Angle Recess Area Decreases With Age in Normal Japanese

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Purpose: To investigate prospectively the relationships between anterior chamber angle configuration and refractive error, axial length, age, and body height in the Japanese.

Methods: We studied 65 eyes of 65 subjects (30 men, 35 women) who were either patients at the Ophthalmology Department of Mie University or volunteers. The 65 subjects underwent a complete eye examination, A-scan biometry, and ultrasound biomicroscopy. Images were exported to an IBM-compatible personal computer in PCX format. The angle recess area (ARA) was measured using a software program of our own design.

Results: The ARA decreased with age in all quadrants of all eyes. In older individuals, the angle in the superior quadrant was significantly narrower than in the other quadrants. The ARA correlated directly with anterior chamber depth ($P < .001$), axial length ($P < .001$), and body height ($P = .003$), and inversely with age ($P < .001$) and refractive error ($P = .003$) in pairwise analysis. Multivariate analysis revealed a significant association between ARA and anterior chamber depth ($P < .001$), axial length ($P = .016$), and younger age ($P = .043$).

Conclusions: The anterior chamber area narrows with age, especially in the superior quadrant. Narrowing of the angle in Japanese is associated with older age, shorter axial length, and shallower anterior chamber depth. We hypothesize that because of the increasing prevalence of axial myopia in younger Japanese, angle-closure glaucoma could become less common in Japan in the future. **Jpn J Ophthalmol 2000;44:46–51** © 2000 Japanese Ophthalmological Society

Key Words: Angle-closure glaucoma, angle recess measurement, racial prevalence of angle-closure glaucoma, ultrasound biomicroscopy.

Introduction

Primary angle-closure glaucoma occurs more commonly in Asians than in other racial groups.[1–5] Angle-closure is more common among the Chinese than the Malaysians in Singapore, where its prevalence is greater than that of primary open-angle glaucoma. Of 1,627 new glaucoma patients in a Taiwan clinic, 78% had angle-closure glaucoma.[6] The precise reasons for this high incidence remain largely unknown. Biometric factors reported to predispose eyes of subjects in England to angle-closure glaucoma include a smaller corneal diameter, steeper corneal curvature, shorter radii of the posterior corneal curvature and anterior lens curvature, shallower anterior chamber, thicker lens, more anterior lens position, and shorter axial length.[7–10] In the Japanese, chronic angle-closure is extremely common, and severe damage is often present by the time the patient is initially seen.[11] An objective means of earlier detection of this disorder should prove useful.

Although most previous studies evaluating angle configuration have relied largely on gonioscopic methods[2,12] or on the van Herick method,[2,12–14] these methods are subjective and insufficiently precise to measure the angle width. Quantitative methods in-

Received: January 6, 1999

Presented in part at the annual meeting of the Association for Research in Vision and Ophthalmology, Fort Lauderdale, FL, May 1997.

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Jpn J Ophthalmol 44, 46–51 (2000)

Published by Elsevier Science Inc.

0021-5155/00/$–see front matter
PII S0021-5155(99)00173-2

clude Scheimpflug photography[15–18] and low frequency ultrasonography.[19] However, these do not provide sufficient resolution to assess the angle in detail. High-frequency ultrasound biomicroscopy (UBM) is much better suited for the evaluation of the anatomy and pathophysiology of the anterior segment. Ultrasound biomicroscopy has been extremely useful in elucidating mechanisms of angle-closure glaucoma and in estimating angle configuration objectively and directly.[20–27]

Biometric studies on the eyes of Asians are notably lacking. When the angle configuration was evaluated in Japanese individuals using the Shaffer classification, angle width correlated significantly with anterior chamber depth, axial length, lens thickness, refractive error, body height, and age.[28] We prospectively investigated these parameters by UBM to obtain objective measurements and to evaluate the relationships between angle configuration, biometric parameters, and age in normal eyes of Japanese individuals.

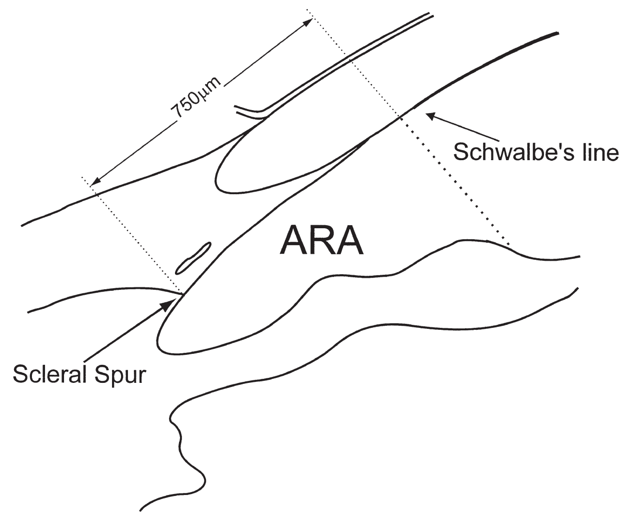

Figure 1. Diagram of angle recess area (ARA).

Materials and Methods

The 65 subjects in this study were either patients attending the Department of Ophthalmology at Mie University Hospital, Mie, Japan, for routine vision examinations or were volunteers. Informed consent based upon the guideline of Mie University was obtained verbally from each subject. Inclusion criteria were as follows: vision better than 20/25, no existing pathology by slit-lamp and fundus examination, and intraocular pressure less than 20 mm Hg. Exclusion criteria were as follows: history of any intraocular surgery including laser treatment, the use of topical drugs affecting pupillary diameter, and history of ocular disease or trauma. If both eyes qualified for the study, the right eye was used.

Recorded data included age, sex, body height and weight, refractive error, axial length, anterior chamber depth, lens thickness, and angle recess area (ARA).[22,29] The position of the scleral spur was defined as the innermost point of a line separating ciliary muscle and scleral fibers, which was localized on the UBM image by the observer. ARA was defined as the triangular area bordered by the anterior iris surface, corneal endothelium, and a line perpendicular to the corneal endothelium drawn from a point 750 μm anterior to scleral spur to the iris surface (Figure 1). The ARA was automatically calculated using a software program of our own design after localization of the scleral spur by the observer. Scanning and measurement of the ARA were performed by a single examiner to exclude interobserver error.

Refractive errors were measured with an autorefractometer (Auto REFKERATOMETER RK2™; Canon, Tokyo) and expressed as spherical equivalents. Axial length, anterior chamber depth, and lens thickness were measured by A-scan ultrasonography (Echo Scan US-1500™; Nidek, Gamagori). Ultrasound biomicroscopy (UBM; Humphrey Systems, San Leandro, CA, USA) was performed with a 50 MHz transducer (tissue resolution, 50 μm; penetration depth, 4–5 mm). Scanning was performed in the supine position and the probe was held perpendicular to the structure scanned under standardized room lighting conditions. Fixation and accommodation were held constant by having the patient fixate on a ceiling target with the fellow eye. One image per quadrant was saved and used for analysis. Images were exported to an IBM-compatible personal computer in PCX format. Body height and weight were also measured.

Multivariate analysis was performed to determine how the variables contribute to the determination of angle width. The multivariate analysis was based on modeling through multiple regressions. The angle recess area, age, sex, refractive error, axial length, anterior chamber depth, lens thickness, body height, and body weight were each used as the dependent variable. The dependent variable was regressed on a linear combination of the remaining seven variables. When conducting each multiple regression, we used a stepwise selection technique to find the best of

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Table 1. Clinical and Demographic Data

Clinical Variables	Mean ± SD
Number	65
Gender	
Male	30
Female	35
Age (yrs)	48.9 ± 17.0
(Range)	(21–78)
Refractive error (D)	− 0.28 ± 1.43
(Range)	(−3.5–3.0)
Axial length (mm)	23.36 ± 1.03
(Range)	(21.36–26.48)
Body height (cm)	160.0 ± 8.9
(Range)	(142.0–180.0)
Body weight (kg)	55.3 ± 9.6
(Range)	(37.0–84.0)

competing models for the data by comparing significance levels for the different combinations of independent variables. The level of statistical significance was set at $P < .05$, two-sided. To investigate the effect of age on the angle configuration in more detail, we have divided the ages into three groups: I (20–39 years), II (40–59 years), and III (>60), and analyzed the relationship between the age group and ARA by using a one-way analysis of variance (ANOVA) for between-group comparison, and Student's *t*-test for pairwise comparison.

Table 2. Groups Divided for Investigating the Effect of Age

	Group I	Group II	Group III
Number	19	25	21
Gender			
Male	9	13	9
Female	10	12	12
Age (yrs)*	26.3 ± 4.5	50.5 ± 5.4	67.3 ± 4.8
(Range)	(21–37)	(41–59)	(60–78)
Refractive error (D)*	−1.61 ± 1.34	−0.03 ± 0.98	0.61 ± 1.11
(Range)	(−3.5–0.5)	(−2.0–2.0)	(−3.5–3.0)

*Mean ± SD.

Results

Sixty-five eyes of 65 patients (30 men, 35 women) were studied. There were 60 right eyes and 5 left eyes. The mean age of the patients was 48.9 ± 17.0 years (range, 21–78 years) (Tables 1 and 2). The anterior chamber depth (P < .001), axial length ($P < .001$), age ($P < .001$), body height ($P = .003$), and refractive error ($P = .003$) were significantly correlated with the ARA using pairwise analysis (Pearson product–moment correlation coefficients: 0.68, 0.58, −0.49, 0.37, −0.36, respectively) (Table 3). Multivariate regression analysis showed that the anterior chamber depth ($P < .001$), axial length ($P = .016$), and age ($P = .043$) to be significantly correlated with the mean ARA (Table 4).

Table 3. Pairwise Analysis*

Variable	ARA	Age	Gender	RE	AL	ACD	LT	Body H	Body W
ARA	–	−0.49	−0.23	−0.36	0.58	0.680	−0.23	0.37	0.21
		<.001	.06	*.003*	*<.001*	*<.001*	.07	*.003*	.09
Age	−0.49	–	0.02	0.67	−0.36	−0.45	0.53	−0.40	−0.11
	<.001		.87	*<.001*	*.004*	*<.001*	*<.001*	*<.001*	.38
Sex	−0.23	0.02	–	−0.15	−0.22	−0.36	−0.004	−0.71	−0.70
	.06	.87		0.24	.08	*.003*	.98	*<.001*	*<.001*
RE	−0.36	0.67	−0.15	–	−0.54	−0.37	0.33	−0.15	−0.03
	.003	*<.001*	.24		*<.001*	*.003*	*.007*	.24	.79
AL	0.58	−0.36	−0.22	−0.54	–	0.55	−0.10	0.33	0.28
	<.001	*.004*	0.08	*<.001*		*<.001*	.45	*.008*	*.02*
ACD	0.68	−0.45	−0.36	−0.37	0.55	–	−0.40	0.47	0.42
	<.001	*<.001*	*.003*	*.003*	*<.001*		*<.001*	*<.001*	*<.001*
LT	−0.23	0.53	−0.004	0.33	−0.10	−0.40	–	−0.24	−0.06
	.07	*<.001*	.98	*.007*	.45	*<.001*		.06	.64
Body H	0.37	−0.40	−0.71	−0.15	0.33	0.47	−0.24	–	0.71
	.003	*<.001*	*<.001*	.24	*.008*	*<.001*	.06		*<.001*
Body W	0.21	−0.11	−0.70	−0.03	0.28	0.42	−0.06	0.71	–
	.09	.38	*<.001*	0.79	*.02*	*<.001*	.64	*<.001*	

ARA: mean angle recess area, RE: refractive error, AL: axial length, ACD: anterior chamber depth, LT: lens thickness, H: height, W: weight.

Significant associations are italic.

*Upper value is Pearson correlation coefficient, lower value is P.

In all quadrants, the ARA of group I was significantly greater than that of groups II and III. In group III, the ARA was significantly smaller in the superior quadrant than in group II, but not in the other 3 quadrants (Figure 2). In groups I and II, there were no significant differences in ARA when any quadrant was compared with any other quadrant within each group. However, the ARA of the superior quadrant in group III was significantly smaller than that of other quadrants in this group (inferior: $P < .0001$, nasal: $P = .012$, temporal: $P = .045$, respectively, paired Student's t-test).

Discussion

Eyes with narrow angles are at risk for angle-closure glaucoma. Although the clinical features of primary angle-closure glaucoma have been well described, the relationships between angle configuration and multiple associated ocular and systemic anatomic variables remain incompletely understood, particularly in eyes of Asians. Okabe et al.[28,30] used gonioscopy to evaluate the angle configuration in Japanese subjects, and reported that the angle width was significantly correlated with the anterior chamber depth, refractive value, axial length, age, corneal diameter, lens thickness, lens position, and body height (pairwise test). Using multiple regression analysis, Okabe et al[28,30] reported that the role their measured factors play in determining angle width is limited, and that some other unknown factors may play a significant role. However, gonioscopic assessment is highly observer dependent. In addition, the contour of the anterior iris surface can influence the configuration, occludability, and pattern of closure for the anterior chamber angle.[29]

Ultrasound biomicroscopy provides objective, high-resolution, cross-sectional information on the anterior segment anatomy. A method for making quantitative estimation of the angle width by measuring the trabecular-iris angle or angle opening distance (AOD) by UBM has been reported.[31] However, this method does not take the iris contour into consideration. We have developed a method of measuring the angle recess area that takes the iris surface irregularities into consideration,[32] and we have applied this method to investigate the parameters studied earlier by Okabe et al.[30]

As expected, eyes with shallower anterior chambers and shorter axial lengths tended to have narrower angles. Anterior chamber depth is considered to be the most important biometric factor that correlates with angle width.[33] This is supported by our data; pairwise and multivariate analyses showed that anterior chamber depth and axial length were highly correlated with ARA. This indicates that larger eyes have wider ante-

Table 4. Multivariate Analysis

Dependent Variable	R	Variable	Estimate Value	P value
Mean ARA	0.550	ACD	0.082	< .001
		Axial length	0.021	.016
		Age	−0.001	.043
Refractive error	0.612	Axial length	−0.559	< .001
		Age	0.045	< .001
		Sex	0.351	.004
Axial length	0.492	Mean ARA	4.807	< .001
		Refractive error	−0.282	< .001
		Body weight	0.020	.05
ACD	0.602	Mean ARA	3.015	< .001
		Body weight	0.013	.001
		Lens thickness	−0.199	.003
Lens thickness	0.355	Age	0.016	< .001
		ACD	−0.432	.013
		Axial length	0.146	.046
Body height	0.716	Sex	4.147	< .001
		Age	−0.185	< .001
		Body weight	0.313	< .001
Body weight	0.578	Body height	0.453	< .001
		Sex	3.837	.001
Age	0.641	Refractive error	5.734	< .001
		Lens thickness	7.949	.002
		Body height	−0.376	.023
		Mean ARA	−36.915	.041

ARA: angle recess area, ACD: anterior chamber depth.

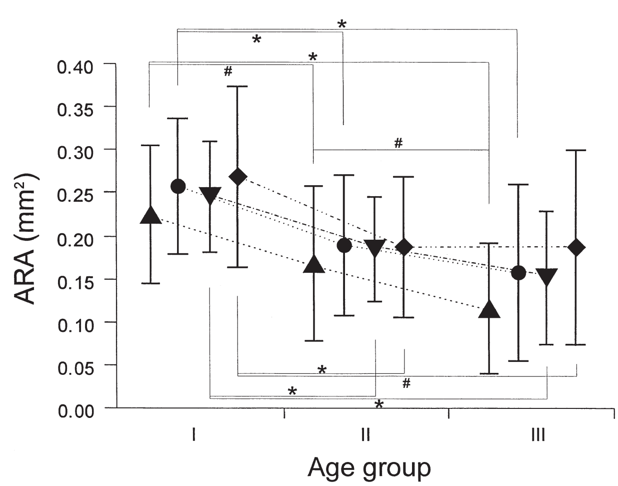

Figure 2. Angle recess area (ARA) of quadrants in each of three age groups: I (20–39 years), II (40–59 years), and III (over age 60). $*P < .01$, $\#P < .05$ Error bar = standard deviation. ▲ – – – – Superior quadrant; ▼ -·-· Interior quadrants; ● ···· Nasal quadrant; ◆ — — Temporal quadrant.

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rior chamber angles. Increasing degrees of myopia are correlated with wider angles and with increasing axial length and anterior chamber depth.

Age is known to be a significant factor in angle-closure glaucoma. We found a narrowing of the angle with age in all quadrants, especially superiorly. Furthermore, the ARA showed no difference in any quadrant in the younger and middle-aged groups (groups I and II), but in the older group (group III) the superior quadrant was significantly narrower than the other quadrants. This is consistent with the tendency for peripheral anterior synechiae to form initially in the superior quadrant of the angle in angle-closure glaucoma,[34,35] and with our clinical impression that the anterior chamber angle is narrower in the superior quadrant than in the inferior quadrant. The reason why the superior quadrant is narrower even in normal subject remains unknown, and further investigation is required.

We found body height to be statistically significant factor associated with ARA, age, sex, axial length, anterior chamber depth, and body weight by pairwise testing (Table 3). Moreover, anterior chamber depth and axial length were significantly correlated with body height, as reported previously.[36,37] This suggests that taller individuals have larger eyes, and thus, wider angles.

Considering these results, there are two possible reasons for the increasing prevalence of angle-closure glaucoma in older people. One is that aging makes the anterior chamber angle narrower, and the other is that older people generally have shorter body height, which is a strong determinant of angle-closure glaucoma. Further investigation is needed.

The change in the phenotypic appearance of Japanese after World War II may alter the incidence of angle-closure glaucoma.[38–40] Japanese have become taller and differences in height between Japanese in Japan and Japanese-Americans are no longer so evident.[41]

The prevalence of myopia has been reported to be increasing among Chinese,[42,43] Eskimos,[44] and other nationalities.[45–47] These changes have been attributed more to environmental factors (urbanization,[38] improved nutritional status,[39] and life-style changes[40]) rather than genetic changes. The prevalence of primary angle-closure glaucoma and narrow angle shows racial and gender differences, and previous surveys show these are found more frequently in Japanese than other races.[28] Women are more often affected than men. This may be attributed to the difference in height to some extent.

The progressive increase in body height, and increased prevalence of axial myopia, suggests that the angle width among Japanese is also increasing gradually. Primary angle-closure glaucoma may become less common in Japan in the future. Our data imply a relationship between body height and anterior segment anatomy. This relationship, coupled with known epidemiologic features of Japanese individuals, may have an impact upon the prevalence of primary angle-closure glaucoma. Longitudinal studies are necessary to support this speculation.

Supported in part by the New York Glaucoma Research Institute, The New York Eye and Ear Infirmary Department of Ophthalmology Research Fund, New York, New York, and the David Warfield Fellowship in Ophthalmology of The New York Community Trust and The New York Academy of Medicine (Dr. Ishikawa).

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