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Quantitative assessment of anterior chamber volume using slit-lamp OCT and Pentacam

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PURPOSE. *To quantitatively assess and compare the anterior chamber volume (ACV) by different anterior segment imaging techniques.*
METHODS. *Forty healthy eyes of 40 patients were recruited and three consecutive measurements of ACV were determined prospectively utilizing SL-OCT and Pentacam. Statistical significance of interdevice differences between measurements was evaluated by unpaired t test and Bland-Altman analysis. The repeatability of three consecutive measurements was analyzed by repeated measured analysis of variance.*
RESULTS. *Eighty eyes of 40 patients (18 female, 22 male) with a mean spherical error of –0.55±1.4 diopters were included in the study. Mean ACV were detected as 163.34±29.76 mm^3 by Pentacam and 164.14±28.44 mm^3 by SL-OCT (unpaired t test, p=0.872). Pentacam and SL-OCT displayed a high intrasession repeatability (repeated measured analysis of variance, p>0.05). ACV values detected by SL-OCT were clinically interchangeable with Pentacam.*
CONCLUSIONS. *Noncontact measurements of ACV using SL-OCT and Pentacam were easy to handle and demonstrated good repeatability. The tested devices were regarded as compatible in measuring ACV. (Eur J Ophthalmol 2009; 19: 411-5)*

KEY WORDS. *Anterior chamber volume, SL-OCT, Pentacam*

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INTRODUCTION

In current practice, quantitative evaluation of anterior chamber parameters like anterior chamber diameter, depth, and volume are possible with the use of ultrasound biomicroscopy, optical coherence biometry, scanning slit topography, Scheimpflug imaging, and anterior segment optical coherence tomography devices (AS-OCT). Video acquisitions of rotating Scheimpflug sections like Pentacam combine multiple two-dimensional sections to reconstruct the three-dimensional anatomy of the cornea and anterior chamber (1). AS-OCT is introduced as a novel method for the diagnosis, treatment, and follow-up of anterior segment diseases and surgeries. Izatt and colleagues were the first to suggest AS-OCT for anterior segment imaging in 1994 (2). High-speed AS-OCT started to be used to obtain anterior segment images of good quality in 2001 (3).

Assessment of anterior chamber volume (ACV) is useful in physiopathologic research of aqueous humor dynamics, primary angle closure glaucoma, pigmentary glaucoma, ocular pharmacokinetics, and keratorefractive surgery (4). Pentacam and SL-OCT may serve as a noncontact and imaging tool for anterior chamber parameters in daily clinical practice. Nevertheless, there is no proven consistency between these imaging methods. The objective of the current study was to compare the anterior chamber volume (ACV) assessed by SL-OCT and Pentacam. Intrasession repeatability of each device was evaluated by analyzing three consecutive measurements.

METHODS

Healthy phakic volunteers were enrolled in the study. An informed consent was obtained from all of the patients,

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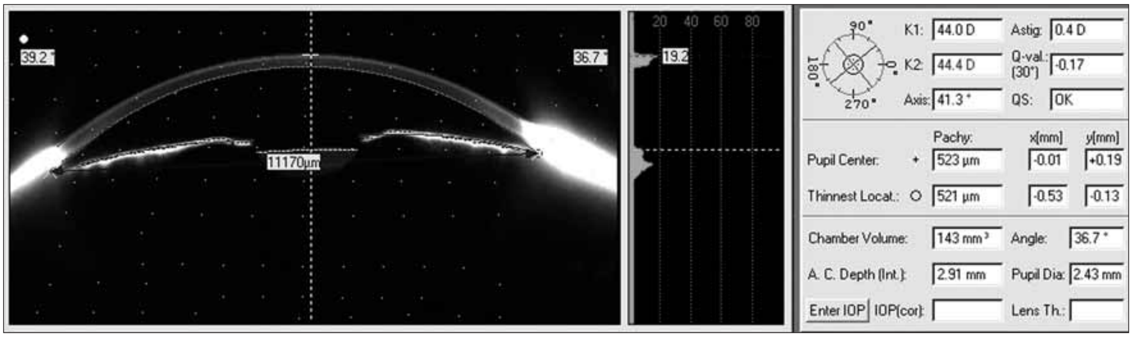

Fig. 1 - *Anterior chamber parameters and volume assessment using Pentacam.*

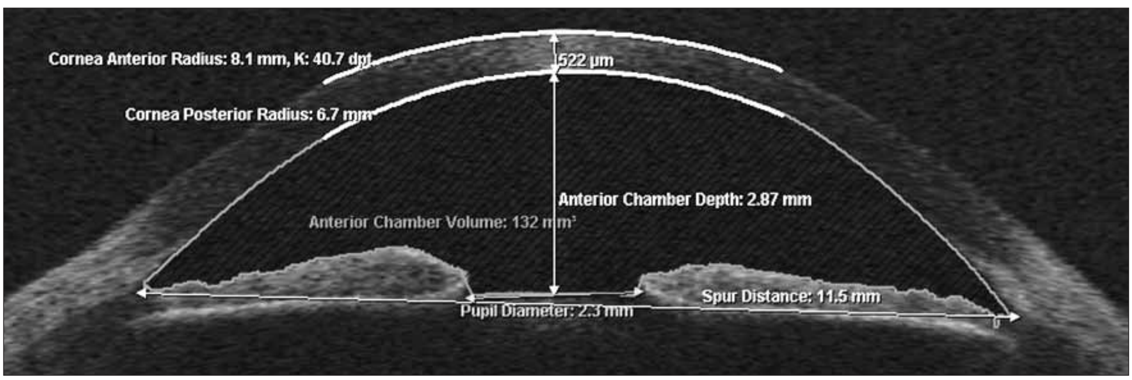

Fig. 2 - *Anterior chamber parameters and volume assessment of the same eye in Figure 1 using SL-OCT.*

and all tenets of the Declaration of Helsinki were followed. A complete ophthalmologic examination was performed including visual acuity, intraocular pressure measurement with automated tonometer, and anterior and posterior segment evaluation. Patients younger than 18 years and with any ocular disease, previous ocular surgery, laser trabeculoplasty, laser iridoplasty, or laser iridotomy were excluded from the study.

For each patient, three consecutive measurements were obtained using SL-OCT (Heidelberg Engineering GmbH, Heidelberg, Germany) and Pentacam (Oculus Optikgeräte GmbH, Wetzlar, Germany) under the same conditions by a single examiner in the same session. Imaging with all devices was performed with room lights switched off. All measurements were performed perpendicularly to the ocular surface using SL-OCT and Pentacam consecutively that allowed a perpendicular radial projection of anterior segment in the 0- to 180-degree meridian. Anterior segment images having unclear scleral spurs were excluded.

Anterior chamber volume measurement

Slit-lamp OCT. SL-OCT device is a slit-lamp-adapted time-domain system and employs a noncontact low coherence interferometry that obtains high resolution images. It uses a light source of a superluminescent diode with a 1310 nm wavelength. The axial resolution is approximately 15 µm and the transverse resolution is approximately 75 µm. The sample arm of the interferometer and the scanning module are integrated into the projected slit of a standard clinical slit-lamp which enables the exact adjustment of OCT infrared light to the anterior segment structures to be examined. Manual rotation of the slit beam is required and there is no internal fixation target. The scanning depth and width are 7.0 and 15.0 mm, respectively, with a scanning speed of 200 Hz. The corneal refractive index is 1.376, which is derived from the Gullstrand model of the human eye. The final image is a grayscale two-dimensional representation in a cross-sectional plane. In order to determine the ACV, measuring points were set at the corresponding scleral spur and the apex of iris manually. Consequently, ACV was calculated automatically by the internal software.

Pentacam

Pentacam system uses rotating Scheimpflug imaging for noninvasive and three-dimensional anterior segment evaluation. It uses a monochromatic slit-light source (blue LED at 475 nm) to measure anterior segment topography.

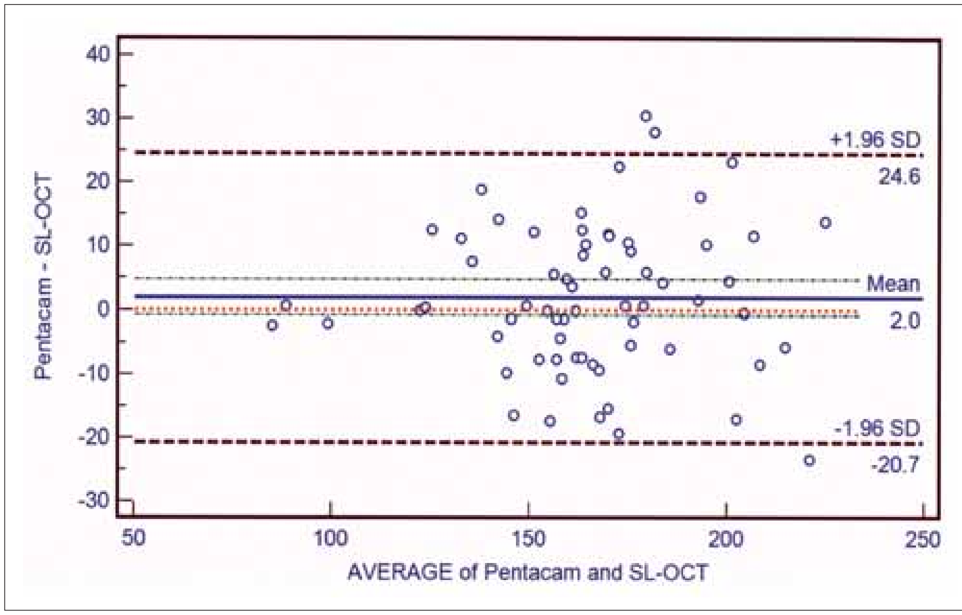

Fig. 3 - *Bland-Altman plots of difference in anterior chamber volume between SL-OCT and Pentacam against the average of the anterior chamber volume.*

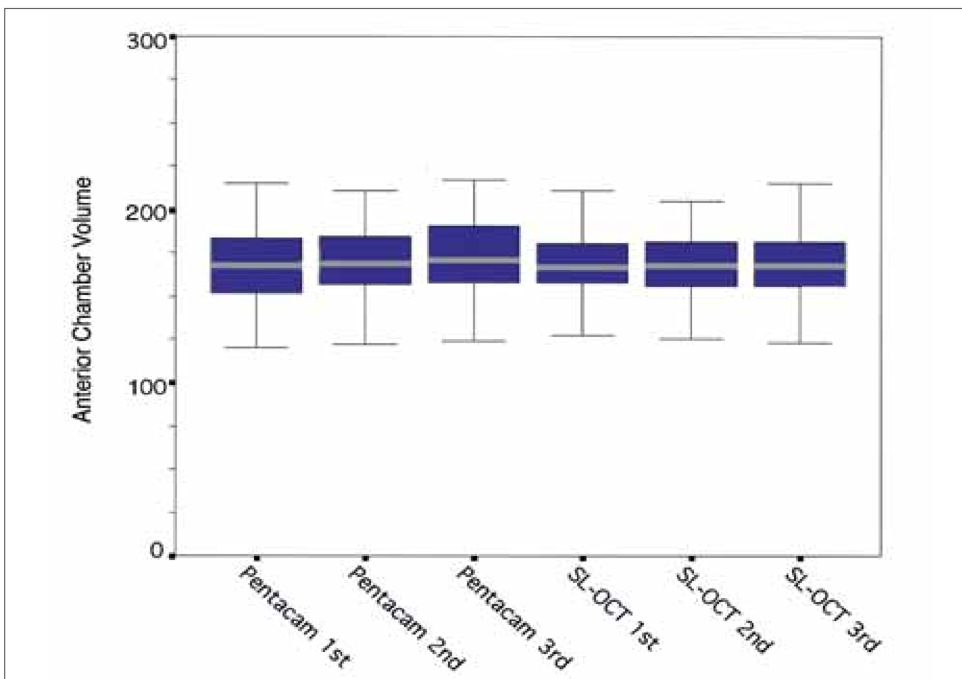

Fig. 4 - *Mean values of each repeated anterior chamber volume measurement (first, second, and third consecutive acquisitions) by SL-OCT and Pentacam are demonstrated.*

Up to 50 slit images with 500 measurement points on the front and the back of the corneal surface are acquired over a 180-degree rotation in 2 seconds. The internal software creates a three-dimensional reconstruction of the anterior segment by using the elevation data of these images. Pentacam measures 360° anterior chamber angle, anterior chamber depth, and volume. The internal software automatically determines ACV.

Statistical analysis

Statistical analyses were performed using SPSS (version 11.0, SPSS Inc.) and a p value less than 0.05 was considered statistically significant. Only the right eyes were recruited for statistical analysis. Statistical significance of interdevice differences between measurements was evaluated by unpaired *t* test and Bland-Altman analysis. The mean of three consecutive measurements was used for statistical analysis. In Bland-Altman analysis, the distribution of interdevice differences was expressed as the mean difference. The mean difference indicates the bias between two sessions. The repeatability of three consecutive measurements was analyzed by repeated measured analysis of variance (Scheffe multiple comparison).

RESULTS

Eighty eyes of 40 patients (18 female, 22 male) were included in the study. Mean age of the patients was 29.6±5.3 years (range 19 to 40 years). Mean spherical error was found to be –0.55±1.4 diopters.

Mean ACV were detected as 163.34±29.76 mm^3 by Pentacam (Fig. 1) and 164.14±28.44 mm^3 by SL-OCT (Fig. 2). No significant difference was detected between ACV measurements recorded by SL-OCT and Pentacam (unpaired *t* test, p=0.872). Also, the results of Bland-Altman analysis to consider the interdevice differences of ACD measurements are displayed in Figure 3.

SL-OCT and Pentacam were all extremely repeatable when the mean values of first, second, and third acquisitions measurements of ACV were analyzed (Scheffe multiple comparison, p=0.943 for SL-OCT and p=0.895 for Pentacam, respectively) (Fig. 4).

DISCUSSION

Examination of the anterior segment structures and measurement of anterior chamber parameters are essential in various fields of ophthalmology practice. After installation of fluorescein by iontophoresis to the anterior chamber, fluorophotometry or photogrammetric methods were used to measure the rate of aqueous production in previous studies. During fluorophotometry, the change in concentration of fluorescein in the anterior chamber is measured. Fluorophotometry was accepted to be the gold standard for calculating ACV (5). However, this invasive method particularly calculates aqueous humor flow rather than anterior chamber volume. Using photogrammetric methods, the flow of unstained aqueous from the posterior to anterior chamber is calculated (6-10). These vertical slit-lamp photographic images may have a low reproducibility since different cross-sectional images would not be identical and the width of the anterior chamber is not equal in different sections of the anterior chamber. SL-OCT and Pentacam allow fast, noncontact, and precise examination of the anterior segment of the eye. According to the current results, both devices revealed a highly repeatable measurement of ACV. In addition, the results were found to be clinically interchangeable with a mean difference of 2.0 mm^3 (Fig. 4).

Wang and colleagues developed an image-processing software and evaluated the repeatability of ACV measurements using Visante OCT (4). However, during daily practice only anterior chamber depth, internal anterior chamber diameter, and anterior chamber angles can be measured manually using the measuring calipers and tools by Visante OCT. On the contrary, after the scleral spurs are marked by the clinician, the internal software of SL-OCT automatically calculates the anterior and posterior corneal radius, anterior chamber depth, ACV, spur distance, pupil diameter, angle opening distance, and trabecular iris space area. There is no internal fixation target in SL-OCT and the strong light reflecting from the slit-lamp may cause difficulty for the patients to keep their eyes open during acquisition, resulting in motion artifacts and miosis. Another limiting factor of SL-OCT acquisitions is the relatively long acquisition time for multiple images.

The Scheimpflug technique requires a complex reconstruction software since the distances observed on the images change depending on the position in the anterior segment (11). Rabsilber and colleagues detected a mean ACV of 182.14±33.15 mm^3 when they evaluated 27 patients between 18 and 39 years of age (12). They found a reduced ACV with increasing age. The ocular media quality affects the measurements obtained by Pentacam because of interfering signals reflected on iris. On the contrary, AS-OCT evaluation is less affected by the optical clarity of the anterior segment. The clinician is able to visualize the anterior chamber directly and measure ACD precisely by AS-OCT (2, 3). The elimination of the subjectivity of the clinician by automatized acquisitions and data analysis is one of the most important advantages of Pentacam. However, the anterior chamber evaluation using SL-OCT depends on the examiner to some extent. The evaluation of AS-OCT data needs precaution, and the measuring calipers and points must be located accurately. Another shortcoming of AS-OCT devices is that the direct biometric evaluation is only accurate for strictly axial measurements. Therefore, off-axis measurements should be excluded and such acquisitions should be repeated.

One of the drawbacks of our study is that we only investigated intraobserver reproducibility of the current imaging methods. Interobserver reproducibility was not studied. To our knowledge, our study is the first to compare the measurement of ACV using SL-OCT and Pentacam.

In conclusion, SL-OCT and Pentacam provided highly reproducible quantitative data on the ACV in healthy participants and the measured ACV values detected by both devices were found to be clinically interchangeable.

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