Anterior Chamber Measurements by Pentacam and AS-OCT in Eyes With Normal Open Angles

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Purpose: To assess the reproducibility and agreement of anterior chamber measurements between the Pentacam (PTC) and the Anterior segment optical coherence tomography (AOCT) in normal healthy eyes with open angle.

Methods: Prospective cross-sectional comparative case series. A total of 162 eyes of 81 healthy volunteers with normal open angle were included in this study. Anterior chamber angle (ACA) and anterior chamber depth (ACD) were measured with PTC and AOCT. Intra-observer variability and inter-methods agreement of both instruments for ACA and ACD were evaluated.

Results: Values of temporal and nasal ACA measured by two instruments were similar, and the results of ACD were also not significantly different between modalities (p>0.01). ACA and ACD measurements by PTC and AOCT showed good intra-observer and inter-method agreements (all >0.9).

Conclusions: PTC and AOCT are presumed to be very useful for the anterior chamber angle examination. They may provide good images and quantitative data about the angle structures including ACA and ACD.

Key Words: Anterior chamber angle, Anterior chamber depth, Anterior segment optical coherence tomography, Pentacam.
Subjects and Methods

After obtaining approval of the Institutional Review Board, 81 healthy volunteers with gonioscopically confirmed normal open angle were enrolled to this study. Informed consent was obtained from each subject, then ACA and ACD were measured by PTC and AOCT under the uniform dim illumination by a single investigator. Images of the temporal and nasal angles can be taken more easily than those of superior and inferior angles, and they need no eyelid manipulation to expose the limbus. So, the angle images were captured using the horizontal linear scan protocol (from 3-o’clock to 9-o’clock direction). ACA was measured automatically by PTC and AOCT. ACA was defined as the distance from the posterior vertex of the corneal endothelium to the anterior surface of the crystalline lens along the optical axis. All measurements were repeated 3 times, and their average was used to further analyses.

All statistical analysis were performed using SPSS for Windows, version 11.0 (SPSS Inc, Chicago, Illinois, USA) except intraclass correlation coefficient (ICC) test calculated by using Statistical Analysis Software, version 8.2 (SAS Institute, Cary, NC, USA). p<0.01 was considered as statistically significant.

Results

Among 81 healthy volunteers, 51 (63.0%) were men. Mean age was 22.3±3.5 years (range, 18 to 33 years). And mean refractive error was -3.70±2.68 diopters for right eye and -3.62±2.81 diopters for left eye.

Data about ACA and ACD by two modalities are shown in Table 1. ACA taken with PTC were 45.41±5.30° (31.47-59.47) (temporal side), 43.58±5.04° (33.97-56.67) (nasal side) on right eyes and 47.32±5.66° (33.50-60.40) (temporal side), 44.80±5.38° (31.50-56.90) (nasal side) on left eyes. ACA taken with AOCT were 46.18±5.50° (31.67-59.67) (temporal side), 45.13±5.89° (31.00-57.33) (nasal side) on right eyes and 46.67±5.98° (34.67-61.00) (temporal side), 44.90±5.94° (30.33-59.67) (nasal side) on left eyes. ACD taken with PTC were 3.33±0.27 mm (2.57-3.96) on right eyes and 3.34±0.28 mm (2.59-4.04) on left eyes. ACD taken with AOCT were 3.32±0.26 mm (2.56-3.95) on right eyes and 3.31±0.28 mm (2.54-4.06) on left eyes.

Temporal and nasal ACA did not show significant difference between PTC and AOCT (p>0.01). And ACD measured by two instruments were also similar (p>0.01).

ICC for evaluating intra-observer variability of each instrument are shown in Table 2. Each parameter was measured 3 times. ACD and ACA measurements using two study modalities had good intraobserver agreements.

Inter-methods agreement was analyzed using the Bland-Altman analysis (Fig. 1). ACA and ACD measurements by two study modalities showed a good agreement each other.

At last, the linear regression analysis was performed to seek the relationship between ACD and ACA (Fig. 2).

Table 1. Anterior chamber angle and anterior chamber depth measurements by Pentacam and anterior segment optical coherent tomography

|                | Right eyes |                | Left eyes |                |
|----------------|------------|----------------|-----------|----------------|
|                | PTC        | AOCT           | p-value   | PTC            | AOCT           | p-value   |
| Temporal ACA   | 45.41±5.30°| 46.18±5.50°    | 0.143     | 47.32±5.66°   | 46.67±5.98°   | 0.432     |
|                | (31.47-59.47) | (31.67-59.67) |           | (33.50-60.40) | (34.67-61.00) |           |
| Nasal ACA      | 43.58±5.04°| 45.13±5.89°    | 0.016     | 44.80±5.38°   | 44.90±5.94°   | 0.673     |
|                | (33.97-56.67) | (31.00-57.33) |           | (31.50-56.90) | (30.33-59.67) |           |
| ACD            | >0.01*     | >0.01*         | 0.34      | >0.01*        | >0.01*        | 0.05      |
|                | 3.33±0.27 mm | 3.32±0.26 mm   |           | 3.34±0.28 mm  | 3.31±0.28 mm  |           |
|                | (2.57-3.96) | (2.56-3.95)    |           | (2.59-4.04)   | (2.54-4.06)   |           |

ACA=anterior chamber angle; ACD=anterior chamber depth; AOCT=Anterior segment optical coherent tomography; PTC=Pentacam; °=degrees; Values given as means±standard deviation; If p<0.01: statistically significant; * p-value when compared temporal and nasal anterior chamber angle measured by each methods.

Table 2. Intraobserver agreement between the Pentacam and anterior segment optical coherence tomography based on intraclass correlation coefficients for measuring anterior chamber angles and anterior chamber depth

|                | Right eyes |                | Left eyes |                |
|----------------|------------|----------------|-----------|----------------|
|                | PTC        | AOCT           | PTC        | AOCT           |
| Temporal ACA   | 0.96       | 0.91           | 0.91       | 0.93           |
| Nasal ACA      | 0.92       | 0.93           | 0.96       | 0.94           |
| ACD            | 0.99       | 0.99           | 0.99       | 0.99           |

ACA=anterior chamber angle; ACD=anterior chamber depth; AOCT=Anterior segment optical coherent tomography; PTC=Pentacam.
Average of measurements on each eye were used for analysis, and the best-fit line is also shown in the figures (PTC, $R^2=0.40$, $p<0.001$; AOCT, $R^2=0.55$, $p=0.001$).

**Discussion**

In the present study, the measurements of ACA and ACD were evaluated by two new image modalities; PTC and AOCT. Their data were similar each other, and they showed good intra-observer reproducibility and inter-method agreement.

To judge the intra-observer reproducibility, the ICCs were calculated. It is one of the most popularly used in order to find an intra-observer agreement for various tasks in other area of medical imaging.$^{11}$ To our knowledge, this is the first article to report the intra-observer agreement of ACA and ACD by PTC and AOCT. They showed the excellent reproducibility of ACA and ACD using PTC and AOCT by a single observer.

Previously, Bland and Altman proposed an informative method to evaluate actual interdevice agreement that allows clinicians to determine for any given use whether the measurements provided by two devices are interchangeable.$^{12}$ Numerically, the 95% Limit of agreement (LoA) gives the clinician an indication of how much the devices may differ in 95% of cases- that is, in most of their patients. In this

![Fig. 1. Bland-Altman analysis for the inter-methods agreement for Pentacam (PTC) and Anterior segment optical coherence tomography (AOCT). (a) Anterior chamber angle; (b) Anterior chamber depth.](image1)

![Fig. 2. Linear regression analysis between anterior chamber angle and anterior chamber depth for the Pentacam (PTC) (a) and the Anterior segment optical coherence tomography (AOCT) (b).](image2)
report, the mean differences in ACA and ACD as measured with PTC and AOCT were not statistically significant and clinically negligible—approximately 0.543°, 0.021 mm (approximately 1%, 0.6%). The 95% LoA and Brand-Altman plots show a relatively large range of interdevice differences for all comparison, especially ACA (approximately 20° (45% of mean ACA); 0.47 mm (15% of mean ACD)), and this may be too broad for use interchangeably. Other studies have assessed agreement of ACD with Orbscan and PTC. Measurements with Orbscan were on the average 0.046 mm longer than with Pentacam. The 95% LoA corresponds to +5.6 to −2.5% of the mean ACD. Reddy and associates compared ACD measurements by three methods: Orbscan II, IOL Master, and contact A-scan ultrasound. They found that ultrasound measured ACD 13% shorter, whereas the other two modalities showed good correlation. The authors, however, did not assess interdevice agreement by Bland-Altman plots or 95% LoA. Koranyi et al. also showed excellent correlations between three optical modalities, Orbscan, conventional noncontacting Scheimpflug camera, and optical pachymetry, to determine ACD with mean differences of approximately 1.5%, whereas ultrasound measured ACD shorter. In a recent study by Buehl et al., 95% LoA of approximately 0.4 mm were reported when ACD measurements by PTC, Orbscan I, and ACMaster were compared. It is similar to the result of this study.

In addition, in this study, it is also noticed that the temporal ACA was significantly larger than the nasal ACA by both instruments (all p<0.001, Table 1). And ACA and ACD showed moderate correlation, however they did not have an excellent relationship (Fig. 2).

Even though this study included only normal subjects with open angle, our methodology could be applied to other patients who had closed or occludable angle. PTC and AOCT are presumed to be very useful for angle examination. They may provide good images and quantitative data about the angle structures including ACA and ACD.

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