Chapter 12

Screening for Narrow Angles in the Japanese Population Using Scanning Peripheral Anterior Chamber Depth Analyzer

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Additional information is available at the end of the chapter

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1. Introduction

Primary chronic angle-closure glaucoma (PACG) is a leading cause of blindness, and has particularly high prevalence rate in East Asia [1–3]. The Handan Eye Study [4] reported that the standardized prevalence of PACG is 0.5%, and two thirds of those with PACG were blind in at least one eye. Many cases of PACG are asymptomatic and often present with severe visual field loss at the first visit. The severe visual impairment from PACG is related to the insidious development of the disease. [5]

Primary angle closure suspect (PACS) is characterized by narrow or occludable angles without raised intraocular pressure (IOP) or glaucomatous optic neuropathy. Primary angle closure (PAC) is the eyes with narrow angles and the appositional closure, peripheral anterior synechiae (PAS) and/or raised IOP but without glaucomatous optic neuropathy. PACG is defined as the case of PAC with glaucomatous optic neuropathy. It has been estimated that 22% of the eyes with PACS progress to PAC and 28.5% progress from PAC to PACG over 5–10 years [6]. Prophylactic laser iridotomy (LI) is the first-line treatment for narrow angles, and may stop the progression of the angle closure process and prevent development of PACG. However, LI is less effective in controlling IOP if optic nerve damage with PAS has already occurred [7].

Assessment of angle width is essential for the diagnosis and managing angle closure [8–10]. Currently, the golden standard for angle assessment has been indirect visualization by

gonioscopy. However, it is limited by its dependency on subjective interpretation and difficulties in manipulation techniques. Ultrasound biomicroscopy (UBM) generates high-resolution images of the angle, which can be used in quantitative analysis, and it adds useful information regarding causal mechanisms of angle closure. However, this method also requires trained and experienced technicians and is time consuming. Both gonioscopy and UBM require contact with the globe, and as a result, they can be unpleasant for the patient and can induce artifacts.

New devices for evaluating the anterior ocular segment in a more objective and quantitative manner have been introduced. Anterior-segment optical coherence tomography (AS-OCT) is a noninvasive technique allowing the measurement of the anterior ocular structures. A new generation of OCT, swept-source OCT (SS-OCT), has been recently introduced for the measurement of the anterior ocular segment. The SS-OCT is over ten-fold faster than the time-domain OCT and gives a three-dimensional (3D) observation of the anterior ocular segment. The SS-OCT employs 1,310 nmin the nearinfrared light source and its scan rate is 30,000 A scan/s.

The scanning peripheral anterior chamber depth analyzer (SPAC) is a non-invasive device that objectively and quantitatively assesses the anterior ocular segment by employing the Scheimpflug camera principle. The SPAC measures the peripheral ACD and converts the measurements into numerical and categorical grades by comparison with a normative database. The SPAC has been proposed as a clinician-independent screening tool for angle closure.

In the study reported here, we review the advantages and limitations of newer anterior chamber imaging technologies, namely ultrasound biomicroscopy (UBM), anterior segment optical coherence tomography (AS-OCT), and scanning peripheral anterior chamber depth analyzer (SPAC). Additionally, the present study assessed the effectiveness and possibility of the SPAC in the glaucoma screening.

2. Ultrasound biomicroscopy (UBM) (Fig. 1)

UBM, which originally was used in ophthalmology to image the posterior segment (B-scan ultrasonography), is an objective alternative for anterior chamber angle assessment. Although ultrasound and UBM are based on the same principle, the frequencies are different. Objective and reproducible measurements of the anterior chamber structures can be obtained with cross-sectional imaging by UBM. Electric signals are converted by a radiofrequency signal generator coupled to a piezoelectric transducer into 50 MHz frequency ultrasonic sound waves, which are transmitted to the eye via saline solution that is held in a cup reservoir [11]. The examination may be performed through a viscous material such as sodium hyaloronate. UBM generates high-resolution images of the angle, which can be used in quantitative analysis, and it adds useful information regarding mechanisms of angle closure [11]. Although angle dimensions measured by UBM correlated significantly with gonioscopy in general [12], gonioscopic assessment sometimes resulted in an overestimation of the angle width in eyes with occludable angles [13]. Gonioscopy is the gold standard examination, because it allows direct viewing of

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the angle. Nevertheless, it may induce changes in the apposition of the iris depending on the technique and the lens.

The UBM measurement requires trained and experienced technicians and is time consuming. In addition, UBM require contact with the globe, and as a result, UBM can induce artifacts by inadvertent compression of the globe. Consequently, UBM is not suitable for glaucoma screening examination.

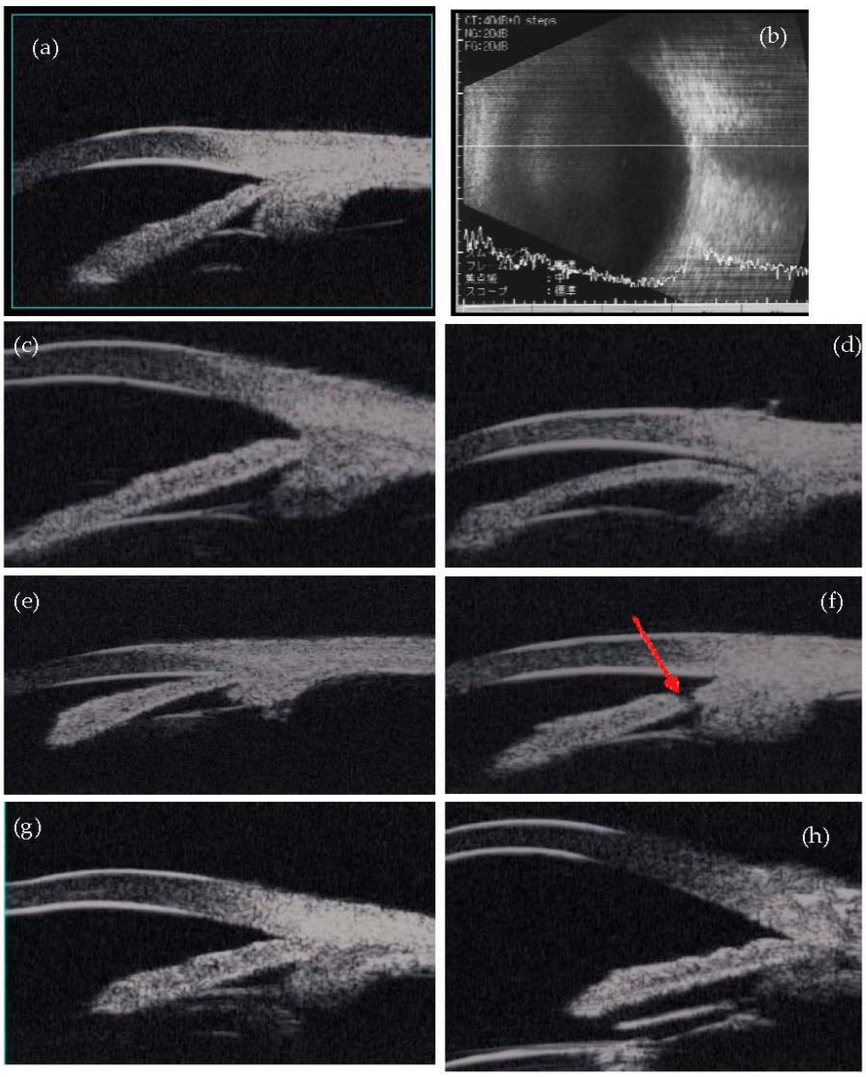

Figure 1. (a) UBM image of the normal anterior segment. This scan demonstrates all anterior segment structures, including anterior lens surface, iris, and ciliary body. In UBM, frequencies of 35-50 MHz and above provide over a threefold improvement in resolution compared with conventional ophthalmic ultrasound systems **(b)**. **b.** Conventional B-mode ultrasound image of the posterior segment. **c and d.** UBM image of the normal **(c)** and the PAC anterior segment **(d)**. Note the shallow anterior chamber depth of the PAC compared with the normal. **e and f.** UBM image of the anterior segment of the PACG patient before **(e)** and after laser iridotomy **(f)**. Note the increase of anterior chamber depth after laser iridotomy (LI). Arrow indicates the portion of the LI. **g and h.** UBM image of the anterior segment of the PACG patient before **(g)** and after cataract surgery (phacoemulsification and intraocular lens implantation) **(h)**. Note the increase of anterior chamber depth after cataract surgery.

3. Anterior-segment optical coherence tomography (AS-OCT)

AS-OCT is a non-contact imaging device allowing the visualization and measurement of the anterior ocular structures [11]. The Visante AS-OCT (Carl Zeiss Meditec Inc., Dublin, CA, USA) and the slit-lamp OCT (SL-OCT) (Heildelberg Engineering, Heildelberg, Germany) are the commercially available AS-OCT devices [11]. Compared with the OCT, the SL-OCT has a lower axial and transverse resolution of <25 μm and 20–100 μm, respectively. A major difference between the two devices is their scan speed, which is 2000 A-scans per s for Visante OCT, and 200 A-scans per s for SL-OCT. With a line scan of 256 and 215 A-scans, each image frame takes 0.13 and 1.08s for Visante OCT and SL-OCT, respectively [11]. Furthermore, the SL-OCT requires manual rotation of the scanning beam.

The advantages of the AS-OCT devices are non-contact, easy operation and a rapid image acquisition. The incorporation of automated analysis software allows for rapid estimation of the various anterior segment parameters, including corneal thickness, anterior chamber depth, etc.

Precise location of the scleral spur is a pre-requisite for reliable measurement of the angle. Limited by a relatively low-image resolution, the scleral spur may not always be visible even with the anterior segment OCT. Currently available software analysis programs require the manual localization of the scleral spur, which can at times be difficult, especially in closed angles or where there is a smooth transition from cornea to sclera [14]. Sakata et al. found that the sclera spur could not be detected in approximately 30% of the quadrants, this problem being worse in the superior and inferior quadrants [14].

It has been reported that AS-OCT is highly sensitive in detecting angle closure when compared with gonioscopy. Using gonioscopy as a reference standard results in AS-OCT having a sensitivity of 98.0% [15]. Several explanations have been suggested for the disparate findings between gonioscopy and AS-OCT [11]. The structures of the angle cannot be directly viewed by other techniques than gonioscopy (and may be SS-OCT in future), and therefore, cannot be identified. However, inadvertent pressure on the globe during gonioscopy may alter the configuration of the angle, leading to artificial widening of the angle. Another reason could be a difference in the definition angle closure. On gonioscopy, angle closure was defined as the apposition between the iris and the posterior trabecular meshwork, whereas on the AS-OCT, it was defined as any contact between the iris and the angle structures anterior to the sclera spur in 2-dimensional cross sections obtained by AS-OCT.

When this device is applied to the prospective observational case series, sensitivity and specificity are calculated as 98% (92.2%–99.6%) and 55.4% (45.2%–65.2%) [15]. The low specificity found with AS-OCT may limit the usefulness of these devices in screening for narrow angle.

A new generation of OCT [CASIA, Tomey, Nagoya, Japan], based on swept-source technology (SS-OCT) methods, has been recently developed for the assessment of the anterior ocular segment [16]. The SS-OCT is a variation of the Fourier-domain OCT, over tenfold faster than the time-domain OCT, and gives a three-dimensional (3D) image of the anterior ocular

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segment. Instead of using a spectrometer as in spectral-domain OCT, swept-source OCT uses a monochromatic tunable fast scanning laser source and a photodetector to detect wavelength-resolved interference signal [17]. The iris profiles and the angle configurations can be visualized three dimensionally and evaluated for 360° [16]. There might be apposition of the peripheral iris to the cornea that would be identified as a closed angle. SS-OCT imaging of the anterior segment could be useful to improve detection of angle closure, while the high cost of these devices may be a limiting factor for their use in screening examination.

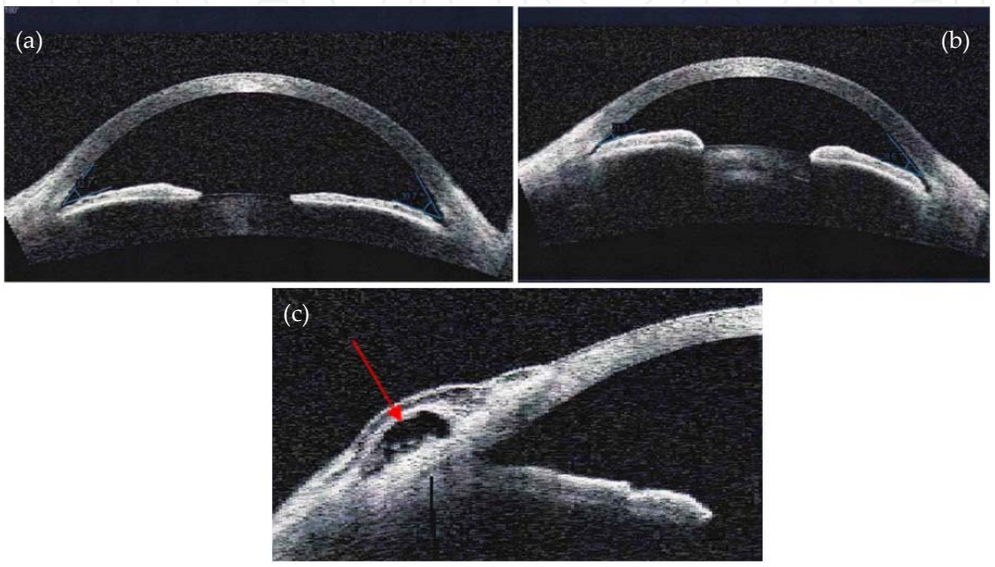

Figure 2. a and b. Transectional images of normal anterior segment **(a)** and plateau iris configuration **(b)** obtained using Visante AS-OCT (Carl Zeiss Meditec Inc., Dublin, CA, USA). Note the shallowperipheral anterior chamber depth of the plateau iris configuration compared with the normal. **c.** Transectional image of the conjunctival bleb after trabeculectomy using Visante AS-OCT.

4. Scanning peripheral anterior chamber depth analyzer

The scanning peripheral anterior chamber depth analyzer (SPAC) is a non-invasive device that objectively and quantitatively assesses the anterior ocular segment by employing the Scheimpflug camera principle [18]. The light from the slit lamp is in the visible spectrum and is projected from the temporal side at an angle of 60° from the optical axis. A camera records cross sectional slit images from the anterior cornea to the anterior iris, and does not rotate as Pentacam-Scheimpflug. The SPAC measures the peripheral ACD and converts the measurements into numerical and categorical grades by comparison with a normative database. SPAC quantitatively measures ACD in a noncontact fashion from the optical axis to the limbus in approximately 0.66 second and takes 21 consecutive slit-lamp images at 0.4 mm intervals. SPAC measurements ranged from 1 to 12, with 1 representing the shallowest anterior chamber. SPAC is equipped with an autofocusing system and a program for the detection of eyes with narrow angle, and usually completes measurement within 15 seconds for a pair of eyes by pressing

the start button. The SPAC also reports 3 categorical grades for risk of angle closure: S (for "suspect angle closure", if there were ≥4 measured points exceeding the 95% confidence interval [CI]), P (for "potential angle closure", if there were ≥4 points exceeding the 72% CI), and no suffix (for "normal") [18].

It has been previously reported that the results of peripheral anterior chamber measurement by SPAC were well correlated with those by the van Herick technique as well as Shaffer's grading system and the ultrasound biomicroscope [19].

Pentacam-Scheimpflug (rotating scheimpflug imaging) uses the Scheimpflug principle in order to obtain images of the anterior segment [10]. It has a rotating Scheimpflug camera that takes up to 50 slit images of the anterior segment in less than 2 seconds [20]. Software is then used to construct a three-dimensional image. It calculates data for corneal topography (anterior and posterior corneal surface) and thickness, anterior chamber depth (ACD), lens opacification and lens thickness. It also provides data on corneal wavefront of the anterior and posterior corneal surface using Zernike polynomials. Compared with SPAC, Pentacam is highly expensive.

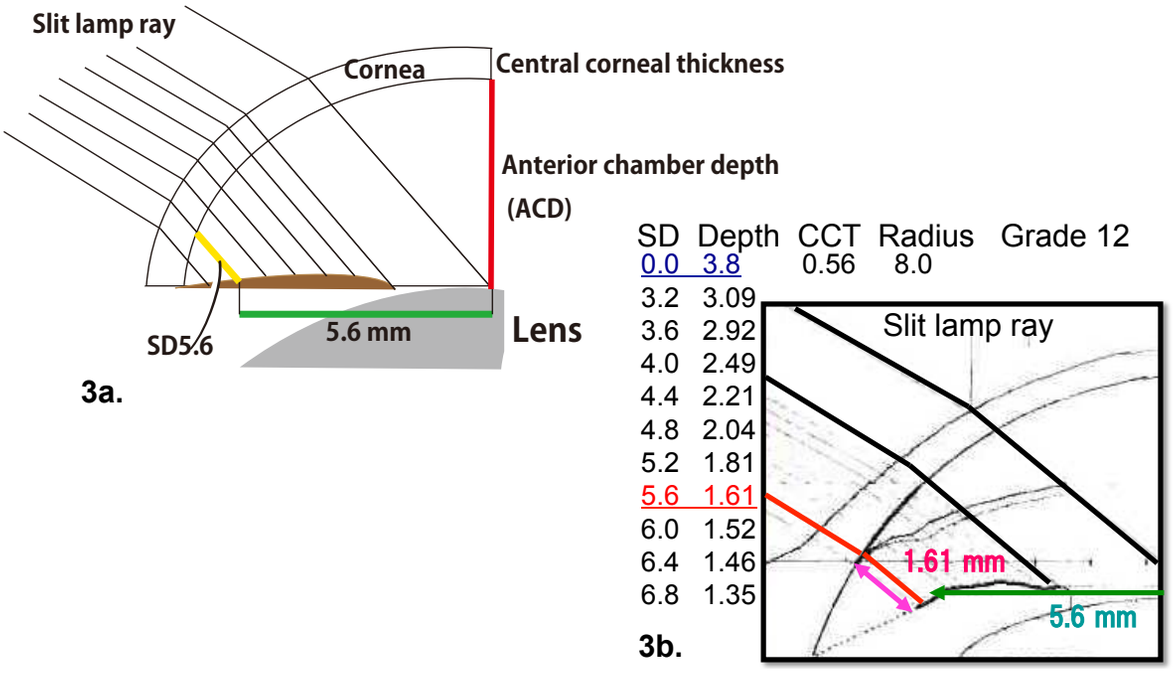

Figure 3. The SPAC automatically calculates central anterior chamber depths (ACD, red line) along the visual axis. SD5.6 (yellow line) means peripheral anterior chamber depth at 5.6 mm apart from the anterior pole of the lens. b. Printout of the results of SPAC measurement. The radius of curvature, the corneal thickness, and the anterior chamber depth are displayed. The SPAC anterior chamber depth value (corneal epithelium to anterior lens) was calculated by summing the corneal thickness and true anterior chamber depth measurements.

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5. Application of anterior chamber imaging instruments for glaucoma

The ideal community-based screening test should be clinician-independent, quick, and noninvasive, and have high sensitivity and specificity. SPAC has an advanatage of detecting eyes at risk of ACG by non-physicians in public health screening [20]. When using gonioscopy as the gold standard [8,10], the performance of SPAC combined grade (P or S and/or ≤ grade 5) gave a sensitivity and specificity of 93.0% and 70.8%, respectively [19]. With sequential testing using both SPAC and van Herick, the specificity and sensitivity improves to 94.4% and 87.0%, respectively [21, 22]. Therefore, the SPAC examination in conjunction with the van Herick method is considered as a choice of the first-line screening tests for angle closure following precise examination by OCT, UBM, or gonioscopy (Fig. 4). Kashiwagi et al. [23] proposed the protocol of detecting angle closure glaucoma using SPAC in public health examination. Their protocol consisted of 2 phases: primary screening using SPAC measurements of ACD by nonphysicians and definitive examination by glaucoma specialists (Fig. 4), and was revealed useful for detecting eyes at risk of angle closure glaucoma [22].

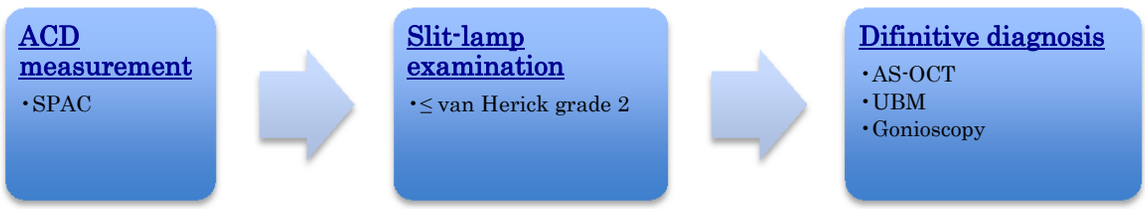

Figure 4. Flow chart for the detection and diagnosis of the narrow anterior chamber.

6. Research course

To investigate the frequency of eyes with a shallow anterior chamber at risk, the SPAC was used in subjects visiting a health screening center. In addition, the influences of age and sex on the distribution of central and peripheral ACD were also examined. Indeed, a productive approach would be to target high-risk groups, such as the elderly, far- sighted, and in particular, women.

7. Method used

Cross-sectional, observational, community-based study.

8. Participants

This was a cross-sectional study in an institutional setting [24]. Subjects older than 30 years were recruited at an annual community health checkup project held in the city of Akita (with a population of 325,537), the capital of Akita Prefecture, Japan. A total of 1,173 subjects participated in the comprehensive examinations from September 10, 2007 to October 26, 2007. Of these, 710 individuals underwent glaucoma screening. All of the participants were ethnically Japanese.

This study was performed after the approval by the Ethical Committee of Akita Prefecture Health Care Foundation. All study procedures adhered to the principles outlined in the Declaration of Helsinki for research involving human subjects, and all participants gave written informed consent for this research prior to their participation.

Exclusion criteria were (1) eyes with previous ocular surgery, trauma, or significant ocular disease; (2) eyes with any inborn aberrations, which might affect the morphology of the optic disc (eg, superior segmental optic disc hypoplasia).

9. Screening examination

The initial non-contact ocular examination was conducted by trained non-ophthalmologists and included measurement of refraction and keratometry (Topcon KR-8100PA, Tokyo, Japan), IOP by noncontact pneumotonometry (Topcon CT-90A, Tokyo, Japan), angle width (Scanning Peripheral Anterior Chamber Analyzer, Takagi Seiko, Nagano, Japan), non-mydriatic optic disc photography by stereoscopic fundus camera (30º angle, 3-DX/NM, Nidek, Gamagori, Japan), and confocal laser scanning tomography (Heidelberg Retina Tomograph II, software version 3.0, Heidelberg Instruments, Heidelberg, Germany). IOP was measured three times, and the mean value was adopted.

10. Definitive examination

When at least 1 finding suggested the presence of glaucoma, the subjects were recruited for definitive examination (Table 1). A definitive examination was performed when a subject was suspected to have glaucoma based upon the findings of the initial non-contact ocular examination. The definitive examination consisted of the following procedures: slit-lamp biomicroscopy, Goldmann applanation tonometry, gonioscopy, and optic nerve head evaluation using a Goldmann three-mirror lens (Haag-Streit International, Koeniz, Switzerland) and a visual field test with the Humphrey Field Analyzer II 24-2 SITA Standard Program (Carl Zeiss Meditec Inc, Dublin, CA, USA). Diagnosis of glaucoma was made based on optic disc appearance, including cup-to-disc ratio, rim width, nerve fiber layer defect, the visual field test, and the clinical records that were obtained through screening and definitive examinations. When

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present or suspected, glaucoma was categorized based upon the criteria of previous population studies (Table 2). In the definitive diagnosis, anomalous discs, including tilted discs, were carefully excluded. The final diagnosis of glaucoma was determined by 4 glaucoma specialists.

1) Intraocular pressure of 21mm Hg or higher in either eye
2) Presence of abnormalities in the stereoscopic fundus photographs, including one or more of the following glaucomatous changes:
1. Vertical cup/disc ratio of the optic nerve head was more than or equal to 0.6
2. Rim width at the superior portion (11-1 h), or inferior portion (5-7 h) was less than or equal to 0.2 of disc diameter ratio was
3. Difference in the vertical cup/disc more than or equal to 0.2 between both eyes
4. Nerve fiber layer defect or splinter disc hemorrhage was found
3) Failure to take stereoscopic fundus photographs

Table 1. Criteria for Definitive Examination Eligibility.

Category 1
The vertical cup-to-disc ratio of the optic nerve head is 0.7 or more, or the rim width at the superior portion (11-1 h) or the inferior portion (5-7 h) is 0.1 or less of the disc diameter, or the difference of the vertical cup-to-disc ratio is 0.2 or more between both eyes, or a nerve fiber layer defect is found, and the hemifield based visual field abnormality is compatible with optic disc appearance or nerve fiber layer defect.
Category 2
When the visual field test is not reliable or available, the cup-to-disc ratio of the optic nerve head is 0.9 or more, or the rim width at the superior portion (11-1 h) or the inferior portion (5-7 h) is 0.05 or less of the disc diameter, or the difference of the vertical cup-to-disc ratio is 0.3 or more between both eyes
Glaucoma suspect
When the cup-to-disc ratio of the optic nerve head is 0.7 or more portion (5-7 h) is 0.1 or less but more than 0.05 of the disc diameter but less than 0.9, or the rim width at the superior portion (11-1h) or the inferior, or the difference of the vertical cup-to-disc ratio is 0.2 or more but less than 0.3 between both eyes, or the nerve fiber layer defect is found, and the visual field test is not reliable or available or does not show hemi-field based compatible defect, the eye is diagnosed with suspected glaucoma

Table 2. Criteria for Glaucoma Diagnosis.

10.1. Category 1

The vertical cup-to-disc ratio of the optic nerve head is 0.7 or more, or the rim width at the superior portion (11-1 h) or the inferior portion (5-7 h) is 0.1 or less of the disc diameter, or the difference of the vertical cup-to-disc ratio is 0.2 or more between both eyes, or a nerve fiber layer defect is found, and the hemifield based visual field abnormality is compatible with optic disc appearance or nerve fiber layer defect.

10.2. Category 2

When the visual field test is not reliable or available, the cup-to-disc ratio of the optic nerve head is 0.9 or more, or the rim width at the superior portion (11-1 h) or the inferior portion (5-7 h) is 0.05 or less of the disc diameter, or the difference of the vertical cup-to-disc ratio is 0.3 or more between both eyes

10.3. Glaucoma suspect

When the cup-to-disc ratio of the optic nerve head is 0.7 or more portion (5-7 h) is 0.1 or less but more than 0.05 of the disc diameter but less than 0.9, or the rim width at the superior portion (11-1h) or the inferior, or the difference of the vertical cup-to-disc ratio is 0.2 or more but less than 0.3 between both eyes, or the nerve fiber layer defect is found, and the visual field test is not reliable or available or does not show hemi-field based compatible defect, the eye is diagnosed with suspected glaucoma

11. SPAC examination

All subjects underwent examination with SPAC. Paramedical staff correctively measured the ACD of 658 subjects (703 eyes of 354 men, 607 eyes of 304 women). SPAC examines the region from the optical axis to the temporal limbus in approximately 0.66 s, taking 21 consecutive slitlamp images at 0.4-mm intervals. The camera-captured cross-sectional slit-lamp images are immediately subjected to analysis, and the radius of curvature, the corneal thickness, and ACD values are displayed. The SPAC yields numeric and categorical grades that are calculated by comparison with the ACD values derived from a sample of Japanese subjects [18]. In our study, the range of ACD values of the patients was divided into 12 groups, each representing an equal increment in the ACD. Group 12 consisted of eyes with the deepest mean ACD values, whereas eyes with the shallowest mean ACD values were allocated to group 1.

Based on the data provided by SPAC, the following parameters were determined: distribution of ACD from the central and the peripheral region, distribution of the grades of ACD, and frequency of suspected (S) or possible (P) angle-closure eyes. The high risk of angle closure group includes eyes judged as S or P, or grade ≤5 by SPAC. These eyes were eligible for the definitive examination, The SPAC automatically calculates central ACD along the visual axis. Peripheral ACD means anterior chamber depth at 5.6 mm apart from the anterior pole of the lens (Fig. 3).

Of 1420 eyes of the 710 participants of the glaucoma screening study, reliable SPAC results were analyzed in 1310 eyes of 658 participants (Table 3). 104 eyes of fifty two participants were omitted from the study. The main reason for exclusion were that SPAC measurements could not be completed at the screening sites for various reasons, such as subjects' ocular or physical problems. 100 eyes were unable to fixate the fixation lamp due to poor visual acuity, and 2 subjects (4 eyes) were unable to keep their faces on the chin rest during measurement. Between the included and excluded subjects, the male/female ratio was not statistically different ($P = 0.44$, χ^2 test).

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	30's	40's	50's	60's	70's	Total
Male	21 (42, 3.2%)	105 (209, 16.0%)	126 (252, 19.2%)	73 (143, 10.9%)	29 (57, 2.2%)	354 (703, 53.7%)
Female	20 (40, 3.1%)	98 (196, 15.0%)	114 (228, 17.4%)	57 (114, 8.7%)	15 (29, 2.2%)	304 (607, 46.3%)
Total	41 (82, 6.3%)	203 (495, 37.8%)	240 (480, 36.6%)	130 (257, 19.6%)	44 (86, 6.6%)	658 (1310, 100%)

Table 3. Number of patients and eyes and the percentage of eyes (in parenthesis) examined by SPAC in each age group.

12. Data analysis

Descriptive statistical analysis for the determination of mean±standard deviation (SD) for continuous values was performed with SPBS software (Nankodo Publisher, Statistical Package for the Biosciences version 9.51, Tokyo, Japan). Data from both eyes of each individual were used, as it was more efficient and informative than data for single eyes. Comparisons of the different SPAC parameters between males and females or among each age group were analyzed with paired and unpaired t tests. Pearson correlation coefficients were calculated to assess the strength of the correlations between SPAC parameters and potential confounders. For all analyses, $P<0.05$ was considered statistically significant.

13. Results

13.1. Results of primary screening and definitive examination

A glaucoma specialist judged that 26 eyes of 19 subjects required the definitive examination, and all 19 subjects were enrolled in the definitive examination. The definitive examination revealed that 1 subject had PACG (0.08%), 1 subject had PAC (0.08%), and 1 had ciliary cyst (0.08%). None of all these eyes showed IOP elevation of more than 21mm Hg. Laser iridotomy was performed on PACG and PAC subjects. None of these subjects presented with subjective symptoms that are thought to demonstrate a strong association with angle closure.

13.2. Association of gender and age with SPAC parameters

Association of gender and age with SPAC parameters are summarized in Table 4.

In male subjects of 30 to 60 years of ages, the central and the peripheral anterior chamber depths were gradually decreased with ages. There were significant differences in these depths among 30, 40, and 50 age groups ($p<0.0001$). However, there was no significant difference in depths between 60 years and 70 years age group (Fig. 5). In female subjects, the ACD tended to be shallower in women than in men in each generation. The central and the peripheral anterior chamber depths were gradually decreased with ages. There were significant differences among

each age group (p<0.0001) (Fig. 5). Correlation of anterior chamber depth and aging was statistically analyzed using linear regression equation (y = ax + b). Both central and peripheral ACD were significantly correlated with aging (p<0.0001) (Fig. 6). Regression equations were shown in Fig. 6.

		30's	40's	50's	60's	70's
Male	Grade	11.2 (1.7)	10.3 (1.0)	9.6 (0.9)	9.0 (0.9)	9.3 (0.9)
	Central ACD	3.6 (0.3)	3.4 (0.2)	3.3 (0.3)	3.2 (0.3)	3.3 (0.3)
	Peripheral ACD	1.6 (0.2)	1.3 (0.2)	1.1 (0.1)	1.0 (0.1)	1.2 (0.1)
Female	Grade	10.4 (1.2)	9.7 (1.0)	8.8 (0.9)	8.5 (0.9)	7.5 (0.8)
	Central ACD	3.5 (0.4)	3.3 (0.3)	3.2 (0.3)	3.1 (0.3)	2.9 (0.3)
	Peripheral ACD	1.4 (0.1)	1.1 (0.1)	1.0 (0.1)	0.9 (0.08)	0.9 (0.1)

Table 4. Average and standard deviation (parenthesis) of central and peripheral anterior chamber depth in male and female in each age group.

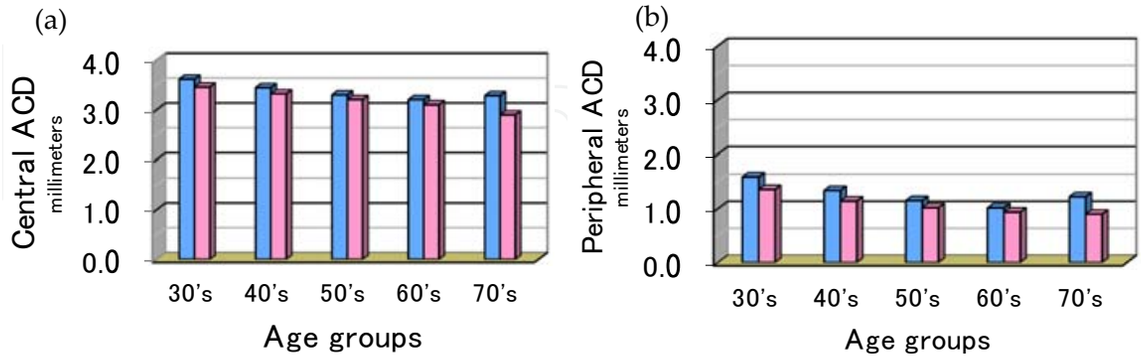

Figure 5. Average of central and peripheral anterior chamber depth at each age group. The central ACD (a) and the peripheral ACD (b) were measured at each age group in male (blue bars) and female (red bars). The y-axis represented anterior chamber depth (ACD) as millimeters. The decrease with age in each ACD was shown quantitatively in both men and women.

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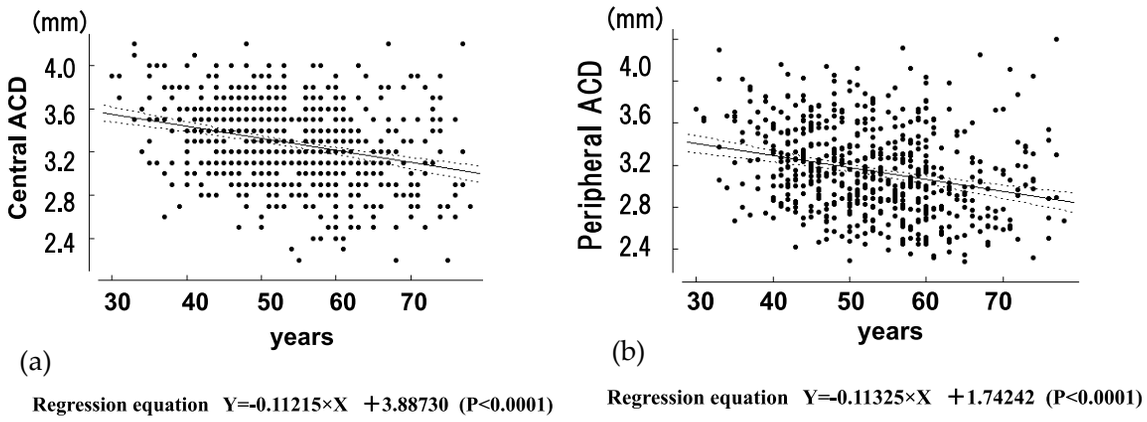

Figure 6. Correlation of the aging and the anterior chamber depth (a: central ACD, b: peripheral ACD) in all subjects. Although the distribution was wide, the central and peripheral ACD decreased with aging. There was a significant negative correlation between ACD and aging by lineal regression analysis.

13.3. Frequencies of eyes at risk

The high risk of angle closure group includes eyes judged as S or P, or grade ≤5 by SPAC. The prevalence of the high risk eyes was 1.7% and 2.3% among men and women, respectively. In particular, the prevalence of the high risk eyes was especially high in women 60 years age (6.1%) and 70 years age (6.9%). These data suggest that women older than 60 years may be vulnerable to possible angle closure. Women older than 60 years were at greater risk than male ($p<0.0021$) or female of younger age ($p<0.0001$) (Table 5). However, these eyes at risk did not show abnormalities in IOP or optic disc.

	30's	40's	50's	60's	70's	Total
Male	0/42 (0%)	0/209 (0.51%)	6/252 (2.4%)	5/143 (3.5%)	1/57 (1.8%)	12/703 (1.7%)
Female	0/40 (0%)	1/196 (0.05%)	4/228 (1.7%)	7/114 (6.1%)	2/29 (6.9%)	14/607 (2.3%)
Total	0/82 (0%)	1/405 (0.24%)	10/480 (2.1%)	12/257 (4.7%)	3/86 (3.5%)	26/1310 (2.0%)

Table 5. Number and frequencies (percentage) of eyes at risk in each age group.

14. Discussion

The present study qualitatively demonstrates the decrease with age in the peripheral and the central ACD in both men and women in the Japanese subjects attending the health community checkup. Eyes at risk for angle closure were more frequent in women 60 years of age or older. Compared with other populations in Japan, the similar results

were reported using SPAC [25] (Table 6). Kamo et al. [25] also reported that the frequency of eyes at risk for angle closure increased in women 50 years of age or older, and it is corresponding to our present results.

It has been reported that the prognosis of eyes with PACG especially acute angle closure is poor compared with that of eyes with PAC undergoing suitable treatment [6, 7]. Therefore, detecting eyes at risk of PACG or PAC is very important. The van Herick technique was employed for primary screening in previous epidemiologic studies of ACG eyes [21]. It has been reported that the results of peripheral ACD measurement by SPAC were well correlated with those by the van Herick technique as well as Shaffer's grading system and the ultrasound biomicroscope [22]. As the sequential testing using both SPAC and van Herick demonstrates high specificity and sensitivity [23], we considered that the SPAC examination in conjunction with the van Herick method is considered as a choice of the first-line screening tests for angle closure following precise examination by OCT, UBM, or gonioscopy. Further, almost all of the previous studies were conducted under the guidance of an ophthalmologist, and there are few reports of angle closure screening conducted as part of a public health examination that does not involve an ophthalmologist. Primary screening using SPAC measurements of ACD by nonphysicians seems to have possibility to induce cost-effective angle closure screening.

It seems that screening for PACG at least with SPAC and van Herick method should be performed in all the patients over 50 every 6 months and in those with shallow (peripheral) anterior chamber or high IOP, the angle should be further evaluated. LI should be performed in all PAC and PACG patients and those who do not respond to LI should undergo cataract surgery.

	40's	50's	60's	70's
Akita	0.24	2.1	4.7	3.5
Yamanashi[30)]	0	2.7	4.1	2.8

Table 6. Comparison of frequencies of eyes at risk (judged as S or P by SPAC) between Akita (the present result) and Yamanashi in Japan.

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