Correlation between Anterior and Posterior Segment Parameters in Normal Eye

Ji Yun Lee, MD, Kyung Rim Sung, MD, PhD, Ho Seok Chung, MD, Seung Bong Han, PhD

Department of Ophthalmology, University of Ulsan College of Medicine, Asan Medical Center, Seoul, Korea
Department of Applied Statistics, Gachon University, Seongnam, Korea

Purpose: To determine the relationship between anterior (AS) and posterior segment (PS) parameters measured by optical coherence tomography (OCT) in healthy subjects.

Methods: All subjects had a standard clinical examination, including axial length (AL) measurements, and good-quality scans obtained from anterior segment OCT and spectral domain OCT. AS parameters included central and peripheral corneal thickness, anterior chamber depth (ACD), angle opening distance (AOD750), iris thickness at 750 µm from the sclera spur, lens vault (LV), and perilimbalscleral thickness. PS parameters included circumpapillary retinal nerve fiber layer thickness (RNFLT), lamina cribrosa thickness, anterior lamina cribrosa depth (ALD), and optic disc area. Correlation matrix modeling and uni- and multivariate linear regression analyses were performed to explore the associations between ocular parameters.

Results: A total of 96 eyes of 96 subjects (mean age, 44.8 ± 12.6 years) were analyzed. The spherical equivalent was -1.6 ± 2.6 diopters, and AL was 24.3 ± 1.2 µm. Among the analyzed parameters, AL was associated with both ACD and LV (correlation coefficient, 0.579, -0.598). Other parameters did not show a significant association with one another. In multivariate analysis, ACD was associated with AOD750 (p < 0.001) and AL (p < 0.001). AL showed a correlation with ACD (p < 0.001) and LV (p < 0.001). Among PS parameters, RNFLT (p < 0.001) and ALD (p = 0.001) were significantly correlated with AL.

Conclusions: Our result revealed that ocular biometric parameters were dependent on AL regardless of their location, and that there was no evidence to support a direct relationship between AS and PS parameters. This study confirms that AL should be considered as one of the most important factors when inspecting and evaluating glaucoma patients.

Key words: Glaucoma, Anterior segment, Posterior segment, Optical coherence tomography, Axial length
develop in small and hyperopic eyes. However, a study by Yong et al. showed that one quarter of angle-closure patients in Singapore were myopic. Myopic angle-closure subjects had long vitreous cavity and axial length (AL), but there was no difference in anterior chamber depth (ACD) between the eyes of myopic angle-closure subjects and emmetropic or hyperopic angle-closure eyes, suggesting that the relationship between the AS and the PS of Caucasian eyes is different from that of Asian eyes.

Recent advances in imaging technology allow the visualization and quantification of the whole eyeball in a non-contact and non-invasive way. Spectral domain-optical coherence tomography (SD-OCT), introduced a few years ago, has been actively implemented in the diagnosis of glaucoma. Non-invasive imaging devices that display the structures of the AS with high resolution are also available. One of these is AS OCT. This technique can generate cross-sectional images showing the full features of the iris, anterior lens surface, anterior chamber (AC) dimensions, and AC angle, all in the same image frame. The reproducibility of measurements and clinical utility of this device were demonstrated in previous studies.

Using AS OCT and SD-OCT, we imaged AS and PS of the eyeball in healthy eyes and estimated the relationship between the various parameters obtained. Age is one of the important risk factors for degenerative ocular diseases including glaucoma. As the parameters may change with age, we included a wide range of healthy subjects of different ages in this study.

**Materials and Methods**

**Subjects**

The current study was a clinic-based, cross-sectional study. The subjects were volunteers, or employees or members of the families of employees of the Asan Medical Center, Seoul, Korea. They were consecutively recruited from March to October 2013. All participants underwent a comprehensive eye examination. This included best corrected visual acuity (BCVA) measurements using the logarithm of minimum angle of resolution (logMAR chart, The Light-house, Long Island, NY, USA), slit-lamp (model BQ 900, Haag-Streit, Bern, Switzerland) examination of the AS, and IOP measurement by Goldmann applanation tonometry. Additionally, the following procedures were performed: stereoscopic optic disc examination with a 90 diopter lens (Volk Optical Inc, Mentor, OH, USA), stereoscopic optic disc photography, retinal nerve fiber layer (RNFL) photography, CCT measurement (DGH-550 instrument, DGH Technology Inc., Exton, PA, USA), a VF test (Humphrey field analyzer, Swedish Interactive Threshold Algorithm [SITA] 24-2, Carl Zeiss Meditec, Dublin, CA, USA), gonioscopy, keratometry, AL measurement (IOL Master, Carl Zeiss Meditec Inc.), SD OCT imaging (Spectralis, Heidelberg Engineering, Heidelberg, Germany), and AS OCT imaging (Visante, version 2.0, Carl Zeiss Meditec).

For inclusion, all enrolled subjects had to meet the following criteria: BCVA of 20/30 or better, open angle on gonioscopy, no existing pathology by slit-lamp microscopy, and no significant media opacity that would prevent fundus examination, and no retinal pathology. Exclusion criteria were a history of any intraocular surgery including laser treatment, the use of topical drugs affecting pupil diameter, and a history of ocular disease or trauma. If both eyes qualified for the study, one eye was chosen at random. All participants consented to the study, and the study was approved by the Institutional Review Board of the Asan Medical Center (Seoul, Korea) and followed the tenets of the Declaration of Helsinki.

**Imaging of the Anterior Segment by AS OCT**

All imaging was performed under constant dim light (0.5 cd/m²), with the patient in a sitting position. Images were captured at the nasal and temporal angle quadrants (3 and 9 o’clock meridians and nasal-temporal angles at 0 to 180°) using an AS OCT operating in the enhanced AS single mode (scan length, 16 mm; 256 A-scans). Internal fixation was used in all subjects, and all scans were taken by a single well-trained operator who was masked to other clinical findings to minimize operator-related measurement variability. Three images were acquired from each eye, and the highest-quality image, defined as the one showing good
visibility of the scleral spur, was selected for analysis. A single examiner (J.Y.L.), who was masked to the other test results and all clinical information of the participants, analyzed all the images. ImageJ software (version 1.44, National Institutes of Health; Fig. 1) was used to measure ACD, angle opening distance (AOD750) and iris thickness at 750 µm from the scleral spur (IT750), CCT, lens vault (LV), peripheral corneal thickness (PCT), and perilimbalscleral thickness (PLST).

ACD was defined as the distance from the corneal endothelium to the anterior surface of the lens capsule. The scleral spur was defined as the point at which a change in curvature of the inner surface of the angle wall became apparent; it often presented as an inward protrusion of the sclera. After locating the scleral spur, IT750 was defined as the iris thickness measured at 750 µm from the spur. LV was defined as the perpendicular distance between the anterior pole of the crystalline lens and the horizontal line joining the two scleral spurs, and AOD750 was defined as the linear distance between the point of the inner corneoscleral wall (which is 750 µm anterior to the scleral spur) and the iris. PCT was the corneal thickness measured at 750 µm anterior to the scleral spur. PLST was the scleral thickness measured at the scleral spur (Fig. 1). The image acquisition procedure and analysis method are described elsewhere in detail.

**Imaging of the Posterior Segment by Spectralis OCT**

Average circumpapillary RNFL thickness (RNFLT) was measured by the Spectralis OCT. Lamina cribrosa assessment was performed using enhanced depth imaging (EDI) mode integrated within Spectralis OCT. The image acquisition procedure is described in detail elsewhere. Briefly, the entire ONH was scanned using a 6 mm length line (512 A-scans) at an interval of 50 µm. In our study, an average of 35 horizontal B-scans was obtained in EDI mode. From these B-scans, five frames (superior, mid-superior, center, mid-inferior, and inferior) that passed through the ONH were selected. Anterior lamina cribrosa depth (ALD), which was defined as the distance between the line connecting

**Figure 1.** Anterior segment parameters determined by anterior segment optical coherence tomography. ACD = anterior chamber depth; AOD750 = angle opening distance at 750 µm from the scleral spur; IT750 = iris thickness at 750 µm from the scleral spur; CCT = central corneal thickness; LV = lens vault; PCT = peripheral corneal thickness; PLST = perilimbalscleral thickness; SS = scleral spur.
both ends of Bruch’s membrane and the anterior border of the lamina cribrosa, was estimated. Lamina cribrosa thickness (LCT) was defined as the distance between the anterior and posterior borders of the LC, which were defined by a highly reflective structure below the optic cup. ALD and LCT were estimated at the presumed vertical center of each of the five B-scans (Fig. 2). Mean values from the five B-scan images were used for analysis. A single well-experienced examiner (H.S.C), who was masked to other test results and all clinical information of the participants, analyzed all of the images. Spectralis OCT also provides infrared scans, which allows better visualization of the optic disc margin. Optic disc margins were then manually measured on infrared images of Spectralis OCT. Optic disc margin was defined as the entire retinal aspect of the optic nerve as delineated by the inner aspect of the ring of Elschnig and optic disc area (DA) was measured using caliper tools, available in proprietary software (Heidelberg Eye explorer, Heidelberg Engineering, Heidelberg, Germany), on the Spectralis OCT.

**Statistical Analysis**

AS parameters included CCT, PCT, ACD, AOD750, IT750, LV, and PLST. PS parameters included RNFLT, LCT, ALD, and DA. AL was added as covariate. Correlation matrix modeling was performed to explore the associations between ocular parameters. Factors associated with AC angle width (AOD750) and AL were determined using univariate and multivariate linear regression analyses, respectively. Variables with a p-value less than or equal to 0.20 in the univariate analyses were included as candidate variables for the multivariate regression analysis. Statistical analyses were performed using SPSS version 15.0 (IBM Corp., Armonk, NY, USA). A p-value less than 0.05 was considered significant.

**Results**

A total of 96 eyes in 96 participants were included in the final analysis. Among the 96 participants, 31 were male and the rest were female. The mean age was 44.8 ± 12.6 years, and all were East Asians (Koreans). Histograms showing age distributions are shown in Fig. 3. The mean spherical equivalent was -1.6 ± 2.6 diopters, and the mean AL was 24.3 ± 1.2 μm. The demographics and outcomes of the AS and PS parameters of the participants are summarized in Table 1.

Table 2 shows the results of correlation matrix modeling. Among the analyzed parameters, those parameters which showed correlation coefficient (CC) greater than 0.5 were as
follows. ACD showed a correlation with three parameters, i.e., LV (CC = -0.553), AOD\textsubscript{750} (CC = 0.581), and AL (CC = 0.579). LV also showed an association with ACD (CC = -0.553) and AL (CC = -0.598). AL was associated with both ACD (CC = 0.579) and LV (CC = -0.598). Age showed the strongest correlation with LV (CC = 0.500).

When we performed multivariate analysis, ACD was associated with AOD\textsubscript{750} (p < 0.001) and AL (p < 0.001). In multivariate analysis to explore the association of AL with other parameters, AL showed a correlation with both AS and PS parameters (Table 3). Among AS parameters, ACD (p < 0.001) and LV (p < 0.001) were associated with AL. Among PS parameters, RNFLT (p < 0.001) and ALD

Table 1. Demographics and outcomes of AS and PS parameters of the participants (96 eyes in 96 patients)

| Value          |   |
|----------------|---|
| Age (years)    | 44.8 ± 12.6 |
| Male/female    | 31/65 |
| Right/left eye | 56/40 |
| SE (diopter)   | -1.6 ± 2.6 |
| CCT (µm)       | 547.8 ± 31.6 |
| AL (mm)        | 24.3 ± 1.2 |
| AOD\textsubscript{750} (mm) | 2.96 ± 0.38 |
| LV (µm)        | 404.5 ± 259.8 |
| AOD\textsubscript{750} (mm) | 0.507 ± 0.23 |
| IT\textsubscript{750} (mm) | 0.37 ± 0.62 |
| PCT (µm)       | 1.011 ± 120.42 |
| PLST (µm)      | 1.186 ± 99.47 |
| DA (mm\textsuperscript{2}) | 0.84 ± 0.16 |
| LCT (µm)       | 184.55 ± 26.33 |
| ALD (µm)       | 483.18 ± 140.39 |
| Circumpapillary RNFLT (µm) | 99.07 ± 9.47 |

Values are presented as mean ± standard deviation or number. AS = anterior segment; PS = posterior segment; SE = spherical equivalent; CCT = central corneal thickness; AL = axial length; ACD = anterior chamber depth; LV = lens vault; AOD = angle opening distance; IT = iris thickness; PCT = peripheral corneal thickness; PLST = perilimbal scleral thickness; DA = disc area; LCT = lamina cribrosa thickness; ALD = anterior lamina cribrosa depth; RNFLT = retinal nerve fiber layer thickness.

Table 2. Relationship between anterior parameters and posterior parameters assessed by correlation matrix modeling

| Value          |   |
|----------------|---|
| Age (years)    | 1.000 |
| Male/female    | -0.189 |
| Right/left eye | 1.000 |
| SE (diopter)   | 0.097 |
| CCT (µm)       | -0.181 |
| AL (mm)        | 0.100 |
| ACD (mm)       | -0.014 |
| LV (µm)        | 0.581 |
| AOD\textsubscript{750} (mm) | 0.042 |
| IT\textsubscript{750} (mm) | 0.058 |
| PCT (µm)       | 0.070 |
| PLST (µm)      | 0.023 |
| LCT (µm)       | 0.097 |
| ALD (µm)       | 0.142 |
| RNFLT (µm)     | 0.012 |
| DA (mm\textsuperscript{2}) | 0.203 |

CCT = central corneal thickness; ACD = anterior chamber depth; LV = lens vault; AOD = angle opening distance; IT = iris thickness; PCT = peripheral corneal thickness; PLST = perilimbal scleral thickness; LCT = lamina cribrosa thickness; ALD = anterior lamina cribrosa depth; RNFLT = retinal nerve fiber layer thickness; AL = axial length; DA = disc area.
Factors associated with ACD in univariate and multivariate linear regression analysis

| Parameter | Univariate model | Multivariate model |
|-----------|------------------|-------------------|
|           | Beta coefficient (95% CI) | p-value | Beta coefficient (95% CI) | p-value |
| CCT       | 0.002 (0, 0.005) | 0.063 | 0.653 (0.399, 0.906) | <0.001 |
| LV        | -0.001 (-0.001, 0) | <0.001 | 0.113 (0.065, 0.161) | <0.001 |
| AOD<sub>750</sub> | 0.929 (0.650, 1.208) | <0.001 | 0.929 (0.650, 1.208) | <0.001 |
| IT<sub>750</sub> | 0.295 (-0.406, 0.996) | 0.405 | 0.295 (-0.406, 0.996) | 0.405 |
| PCT       | 0 (0, 0.001) | 0.406 | 0 (0, 0.001) | 0.406 |
| PSLT      | 0 (-0.001, 0.001) | 0.784 | 0 (-0.001, 0.001) | 0.784 |
| LC        | 0.006 (0.003, 0.008) | <0.001 | 0.006 (0.003, 0.008) | <0.001 |
| ALD       | 0 (-0.001, 0) | 0.451 | 0 (-0.001, 0) | 0.451 |
| RNFL      | -0.007 (-0.015, 0.001) | 0.107 | -0.007 (-0.015, 0.001) | 0.107 |
| AOD<sub>750</sub> | 0.174 (0.123, 0.226) | <0.001 | 0.174 (0.123, 0.226) | <0.001 |
| DA        | -0.602 (-1.058, -0.145) | 0.01 | -0.602 (-1.058, -0.145) | 0.01 |

ACD = anterior chamber depth; CI = confidence interval; CCT = central corneal thickness; LV = lens vault; AOD = angle opening distance; IT = iris thickness; PCT = peripheral corneal thickness; PSLT = perilimbal scleral thickness; LC = lamina cribrosa; ALD = anterior lamina cribrosa depth; RNFL = retinal nerve fiber layer; AL = axial length; DA = disc area.

Factors associated with AL in univariate and multivariate linear regression analysis

| Parameter | Univariate model | Multivariate model |
|-----------|------------------|-------------------|
|           | Beta coefficient (95% CI) | p-value | Beta coefficient (95% CI) | p-value |
| CCT       | 0.007 (-0.001, 0.015) | 0.073 | 1.246 (0.736, 1.757) | <0.001 |
| ACD       | 1.857 (1.307, 2.406) | <0.001 | 1.246 (0.736, 1.757) | <0.001 |
| LV        | -0.003 (-0.004, -0.002) | <0.001 | -0.002 (-0.002, -0.001) | <0.001 |
| AOD<sub>750</sub> | 1.955 (0.928, 2.982) | <0.001 | 1.955 (0.928, 2.982) | <0.001 |
| IT<sub>750</sub> | -1.374 (-3.653, 0.906) | 0.234 | -1.374 (-3.653, 0.906) | 0.234 |
| PCT       | 0 (-0.002, 0.002) | 0.812 | 0 (-0.002, 0.002) | 0.812 |
| PSLT      | 0.001 (-0.001, 0.004) | 0.413 | 0.001 (-0.001, 0.004) | 0.413 |
| LC        | 0.011 (0.002, 0.021) | 0.018 | 0.011 (0.002, 0.021) | 0.018 |
| ALD       | 0.002 (0, 0.004) | 0.019 | 0.002 (0.001, 0.003) | 0.001 |
| RNFL      | -0.051 (-0.076, -0.027) | <0.001 | -0.035 (-0.053, -0.017) | <0.001 |
| DA        | -3.076 (-4.484, -1.669) | <0.001 | -3.076 (-4.484, -1.669) | <0.001 |

AL = axial length; CI = confidence interval; CCT = central corneal thickness; ACD = anterior chamber depth; LV = lens vault; AOD = angle opening distance; IT = iris thickness; PCT = peripheral corneal thickness; PSLT = perilimbal scleral thickness; LC = lamina cribrosa; ALD = anterior lamina cribrosa depth; RNFL = retinal nerve fiber layer; DA = disc area.

(p = 0.001) were significantly correlated with PS parameters (Table 4).

Discussion

This study assessed the relationship between AS and PS biometric parameters in healthy eyes. We found that ocular biometric parameters, regardless of location, were dependent on AL in healthy Korean subjects. AL showed strong correlation with some of both AS and PS parameters. Among AS biometrics, ACD and LV were independently associated with AL. A greater LV and a smaller ACD may cause narrowing of AC angles. Our analyses also showed that AOD<sub>750</sub> was strongly associated with ACD. Those observations that ocular biometric parameters dependent on AL, and angle narrowing is associated with
ACD were reported in previous studies.\textsuperscript{21-23} However, there still exists some controversy regarding these observations.\textsuperscript{24} Many studies showed that ocular risk factors for PACG, which shows a high prevalence in East Asia, include a shallow ACD, a thick lens, and a short AL.\textsuperscript{21,25,26} Furthermore, previous ethnic comparison studies yielded consistent findings; using four gender- and age-matched cohorts, including Caucasians, American Chinese, and Southern and Northern mainland Chinese, in a cross-sectional clinic-based study, Wang et al.\textsuperscript{27} reached the conclusion that Caucasians had deeper AC than each of the Chinese groups, independent of refractive status and integral globe size. However, Yong et al.\textsuperscript{4} found that one quarter of PACG patients have myopic refraction in Singapore, and in terms of refractive status, there was no significant difference with respect to ACD. Moreover, another recent study from Singapore found that, although the most important independent factors of angle closure were female gender, Chinese race, a shorter AL, and a shallower ACD, when evaluating risk of angle closure, differences in race and gender were not fully explained by variations in AL or ACD.\textsuperscript{24,25} Moreover, population-based research showed that only a small proportion of subjects with narrow angles in gonioscopic examination develop PACG.\textsuperscript{28,29}

AL showed a negative correlation with RNFLT in our study. A thinner RNFL was observed in high myopic eyes in previous studies.\textsuperscript{30-32} This may be caused by thinning of the RNFL as the eyeball elongates or by a magnification effect of the OCT measurement.\textsuperscript{33} Lamina cribrosa depth assessed by ALD is positively associated with AL. All three optic disc related parameters, namely, ALD, LCT, and DA, showed an association with AL in univariate analysis. Since these parameters may be related to one another, we performed multivariate analysis and found ALD was most strongly associated with AL. Lamina cribrosa related parameters were recently proposed as diagnostic markers for glaucoma severity in some publications.\textsuperscript{34} However, since these LC related parameters can be affected by AL,\textsuperscript{35} a confounding effect should be considered when using such a diagnostic strategy.

Our study did not find a specific relationship between anterior biometric parameters and posterior biometric parameters. In other words, AS parameters, such as AOD,\textsubscript{750}, LV, and ACD, were associated with one another, and were strongly affected by AL; however, PS parameters were not directly related to AS parameters.

Our study had several limitations. These include the small sample size and the study had a cross-sectional design, changes over time were not considered, and thus the results should be taken with caution.

In summary, our data reveal that ocular biometric parameters are dependent on AL regardless of their location, and that there is no evidence to support a direct relationship between AS and PS parameters. This study confirms that AL should be considered as one of the most important factors when inspecting and evaluating glaucoma patients.

Acknowledgments

The authors have no proprietary interests in, or financial support for, the development or marketing of instruments or equipment mentioned in this article or any competing instruments or equipment.

References

1. Gordon MO, Beiser JA, Brandt JD, et al. The Ocular Hypertension Treatment Study: baseline factors that predict the onset of primary open-angle glaucoma. Arch Ophthalmol 2002;120:714-20;discussion 829-30.
2. Ocular Hypertension Treatment Study Group and the European Glaucoma Prevention Study Group. The accuracy and clinical application of predictive models for primary open-angle glaucoma in ocular hypertensive individuals. Ophthalmology 2008;115:2030-6.
3. Brandt JD. Corneal thickness in glaucoma screening, diagnosis, and management. Curr Opin Ophthalmol 2004;15:85-9.
4. Yong KL, Gong T, Nongpiur ME, et al. Myopia in Asian subjects with primary angle closure: implications for glaucoma trends in East Asia. Ophthalmology 2014;121:1566-71.
5. Na JH, Sung KR, Lee JR, et al. Detection of glaucomatous progression by spectral-domain optical coherence tomography. Ophthalmology 2013;120:1388-95.
6. Na JH, Sung KR, Baek S, et al. Detection of glaucoma progression by assessment of segmented macular thick-
ness data obtained using spectral domain optical coherence tomography. Invest Ophthalmol Vis Sci 2012;53:3817-26.
7. Sung KR, Kim JS, Wollstein G, et al. Imaging of the retinal nerve fibre layer with spectral domain optical coherence tomography for glaucoma diagnosis. Br J Ophthalmol 2011;95:909-14.
8. Kim DY, Sung KR, Kang SY, et al. Characteristics and reproducibility of anterior chamber angle assessment by anterior-segment optical coherence tomography. Acta Ophthalmol 2011;89:435-41.
9. Lee Y, Sung KR, Na JH, Sun JH. Dynamic changes in anterior segment parameters after laser peripheral iridotomy assessed by anterior segment optical coherence tomography. Invest Ophthalmol Vis Sci 2013;54:3166-70.
10. Lee KS, Sung KR, Shon K, et al. Longitudinal changes in anterior segment parameters after laser peripheral iridotomy assessed by anterior segment optical coherence tomography. Invest Ophthalmol Vis Sci 2013;54:3166-70.
11. Cheon MH, Sung KR, Choi EH, et al. Effect of age on anterior chamber angle configuration in Asians determined by anterior segment optical coherence tomography; clinic-based study. Acta Ophthalmol 2010;88:e205-10.
12. Sun JH, Sung KR, Yun SC, et al. Factors associated with anterior chamber narrowing with age: an optical coherence tomography study. Invest Ophthalmol Vis Sci 2012;53:2607-10.
13. Sakata LM, Lavanya R, Friedman DS, et al. Assessment of the scleral spur in anterior segment optical coherence tomography images. Arch Ophthalmol 2008;126:181-5.
14. Wang B, Sakata LM, Friedman DS, et al. Quantitative iris parameters and association with narrow angles. Ophthalmology 2010;117:11-7.
15. Nongpiur ME, He M, Amerasinghe N, et al. Lens vault, thickness, and position in Chinese subjects with angle closure. Ophthalmology 2011;118:474-9.
16. Sung KR, Lee KS, Hong JW. Baseline anterior segment parameters associated with the long-term outcome of laser peripheral iridotomy. Curr Eye Res 2015;40:1128-33.
17. Han S, Sung KR, Lee KS, Hong JW. Outcomes of laser peripheral iridotomy in angle closure subgroups according to anterior segment optical coherence tomography parameters. Invest Ophthalmol Vis Sci 2014;55:6795-801.
18. Lee JR, Sung KR, Han S. Comparison of anterior segment parameters between the acute primary angle closure eye and the fellow eye. Invest Ophthalmol Vis Sci 2014;55:3646-50.
19. Chung HS, Sung KR, Lee KS, et al. Relationship between the lamina cribrosa, outer retina, and choroidal thickness as assessed using spectral domain optical coherence tomography. Korean J Ophthalmol 2014;28:234-40.
20. Kim S, Sung KR, Lee JR, Lee KS. Evaluation of lamina cribrosa in pseudoexfoliation syndrome using spectral-domain optical coherence tomography enhanced depth imaging. Ophthalmology 2013;120:1798-803.
21. Aung T, Nolan WP, Machin D, et al. Anterior chamber depth and the risk of primary angle closure in 2 East Asian populations. Arch Ophthalmol 2005;123:527-32.
22. Lowe RF. Aetiology of the anatomical basis for primary angle-closure glaucoma. Biometrical comparisons between normal eyes and eyes with primary angle-closure glaucoma. Br J Ophthalmol 1970;54:161-9.
23. Lim KJ, Hyung SM, Youn DH. Ocular dimensions with aging in normal eyes. Korean J Ophthalmol 1992;6:19-31.
24. Congdon NG, Youlin Q, Quigley H, et al. Biometry and primary angle-closure glaucoma among Chinese, white, and black populations. Ophthalmology 1997;104:1489-95.
25. Lavanya R, Wong TY, Friedman DS, et al. Determinants of angle closure in older Singaporeans. Arch Ophthalmol 2008;126:686-91.
26. Leung CK, Palmiero PM, Weinreb RN, et al. Comparisons of anterior segment biometry between Chinese and Caucasians using anterior segment optical coherence tomography. Br J Ophthalmol 2010;94:1184-9.
27. Wang D, Huang G, He M, et al. Comparison of anterior ocular segment biometry features and related factors among American Caucasians, American Chinese and mainland Chinese. Clin Exp Ophthalmol 2012;40:542-9.
28. Wang N, Wu H, Fan Z. Primary angle closure glaucoma in Chinese and Western populations. Chin Med J (Engl) 2002;115:1706-15.
29. Alsibirk PH. Anatomical risk factors of angle-closure glaucoma. A 10-year study of limbal and axial anterior chamber depths in a risk population. Ugeskr Laeger 1994;156:5117-21.
30. Rauscher FM, Sekhon N, Feuer WJ, Budenz DL. Myopia affects retinal nerve fiber layer measurements as determined by optical coherence tomography. J Glaucoma 2009;18:501-5.
31. Leung CK, Mohamed S, Leung KS, et al. Retinal nerve fiber layer measurements in myopia: an optical coherence tomography study. Invest Ophthalmol Vis Sci 2006;47:5171-6.
32. Savini G, Barboni P, Parisi V, Carbonelli M. The influence of axial length on retinal nerve fibre layer thickness and optic-disc size measurements by spectral-domain OCT. Br J Ophthalmol 2012;96:57-61.
33. Oner V, Aykut V, Tas M, et al. Effect of refractive status on
peripapillary retinal nerve fibre layer thickness: a study by RTVue spectral domain optical coherence tomography. Br J Ophthalmol 2013;97:75-9.

34. Morgan-Davies J, King AJ, Aspinall P, O’Brien CJ. Measurement of a novel optic disc topographic parameter, “spikiness”, in glaucoma. Graefes Arch Clin Exp Ophthalmol 2000;238:669-76.

35. Ren R, Wang N, Li B, et al. Lamina cribrosa and peripapillary sclera histomorphometry in normal and advanced glaucomatous Chinese eyes with various axial length. Invest Ophthalmol Vis Sci 2009;50:2175-84.