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Evaluation of Anterior Chamber Angle Using Anterior Segment Optical Coherence Tomography and Scheimpflug Camera Based Tomography in Normal Eye

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Abstract
Purpose *-To assess the reproducibility and agreement of anterior chamber angle measurements between the anterior segment optical coherence tomography and scheimpflug camera based tomography in normal eyes .*
Methods *- Prospective observational study including a total of 306 eyes of 153 healthy volunteers were included in this study. Anterior chamber angle was measured with AS-OCT and Scheimpflug camera based tomography. Agreement among the devices was analysed using mean differences (bias) and Bland-Altman analysis with 95% limits of agreement (LoA) .*
Results *-Values of ACA measured by AS-OCT and Scheimpflug camera based tomography were similar, and their results were also not significantly different between both the devices (p >0.05). ACA measurements by AS-OCT and Scheimpflug camera based tomography showed good intra-observer agreements (>0.9). ACA measured by AS-OCT and Scheimpflug camera based tomography showed the closest agreement with a bias of RE: Bias-0.06 º(95% LOA -0.08 -0.21º) and LE bias 0.06 º(95% LOA -0.20-0.33º).*
Conclusions *- AS-OCT and Scheimpflug camera based tomography are very useful for the anterior chamber examination. They provide good images and quantitative data about the anterior chamber angle . They showed good intra-observer reproducibility and inter-method agreement.*

Key Words*: Anterior chamber angle, AS-OCT, Scheimpflug camera , Limits of Agreement*

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I. Introduction

The anterior chamber angle is the actual anatomical angle between the root of the iris and the peripheral corneal vault. It contains the structures involved in the outflow passage of the aqueous, namely the Schwalbe's Line , Trabecular meshwork , Schlemm's canal , Scleral spur and Ciliary muscle band. The depth of the angle in a healthy eye is approximately 30°, with the superior part usually narrower than the inferior half. The depth is influenced by gender, age and refractive error. Females has the greatest influence on iridocorneal angle reduction followed by age and spherical equivalent [1].

The gold standard technique for estimating the anterior chamber angle (ACA) width is gonioscopy; however, there are certain disadvantages with this method, Placing the goniolens in direct contact with the cornea may alter the angle's configuration, It is also dependent on the examiner's skill and experience.[2] Recently, a number of instruments have been introduced to provide more precise, objective, and quantitative measurements of the anterior ocular segment. These instrument include anterior segment optical coherence tomography (AS-OCT) and Scheimpflug camera based tomography.[2]

Anterior segment optical coherence tomography (AS-OCT) has rapidly become popular for ACA assessment. The spectrometer is fitted with a high-speed line camera that captures 26 000 axial (A) scans per second using an 830-nm wavelength light-source providing an axial resolution of 5 mm and a transverse scan resolution of 15 mm. This enables the AS-OCT to utilize higher power, enhancing imaging speed and eliminating motion artifacts.[3] Scheimpflug camera is non-contact approach for angle assessment and can be used for screening purposes. It takes about 2 seconds to generate an image of anterior of the eye. It can acquire 25 or 50 images in single scan. Anterior segment 3D model can therefore be built providing valuable data. These data are corneal thickness, corneal topographic parameters, anterior chamber depth (ACD), anterior chamber volume (ACV), anterior chamber angle (ACA), and other parameters.[4]

II. Subjects and Method

A prospective observational study is conducting at the Upgraded Department of Ophthalmology of J.L.N. Medical College , Ajmer (Raj.). The study was conducted from January 2018 to January 2019. The patients attending ophthalmology outpatient department (OPD) during the study period and fulfilling the selection criteria mentioned below were included in the study. Ethical clearance was obtained from institutional review board.

Inclusion criteria :
1. Best-corrected visual acuity ≥ 20/20;
2. Refractive error between +4.00 to -6.00 diopters of sphere and +3.00 to -3.00 D of cylinder and with anisometropia ≤ 2.00 D;
3. Normal anterior chamber depth, clear refractive media and normal eye fundus;
4. Intraocular pressure ≤ 21 mm Hg;
5. No history of retinal diseases, optic nerve diseases, uveitis, and no history of ocular trauma or intraocular surgeries or any kind of ocular laser therapy, including refractive surgery.

Exclusion criteria:
1.Any history of previous ocular trauma or intraocular disease.
2.Secondary angle closure, such as lens dislocation or intumescence , neovascular glaucoma , uveitis .
3.Patients with a history of contact lens wear.
4.Uveitis

306 eyes of 153 patients were selected on the basis of inclusion and exclusion criteria. All the patients included in the study were examined by the same operator and same observer to eliminate observer's bias. Informed written consent was taken at the time of examination. All patients fulfilling the inclusion criteria , underwent detail ocular examination including comprehensive history, recording of visual acuity ,slit lamp examination ,intraocular pressure, fundus examination, as well as ocular and systemic investigations required .

Patients underwent Scheimpflug camera based tomography and SD-OCT imaging. Scheimpflug camera based tomography and SD-OCT imaging were performed without the use of any mydriatics , and with the subjects sitting in front of the instrument with their face in an upright position. Manufacturer-recommended quality criteria for image acquisition were used as guidelines for acceptance of scan images.

All data were collected from SD-OCT and Scheimpflug camera based tomography in an Excel database for data analysis. Continuous variables were described as mean±SD. Paired t-test was applied to compare ACA measurements between two applications in the healthy volunteer group . To determine a relationship between the measurements of two devices, the Pearson's correlation coefficient (r) was used. The agreement between two devices was studied using the method described by Bland and Altman . This method also computed 95% limits of agreement (LoA=mean difference ± 1.96 SD). To determine intraobserver reliability between measurements in the healthy volunteer , the mean standard deviation (SD), the coefficient of variation (CV) (ratio of SD and mean in percentage), and precision (1.96 * SD) were calculated. A P-value of <0.05 was considered significant.

III. Results

The study was perform on 306 eyes of 153 healthy individuals including 86 female and 67 male with the mean age of 38±20 years.

Data about ACA taken with AS-OCT and Scheimpflug camera based tomography are shown in table 1 and 2. ACA taken with AS-OCT were 37.66±5.76º on right eyes and 38.44±5.67º on left eyes. ACA taken with Scheimpflug camera based **t**omography were 37.49±6.36º on right eyes and 37.44±6.18º on left eyes. Right and left eyes ACA did not show significant difference between AS-OCT and Scheimpflug camera based tomography (p>0.05).

Right eye			
	AS-OCT	**Scheimpflug camera**	**p-Value**
ACA	**37.66+/-5.76**	**37.49+/-6.36**	**0.40**

Table 1 Comparison Right eye Anterior chamber angle measurements by anterior segment optical coherence tomography and Scheimpflug camera based tomography

Left eye			
	AS-OCT	**Scheimpflug camera**	**p-Value**
ACA	**38.44+/-5.67**	**37.93+/-6.18**	**0.22**

Table 2 Comparison Left eye Anterior chamber angle measurements by anterior segment optical coherence tomography and Scheimpflug camera based tomography

	Right eye	**Left eye**
ACA	**0.97**	**0.96**

Table 3. Intra-observer agreement between anterior segment optical coherent tomography and Scheimpflug camera based tomography based on correlation coefficient for measuring Anterior chamber angle

ACA measurements by AS-OCT and Scheimpflug camera based tomography showed good intra-observer agreements (>0.9), (Table 3).
ACA measured by AS-OCT and Scheimpflug camera based tomography showed the closest agreement with a bias of RE: Bias-0.06 º(95% LOA -0.08 -0.21º) and LE bias 0.06 º(95% LOA -0.20-0.33º).

IV. Discussion

In this present study Anterior chamber images were taken by Scheimpflug camera based tomography and SD-AOCT to evaluate their discriminating ability to detect ACA.

When perform a hypothesis test in statistics , a P-value helps to determine the significance of results. P-value is a number between 0-1. P-value address only , how likely are your data, assuming a true null hypothesis. In this study difference in the mean ACA were not statistically significant P-value >0.05 , indicates weak evidence against the null hypothesis , so fail to reject the null hypothesis.

Bland and Altman proposed an informative method to evaluate actual inter-device agreement that allows clinicians to determine for any given use whether the measurements provided by two devices are interchangeable. Their data were similar each other and they showed good intra-observer reproducibility and inter-method agreement. Bland and Altman recommended that 95% of the data points should lie within ± 2*s* of the mean difference.

Correlation is a statistical technique that can show whether, and how strongly, pairs of variables are related. The main result of a correlation is called the correlation coefficient (or "*r*"). It is computed as the ratio of covariance between the variables to the product of their standard deviations. The numerical value of *r* ranges from -1.0 to +1.0 . This enables us to get an idea of the strength of relationship or rather the strength of linear relationship between the variables. The closer the coefficients are to +1.0 or -1.0, the greater the strength of the linear relationship is.

ACA measured by AS-OCT and Scheimpflug camera based tomography showed the closest agreement with a bias of RE: Bias-0.06 º(95% LOA -0.08 -0.21º) and LE bias 0.06 º(95% LOA -0.20-0.33º).

Kurita and colleagues compared anterior chamber angles obtained with the Pentacam and by gonioscopy. The correlation was weaker (r = 0.65) than that obtained with ultrasonic biomicroscopy (r = 0.90), possibly because Pentacam has difficulty visualising the most extreme end of the angle. Sakata and colleagues found that AS-OCT detected more closed angles than gonioscopy.

Kim et al.,2011 reported that reproducibility of the superior and inferior quadrants was low because of lid effect, and an excellent reproducibility of nasal and temporal angles. In agreement with this, we used only nasal and temporal quadrant data for comparison although Nidek AS-OCT can measure nasal, temporal, superior and inferior angles.[5]

Similar results to our study Nolan, et al.,2005 examined ACA by gonioscopy as well as AS-OCT and reported that there was no significant difference between OCT and gonioscopy. This study evaluated the sensitivity of OCT in detecting angle closure compared with gonioscopy. AS-OCT showed a sensitivity of 81.5% and a specificity of 68.5% in the nasal quadrant; 66.1% and 77.2% in the temporal area.[6]

On the other hand Cindy X. Hu et al.,2016 reported that Visante and Cirrus had moderate agreement with each other in detecting angle closure with greeter agreement in the dark, but only slight-to-fair agreement with gonioscopy. The study also found that OCT imaging in their current forms may not be able to identify angle closure because of difficulty in identifying angle structures ,while Gonioscopy by well trained clinicians had remarkably consistent agreement in identifying angle closure risk.[7]

Jeong-Ho Yi et al.,2008 stated that both Scheimpflug camera and AS-OCT are very useful for the anterior chamber angle examination, they provide good images and quantitative data about the angle structures including ACA and ACD, the values of temporal and nasal ACAs measured by two instruments were not significantly different ,they showed good intraobserver and inter-method agreements (all >0.9).[8]

However , this study had some limitations. We only included healthy eyes and further investigations are needed to assess both instruments for other categories of patients (such as those affected with keratoconus or previous refractive surgery,corneal edema and opacity).

V. Conclusion

ACA measured by AS-OCT is slight higher as compare to scheimpflug camera based tomography but both procedures gave no significant difference (p-value > 0.05) in result.

In shallow anterior chamber scheimpflug camera based tomography has difficulty to visualizing the most extreme end of the angle however, AS-OCT is far better than scheimpflug camera based tomography in such cases .

Scheimpflug camera based tomography and AS-OCT both are very usefull for the anterior chamber examination. They may provide good images and quantitative data about the anterior chamber angle .

Pair-wise comparison of the imaging technologies showed 95% limits of agreement. Their data were similar each other and they showed good intra-observer reproducibility and inter-method agreement. The measurements provided by two devices are interchangeable.

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