 0.30	7.11 ± β.36	0.32 ± 0.02	22.47 ± 0.70	−0.25 ± 0..87	3.58 ± 0.54
40–49 y	520	3.18 ± 0.32	3.96 ± 0.41	7.14 ± 0.52	0.32 ± 0.02	22.41 ± 0.86	0.23 ± 0.48	3.77 ± 0.44
50–59 y	142	3.16 ± 0.35	3.98 ± 0.50	7.14 ± 0.59	0.32 ± 0.03	22.32 ± 0.68	0.82 ± 0.99	3.86 ± 0.39
60–69 y	69	3.06 ± 0.36	4.13 ± 0.48	7.18 ± 0.57	0.32 ± 0.03	22.28 ± 0.60	1.21 ± 1.28	3.96 ± 0.21
70–79 y	1	2.91	2.22	5.13	0.23	22.25	−3.00	3

Karls-University Heidelberg and the ethics committee of the Suraj Eye Institute/Nagpur approved the study; all participants gave informed consent, according to the Declaration of Helsinki. The villages included in the study were located at the border of the Indian Tribal Belt. Of a total population of 13,606 villagers, 5885 subjects met the inclusion criterion of an age of 30+ years. Of these 5885 subjects, 4711 (80.1%) participated.

The study participants underwent a detailed ophthalmologic examination, including refractometry and visual acuity assessment, keratometry, frequency-doubling perimetry, Goldmann applanation tonometry, slit-lamp biomicroscopy, and photography of the cornea, lens, optic disc, and macula. The digital lens photographs were graded for nuclear sclerosis according to the Age-Related Eye Disease Study criteria (AREDS).[11] Keratometry was performed using a nonautomatic keratometer (Appassawamy Ass., Chennai, India). We measured the corneal refractive power in the horizontal and vertical meridians. Corneal pachymetry and biometry were done via sonography using the Pacscan (Sonomed, Lake Success, NY, USA). The examinations were performed up to five times each, and the mean values were taken. In subjects with poor visual acuity and poor fixation, or in highly myopic subjects with posterior staphyloma, the measurements were repeated, if they varied, until reproducible readings were obtained. All measurements were done for both eyes of all subjects. The study design has been described in detail previously.[6,7,10]

Inclusion criteria for the study were the availability of biometric measurements of corneal thickness, anterior chamber depth, lens thickness, axial length, and corneal curvature, and a nuclear cataract grade of 4 or less. We excluded individuals with a nuclear cataract grade of 5 or more, since nuclear cataract can affect the refractive power and refractive index of the lens index and the ultrasound velocity inside of the lens. An additional exclusion criterion was any intraocular surgery.

Statistical analysis was performed using a commercially available statistical software package (SPSS for Windows, version 22.0; IBM-SPSS, Chicago, IL, USA). Only one randomly selected eye was included into the statistical analysis. We first calculated the mean values and the statistical distribution of the biometric variables. We calculated the ASL as the sum of anterior chamber depth and lens thickness. We then assessed the associations between ASL and other ocular and general parameters in a univariate manner. In the third step of the statistical analysis, we performed a multivariate analysis with ASL as dependent parameter and all parameters, which were associated significantly with ASL in the univariate analysis, as independent variables. The data were given as mean ± SD; 95% confidence intervals (CI) were presented. We calculated the standardized correlation coefficient β and the nonstandardized correlation coefficient B. The β value is a measure of how strongly each predictor variable influences the dependent variable, and it is measured in units of SD. To cite an example, a β value of 2.5 indicates that a change of 1 SD in the predictor variable will result in a change of 2.5 SDs in the criterion variable. The standardized correlation coefficient β thus describes which of the independent variables have a greater effect on the dependent variable in a multiple regression analysis, when the variables are measured in different units of measurement. The nonstandardized coefficient B describes the relationship between the dependent variable and the independent variable in terms of the original units of measurement of those variables. A 1-unit change in the independent variable is associated with b units of change in the dependent variable. All *P* values were based on a 2-sided test and were considered statistically significant when the values were less than 0.05.

Results

Of the 4711 subjects of the CIEMS, anterior chamber depth measurements were available for 9281 (98.5%) eyes of 4671 (99.2%) subjects. Of these 4671 individuals, 2468 subjects (1176 [47.6%] men) fulfilled the inclusion criterion of a degree of nuclear cataract of 4 or less. Mean age was 41.2 ± 8.5 years (median, 40.0 years), mean refractive error was 0.05 ± 1.25 diopters (median, 0 diopters), mean axial length was 22.68 ± 0.81 mm (median, 22.65 mm;), and mean ASL was 7.21 ± 0.46 mm (median, 7.26 mm; Table 1). The mean ASL was 7.30 ± 0.44 mm for men and 7.12 ± 0.47 mm for women.

In univariate analysis, ASL was significantly ($P < 0.001$) larger in men than in women (Table 2). It increased significantly correlated with the systemic parameters of older age, higher body height, heavier body weight, higher body mass index, and higher presence of arterial hypertension, and with the ocular parameters of deeper anterior chamber depth, greater lens thickness, longer axial length, more myopic refractive error, and higher degree of nuclear cataract (Table 2). It was marginally associated with greater central corneal thickness ($P = 0.07$), and ASL was not significantly associated with refractive error ($P = 0.11$). The difference in ASL was statistically significant for the comparison between the age group of 30 to 39 years and the age group of 40 to 49 years ($P = 0.004$), while the differences in ASL between the age groups of 40 to 49 and 50 to 59 years ($P = 0.13$), between the age groups

Table 2. Associations Between ASL as Measured by Sonography in the CIEMS, and Ocular and General Parameters (Univariate Analysis)

	P Value	Standardized Correlation Coefficient β	Correlation Coefficient B	95% CI of B
Age, y	<0.001	0.08	0.004	0.002, 0.006
Sex	<0.001	−0.19	−0.18	−0.21, −0.14
Body height, cm	<0.001	0.16	0.008	0.006, 0.010
Body weight, kg	<0.001	0.15	0.005	0.007, 0.009
Body mass index, kg/m^2	<0.001	0.07	0.010	0.005, 0.015
Arterial hypertension	0.02	0.05	0.07	0.01, 0.14
Diabetes mellitus	0.22	−0.03	−0.07	−0.19, 0.04
Corneal refractive power, diopters	0.31	0.02	0.01	−0.01, 0.17
Central corneal thickness, um	0.065	0.04	0.001	0.000, 0.001
Lens thickness, mm	<0.001	0.75	0.89	0.86, 0.92
Anterior chamber depth, mm	<0.001	0.55	0.82	0.77, 0.87
Axial length, mm	<0.001	0.19	0.11	0.09, 0.13
Nuclear cataract, degree 0-4	0.001	0.07	0.07	0.03, 0.11
Refractive error, diopters	<0.001	−0.12	−0.02	−0.02, −0.01

of 50 to 59 and 60 to 69 years ($P = 0.71$), and between the age groups of 60 to 69 and 70 to 79 years ($P = 0.64$) were statistically not significant (Fig.).

The multivariate analysis included all parameters that were significantly (defined as a *P* value of <0.10) associated with the dependent variable of ASL in the univariate analysis. In a first step, we dropped the parameters of anterior chamber depth and lens thickness from the list of independent variables, since their sum was the ASL. For reasons of collinearity, we then deleted the parameters of body weight (variance inflation factor, 107). We dropped body height ($P = 0.69$), central corneal thickness ($P = 0.63$), and prevalence of arterial hypertension ($P = 0.13$), since these parameters were no longer significantly associated with ASL. We arrived at a model (overall correlation coefficient *r*, 0.26), in which longer ASL was associated with male sex ($P < 0.001$), longer axial length ($P < 0.001$), higher degree of nuclear cataract ($P = 0.001$), higher body mass index ($P = 0.02$), and older age ($P = 0.0$, Table 3). For each year increase in age, ASL increased by 0.002 mm. If refractive error was added to the model, it was not significantly ($P = 0.10$; β, 0.04) associated with ASL. If body mass index was replaced by body height in the model, body height was not significantly ($P = 0.58$) associated with ASL. If body mass index was dropped, the association between longer ASL and older age increased only slightly ($P = 0.01$; standardized correlation coefficient β, 0.05; correlation coefficient B, 0.003). If the study population was stratified by sex, men showed a significant association between longer ASL and older age ($P = 0.02$; β, 0.07; B, 0.004), while the association was not significant ($P = 0.48$) in women. If sex was dropped from the multivariate analysis and body length was added, longer ASL was associated with taller body height ($P < 0.001$, β, 0.11; B, 0.005; 95% CI, 0.003, 0.008) after adjusting for longer axial length ($P < 0.001$), higher degree of nuclear

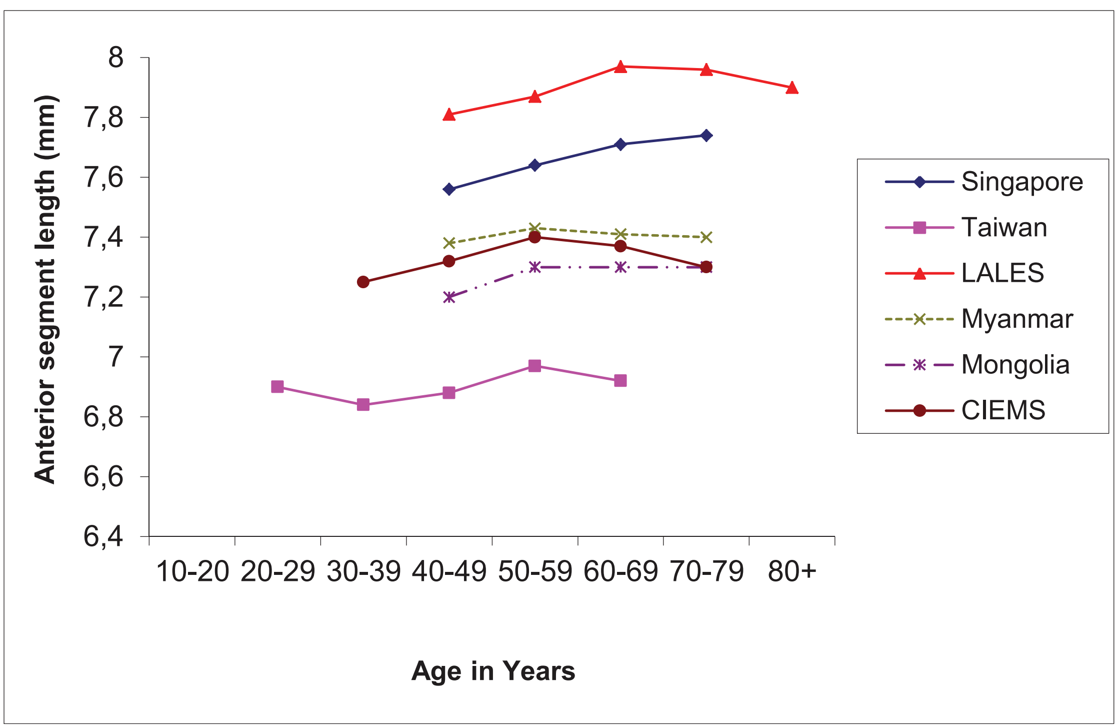

Figure. Graph showing the association between ASL and age in different population-based studies.

TABLE 3. Associations Between ASL or Lens Thickness or Anterior Chamber Depth as Measured by Sonography, and Ocular and General Parameters in a Multivariate Analysis in the CIEMS

	P Value	Standardized Correlation Coefficient β	Correlation Coefficient B	95% CI of B	Variance Inflation Factor
ASL					
Age, y	0.035	0.04	0.002	0.000, 0.005	1.10
Sex	<0.001	−0.13	−0.12	−0.16, −0.09	1.14
Body mass index, kg/m²	0.015	0.05	0.01	0.001, 0.01	1.02
Axial length, mm	<0.001	0.15	0.08	0.06, 0.11	1.15
Nuclear cataract, degree 0–4	0.001	0.07	0.06	0.02, 0.10	1.08
Lens thickness					
Age, y	<0.001	0.20	0.009	0.007, 0.011	1.07
Sex	<0.001	−0.11	−0.09	−0.12, −0.06	1.04
Anterior chamber depth, mm	<0.001	−0.11	−0.14	−0.19, −0.09	1.07
Nuclear cataract, degree 0–4	<0.001	0.08	0.07	0.04, 0.10	1.07
Anterior chamber depth					
Age, y	<0.001	−0.19	−0.007	−0.008, −0.005	1.08
Sex	<0.001	−0.08	−0.05	−0.08, −0.03	1.15
Lens thickness, mm	<0.001	−0.10	−0.08	−0.11, −0.05	1.08
Axial length, mm	<0.001	0.25	0.09	0.08, 0.11	1.13

cataract ($P = 0.001$), higher body mass index ($P = 0.01$), and older age ($P = 0.005$).

In an additional step of the statistical analysis, we assessed associations between lens thickness, and other ocular and systemic parameters in a multivariate analysis. After dropping those parameters that were no longer significantly associated with lens thickness, greater lens thickness was correlated with older age ($P < 0.001$), male sex ($P < 0.001$), shallower anterior chamber depth ($P < 0.001$), and higher degree of nuclear cataract ($P < 0.001$, Table 3). For each year increase in age, lens thickness increased by 0.009 mm.

In a similar manner, we performed a multivariate analysis on the associations between anterior chamber depth, and other ocular and systemic parameters. Greater anterior chamber depth was associated with younger age ($P < 0.001$), male sex ($P < 0.001$), decreasing lens thickness ($P < 0.001$), and longer axial length ($P < 0.001$, Table 3). For each year increase in age, anterior chamber depth decreased by 0.007 mm.

Combining the age-related increase in lens thickness by 0.009 mm per year and the age-related decrease in anterior chamber depth by 0.007 mm per year suggested a slight forward movement of the lens center (defined as the midpoint between the anterior and posterior lens poles) by 0.0025 mm per each year increase in age, while the posterior lens pole moved backward by 0.002 mm.

Discussion

Excluding eyes with a nuclear cataract degree of 5 or more, our population-based study showed that the ASL increased by 0.002 mm for each year increase in age, after adjusting for male sex ($P < 0.001$), longer axial length ($P < 0.001$), higher degree of nuclear cataract ($P = 0.001$), and higher body mass index ($P = 0.02$). Splitting up ASL revealed that lens thickness increased by 0.009 mm for each year increase in age, while as a corollary, anterior chamber depth decreased by 0.007 mm. It resulted in an increase in ASL by 0.002 per year of life. It suggests a forward movement of the lens center by 0.0025 mm per each year increase in age.

The values of the age-related increase in lens thickness and the age-related change in the ASL reported in this study can be compared to the results obtained in previous clinical studies. Dubbelman et al.[8] combined Scheimpflug photography and optical axial length measurements, individually corrected the Scheimpflug images for distortion, and calculated the refractive index and the lens thickness in 90 individuals with an age ranging between 16 and 65 years. They found an average increase in lens thickness of 24 μm/y of life, while the ASL increased by 0.015 mm.[8] Applying magnetic resonance imaging and comparing it to Scheimpflug correction methods, Koretz et al.[9] reported an increase in lens thickness of 0.019 mm per year of life, while the ASL did not vary significantly with age. Using data from other population-based studies, such as the Los Angeles Latino Eye Study (mean axial length in men, 23.65 ± 0.94 mm; women, 23.18 ± 1.02 mm), the Singaporean Tanjong Pagar Survey (mean axial length in men, 23.54 ± 1.10 mm; women, 22.98 ± 1.16 mm), an investigation from Mongolia (mean axial length in men, 23.43 ± 1.06; women, 23.08 ± 1.20 mm), and others investigations showed, similar to the present study, a slight increase in ASL with older age (Fig.).[1–4] In contrast, the Burmese Meiktila Eye Study (mean axial length in men, 23.12 ± 0.98 mm; women, 22.54 ± 1.04 mm) did not reveal an association with age.[5] The differences in the association between older age and longer ASL between the studies may be due to differences in the ethnicities of the study populations, differences in the techniques applied, and differences in the statistical analysis. Since lens thickness and anterior chamber depth as the two components of ASL depend on a panoply of parameters, a multivariate analysis including these factors is needed to avoid a potentially confounding effect. Differences between various study populations in the amount of the ASL also could be explained by ethnic or environmental differences in eye size, since axial length is associated with ASL (Table 2).[1,10]

While previous studies showed an age-related increase in lens thickness, and while other studies revealed an age-related decrease in anterior chamber depth, only few studies addressed age-related changes in ASL as a combination of both parameters. Taking the ASL in combination with anterior chamber depth and lens thickness as surrogate for the axial position of the lens center, the data of our study suggested that for each year increase in age, the lens center moves slightly forward by 0.0025 mm, while the posterior lens pole moves backward by 0.002 mm. The forward movement of the lens

Table 4. Ocular Components for Men Aged 40 to 50, Including the Relation Between ASL and Axial Length for Different Studies

Study Populations	Anterior Chamber Depth, mm	Lens Thickness, mm	ASL, mm	Axial Length, mm	ASL/Axial Length
Taiwanese Chinese, emmetropic eyes, 4	2.62	4.26	6.88	23.28	0.30
Mongolian population, 2	3.00	4.20	7.20	23.40	0.31
Central India, rural population with eyes with cataract excluded	3.25	4.04	7.29	22.96	0.32
Myanmar rural population, 5	3.08	4.30	7.38	23.17	0.32
Chinese in Singapore, Tanjong Pagar, 1	3.25	4.36	7.61	23.80	0.32
Latino males in USA, 3	3.61	4.20	7.81	23.70	0.33

slightly increases the combined power of the two refractive media of the eye (cornea and lens) if all other ocular components were maintained unchanged.

In the multivariate analysis, longer ASL was associated with male sex (Table 3). If age was dropped and body height was added to the list of independent variables, longer ASL was associated with taller body height ($P < 0.001$) in addition to longer axial length, higher degree of nuclear cataract, higher body mass index, and older age. Since ASL strongly depends on axial length, which by itself is associated with body height, future studies may address the question whether ASL is primarily associated with male sex or with taller body height.

Previous studies have shown and discussed that with increasing age before the development of nuclear cataract, emmetropia in the adult is mostly maintained in spite of continuing lens growth with increasing lens thickness and increasing lens curvature.[12–14] That phenomenon has been called the lens paradox, which has been believed to be caused by changes in the refractive index of the lens, due to refractive index differences between lens nucleus and lens cortex, or due to gradient changes within the lens cortex. These changes would produce hyperopic shifts that would be balanced with the myopic shifts produced by increased lens curvature.[12–14] According to our study, a slight forward shift of the lens with increasing age before the development of marked nuclear cataract may be added to the elements of the lens paradox, so far including an increase in lens thickness and lens curvature. The results of our study fit with the previous assumptions, that these age-related changes in the thickness, shape and position of the lens do not markedly affect the refractive power of the lens in the optical ocular system, since also in our study, refractive error, if added to the multivariate model, was not significantly associated with ASL ($P = 0.10$).

Comparing measurements of the various ocular components obtained in previous studies reveals that Asians have smaller anterior chamber depths than Latinos, and that lens thickness is similar for the various ethnic groups (Table 4, Fig.). Although the Central Indian subjects in our study have the shortest axial length compared to the other study populations, their ASL is comparable with the ASL measured in the other ethnic study populations. It suggests that although longer ASL is associated with longer axial length, the dimensions of the anterior segment of the eye may partially be independent of the dimensions of the posterior segment. It is in agreement with findings that the thinning of the sclera in axially elongated eyes mainly starts at the ora serrata and is most pronounced close to the posterior pole.[15]

The results of our study also may have importance for cataract surgery. The shallowing of the anterior chamber with older age can make cataract surgery in elderly patients more difficult, including a higher surgery-associated loss of corneal endothelium cells, since the distance between the tip of the phacoemulsification probe and the posterior corneal surface will be reduced. In addition, if the posterior pole of the lens before cataract surgery moves backward in an age-dependent manner, the artificial intraocular lens may be positioned more backward in elderly patients than in younger patients, which will have an influence on the postoperative refractive status of the eye. It has remained unclear, however, whether the ciliary muscle and the zonular fibers move the lens center forward with older age or whether the lens center is moving forward because the lens changes its shape as it grows, with the anterior lens curvature compared to the posterior lens curvature showing a more marked age-related steepening. If the latter is the case, the lens center would move forward without any change in the lens suspensory apparatus. It would then not influence the position of an eventually implanted intraocular lens.

The results of our study, in particular the shallowing of the anterior chamber, also may have importance for acute primary angle closure and primary angle-closure glaucoma, which have been described to be associated with a shallow anterior chamber depth.[16] In addition, an increased lens vault has been found to be a major risk factor for primary angle closure and primary angle-closure glaucoma. Although lens vault has been defined and measured by anterior segment optical coherence tomography and we applied sonographic biometry in our study, one may infer that the age-related increase in lens thickness found in our study population may translate into an increased lens vault as additional risk factor for the development of acute primary angle closure and primary angle-closure glaucoma.

Limitations of our study should be mentioned. First the strength of the association between older age and increased ASL was relatively low with a standardized correlation coefficient β of 0.04. Correspondingly, the difference in ASL was statistically significant only for the comparison between the age groups of 30 to 39 and of 40 to 49 years ($P = 0.004$), while the difference in ASL between other age groups was not significant (Fig.). The association between older age and shallower anterior chamber depth, as well as of the association between older age and thicker lens thickness, however, were relatively strong with β values of –0.19 and 0.20, respectively. Thus, the low β value for the association between age and ASL may be explained by the complimentary association between both parameters, which both add up to the ASL. One may infer that the clinical impact of the findings of this study is higher when one considers anterior chamber depth and lens thickness separately than as if they are considered together as ASL. Second, ultrasonography determines the thickness of ocular tissues relying on the elapsed time between the echoes on the A-scan. In our study, the sound velocity for the aqueous and vitreous was considered to be 1532 m/s, and 1641 m/s for the crystalline lens. A previous study did not find an age dependency of the sound velocity in the lens; however, it did not include individuals older than 44 years.[17] Thus, it has remained unknown whether nuclear cataract can affect sound velocity in the lens. Therefore, individuals with marked nuclear cataract were excluded in our study. Third, the assessment of nuclear cataract was subjective. It followed, however, the recommendations given by the AREDS Research Group, as they also have been applied in other population-based studies.[11] Fourth, as for any population-based study, the participation rate is crucial. In our study, we had 80% of 5885 eligible subjects participation, and this response rate is comparable with other epidemiological investigations. Fifth, the data presented in our study were based on a cross-sectional investigation. Thus, the data were not longitudinal and there might have been some subtle cohort effects that could have influenced these results. A strength of our study was that individuals starting with an age of 30 years were included, while other investigations had an older age inclusion criterion. A younger age is essential to assess age-related changes in the lens before the development of major cataract.

In conclusion, older age before the development of cataract is associated with a slight forward movement of the lens center, adding to the lens paradox. Simultaneously, the posterior pole of the lens receeds by a small amount with older age in subjects before the development of cataract.

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