Original Article

Agreement of gonioscopy and anterior segment-optical coherence tomography in the assessment of the anterior chamber angle: A cross-sectional study

ABSTRACT

Purpose: The aim of the study was to evaluate the inter instrument agreement between gonioscopy and anterior segment optical coherence tomography (AS-OCT) in the assessment of the anterior chamber angle (ACA) in eyes with all Van Herick's grades. **Methods:** A single examiner performed AS-OCT and gonioscopy with a Goldman single mirror for all study patients. An angle opening distance at 500 μm from the scleral spur in the AS-OCT was considered as the quantitative parameter to assess the ACA. A closed ACA on AS-OCT was defined by the presence of any contact between the iris and angle wall anterior to scleral spur. The agreement between gonioscopy and AS-OCT of the nasal and temporal angles was estimated using the Kappa statistic and the concordance between the instruments using the Lin's concordance coefficient. **Results:** The mean age of the seventy participants in the study was 52.11 ± 5.37 years. Five (15.15%) of nasal angles and 4 (12.12%) of temporal angles identified as closed by gonioscopy were called as open by AS-OCT. The Kappa statistic (0.59), pairwise correlation (0.60), and Lin's concordance correlation coefficient (0.59) showed only moderate agreement and concordance between AS-OCT and gonioscopy. AS-OCT had a moderate sensitivity (73%) and better specificity (86.4%). **Conclusion:** The results of our study show that AS-OCT can be used as a clinical diagnostic test but has limited use as a screening test for ACA. The significant proportion of subjects with a mismatch in the categorization of open and closed ACA and the moderate agreement highlights the need for better objective diagnostic criteria for closed ACA.

Keywords: Agreement, anterior chamber angles, concordance, glaucoma, gonioscopy, optical coherence tomography

INTRODUCTION

Glaucoma is a major cause for blindness and vision impairment worldwide. An estimated 237 million people worldwide have moderate-to-severe vision impairment in 2020 that includes 4.5 million people with glaucoma.[1] Blindness is prevalent in an estimated 38.5 million people worldwide in 2020 that includes 3.2 million people with glaucoma.[1] An estimated 11.76 million individuals (32.65% of the global blindness) were blind, and 61.19 million individuals (28.3% of the global total) had moderate-to-severe vision impairment in south Asia in 2015. Glaucoma was a leading cause of both blindness (5.81%) and moderate-to-severe vision impairment (1.09%) in South Asia.[2] Population-based studies from south India have reported a prevalence of 0.5%–4.3% for primary angle closure glaucoma[3-6] and 1.62%–3.51% for open angle glaucoma.[7,8]

Glaucoma is categorized as two broad categories – open and closed – based on the structure of the anterior chamber angle (ACA). The determination of the structure of the angle is an important consideration in the management of glaucoma. Aqueous humor outflow through the trabecular meshwork can be impaired by partial or complete closure of the ACA and lead to elevated intraocular pressure (IOP) and glaucomatous optic neuropathy. Gonioscopy is the current gold standard

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to determine the structure of the ACA and is widest inferior, narrowest superior with the temporal and nasal sectors being intermediate in width.[9-11] Anterior segment optical coherence tomography (AS-OCT) is a noncontact imaging method that measures optical reflections to assess the anterior segment and its structures through the acquisition of cross-sectional images.[12] Noncontact examination techniques are preferred during the COVID-19 pandemic and can provide an alternate to assess the ACA compared to gonioscopy which is a contact technique. We designed a cross-sectional study to quantify the concordance and agreement for AS-OCT with the gold standard gonioscopy to assess the nasal and temporal ACA among patients attending a glaucoma outpatient unit at a tertiary care public sector teaching hospital in central Kerala.

METHODS

The institutional ethics committee approved the study protocol, and informed consent was obtained from all eligible participants before enrollment in the study. The study recruited subjects from the outpatient and glaucoma units of the department of ophthalmology at the study institute. Patients aged >20 years, presenting with any ophthalmic complaint, who could sit comfortably for a gonioscopy examination and provided informed consent were enrolled consecutively in the study after obtaining informed consent. The study excluded subjects with corneal pathology or corneal endothelial decompensation or with a history of previous intraocular surgery. The sample size was estimated as 75 eyes using the R software, a precision of 20%, and an anticipated kappa of 0.5%.

A comprehensive ophthalmic examination included visual acuity assessments, refractive status, slit-lamp assessment of the anterior segment, applanation tonometry for IOP assessments, and posterior segment assessments. A single examiner performed AS-OCT and gonioscopy for all patients enrolled in the study. Gonioscopy was performed using Goldman single mirror with the eye in the primary position of gaze. The ideal testing condition included a dim room illumination, minimal intensity of slit-lamp illumination, and without application of any pressure on the eye with the gonioscope. ACA in each of the quadrant was graded by Schaffer's grading system. AS-OCT was performed in a dark room by a single operator for all patients. We considered the angle opening distance (AOD) at 500 μm from the scleral spur as the quantitative parameter to assess the ACA. A closed ACA on AS-OCT was defined by the presence of any contact between the iris and angle wall anterior to scleral spur.

Data were initially entered in an MS Excel spreadsheet and subsequently exported to the STATA statistical software (STATA V13.0, College Station, Tx, USA) for analysis. The normal distribution of data was assessed using the Shapiro–Wilk test which showed normality of data. The mean, median, and interquartile ranges of age and IOPs were determined. The ACA determined by gonioscopy and AS-OCT was assessed for overall correlation, and correlation in the nasal and temporal segments using a pairwise correlation test. The Lin's concordance correlation coefficient was determined to further explore agreement between the two instruments.[13] The concordance correlation coefficient combines measures of both precision and accuracy to determine how far the observed data deviate from the line of perfect concordance.[13] Lin's coefficient increases in value as a function of the nearness of the data's reduced major axis to the line of perfect concordance (the accuracy of the data) and of the tightness of the data about its reduced major axis (the precision of the data).[13] The Pearson correlation coefficient, the bias correction factor, and the equation of the reduced major axis show these components. The concordance correlation coefficient is expressed as the product of the measure of precision and the measure of accuracy. A concordance coefficient of 0 indicates no concordance and a coefficient of 1 indicates perfect concordance.[13] The Bland and Altman's Limits of agreement were also determined to examine patterns of disagreement between gonioscopy and AS-OCT.[14] The correlation between difference and mean was also assessed as a part of the concordance correlation coefficient estimation and a value near zero implies concordance.[15] A Bradley Blackwood *F*-test of equality of means and variances was used; a nonsignificant *P* value indicates concordance.[16] We also estimated the overall agreement between gonioscopy and AS-OCT and by nasal and temporal segments and estimated a kappa statistic for agreement.[17] A one-way analysis of variance (ANOVA) test was used to compare the mean AOD by grade of ACA in both the nasal and temporal segments. The diagnostic effectiveness of AS-OCT compared to gonioscopy was assessed using sensitivity, specificity, predictive values, likelihood ratios, and area under receiver operator characteristic curve (AUROC).

RESULTS

The study included seventy eyes. The mean ± standard deviation (SD) age of participants in the study was 52.11 ± 5.37 years (median: 51.0 years; inter quartile range: 48–60 years). Forty-six (65.71%) patients were females. The mean ± SD age of IOP was 14.86 ± 2.98 mmHg (median: 14.00 mmHg, interquartile range: 12–16 mmHg). Table 1 shows the distribution of Van Hericks grade in the study population. Table 2 shows the assessment of ACAs by gonioscopy and AS-OCT. AS-OCT agreed with the grading

of the ACA in 84.85% of nasal angles and 87.88% of temporal angles identified as closed by gonioscopy and 75.67% of nasal angles and 70.27% of temporal angles identified as open by gonioscopy. Five (15.15%) of nasal angles and 4 (12.12%) of temporal angles identified as closed by gonioscopy were called as open by AS-OCT. Table 3 presents the agreement and concordance between gonioscopy and AS-OCT. The broader examination of agreement and concordance between AS-OCT and gonioscopy suggested good results; however, further examination with the Kappa statistic (0.59), pairwise correlation (0.60), and Lin's concordance correlation coefficient (0.59) showed only moderate agreement and concordance between AS-OCT and gonioscopy [Table 3]. Table 4 presents the AOD by van Hericks grades in the nasal and temporal segments with a change in the AOD in both the nasal and temporal ACA (both $P < 0.001$, one-way ANOVA). Table 5 presents the diagnostic effectiveness of AS-OCT compared to gonioscopy as the gold standard for the assessment of ACA. The sensitivity (73%, 95% confidence interval [CI]: 61.4%, 82.6%) of AS-OCT was moderate with a better specificity (86.4%, 95% CI: 75.7%, 93.6%). The positive likelihood ratio (LR+) for AS-OCT was 5.35 (95% CI: 2.87, 9.98).

Table 1: Distribution of Van Hericks grade in the study population

Van Hericks Grade	*n* (%)
Grade 1	13 (18.57)
Grade 2	36 (51.43)
Grade 3	13 (18.57)
Grade 4	8 (11.43)

Table 2: Assessment of anterior chamber angles by gonioscopy and anterior segment optical coherence tomography

Gonioscopy	AS-OCT closed (*n*)	AS-OCT open (*n*)
Nasal closed ($n=33$)	28	5
Nasal open ($n=37$)	9	28
Temporal closed ($n=33$)	29	4
Temporal open ($n=37$)	11	26

AS-OCT - Anterior segment optical coherence tomography

DISCUSSION

The results of our cross-sectional study show only moderate agreement and concordance between AS-OCT and gonioscopy for the assessment of ACA in this population. We found that 5 (15.15%) of nasal angles and 4 (12.12%) of temporal angles identified as closed by gonioscopy were called as open by AS-OCT. A LR+ >10 generally indicates that the test can be applied to a clinical population; however, we found a LR + of 5.35 for AS-OCT in this study although the upper limit of the 95% confidence interval was just below 10.

Previous studies have reported on the moderate agreement between AS-OCT and gonioscopy similar to our study results. Sakata *et al*. reported a kappa of 0.40 for agreement between AS-OCT and gonioscopy in a cross-sectional study from Singapore.[18] They suggested that variations in the iris profile and level of iridoangle contact also may explain some of the differences seen between gonioscopy and AS-OCT. Anatomic variations of the ACA have been previously described based on gonioscopic examinations and AS-OCT imaging and are well recognized.[2,10,11] A study from South Korea[19] reported a poor kappa between gonioscopy and AS-OCT although the discrimination capability of AS-OCT parameters between

Table 3: Agreement and concordance between gonioscopy and anterior segment optical coherence tomography in the study population

	Overall	Nasal	Temporal
Agreement (%)	79.29	80.00	78.57
κ	0.59	0.60	0.57
Pair wise correlation	0.60	0.60	0.59
Concordance correlation coefficient	0.59	0.60	0.58
Measure of precision	0.59	0.60	0.59
Measure of accuracy	0.99	0.99	0.98
Bland altman plot 95% limits of agreement	−0.80, 0.96	−0.82, 0.93	−0.79, 0.99
Correlation between difference and mean	0.004	0.00	0.01
Bradley blackwood *F*, *P*	2.12, 0.12	0.56, 0.57	1.67, 0.20

Table 4: Angle opening distance by Van Hericks grades in the nasal and temporal segments

Van Hericks grades	Mean angle opening distance (μm±SD), nasal	Mean angle opening distance (μm±SD), temporal
Grade 1	115.76±41.68	108.46±33.58
Grade 2	253.38±73.78	238.86±82.37
Grade 3	321.54±112.03	309.69±115.69
Grade 4	483.12±76.38	464.75±75.38

SD - Standard deviation

Table 5: Diagnostic effectiveness of anterior segment spectral domain-optical coherence tomography and gonioscopy for anterior chamber angle assessment

Parameter	Estimate (95% CI)
Sensitivity	73 (61.4-82.6)
Specificity	86.4 (75.7-93.6)
Positive predictive value	85.7 (74.6-93.3)
Negative predictive value	74 (62.8-83.4)
Positive likelihood ratio	5.35 (2.87-9.98)
Negative likelihood ratio	0.31 (0.21-0.46)
Area under ROC curve	0.80 (0.73-0.86)

CI - Confidence interval, ROC - Receiver operating characteristic

open and narrow angles determined by gonioscopy was excellent for all AS-OCT parameters (AUROC 0.99 for nasal and 0.96 for temporal). The results of our study suggest good discriminative ability with AUROC of 0.80 for nasal and 0.79 for temporal angles. A previous review[20] has also reported a good sensitivity and moderate agreement between gonioscopy and AS-OCT in the determination of closed ACA.

There are several ocular factors to consider for the possible differences between AS-OCT and gonioscopy besides factors such as the experience and skill of the assessors. Gonioscopy requires contact with the corneal surface, which can distort the cornea and affect ACA configuration and it is possible that gonioscopy technique can affect the determination of closed or open ACA. All measurements were done by a single investigator in this study and the possibility of a systematic bias in the assessment cannot be ruled out. A previous study has reported from angle visibility index analyses that it is more difficult to visualize and assess the configuration of the ACA in the temporal and nasal quadrants.[18,21] It is possible that small lighting condition changes affected pupil size, an important determinant of ACA configuration and AS-OCT measurements,[22] although examinations were done in a controlled setting with minimized lighting.

CONCLUSION

The results of our study suggest that direct visual assessments of the ACA may not accurately reflect its width and could be affected by other factors such as the configuration of the iris. These findings highlight some of the diagnostic challenges that clinicians face when attempting to visualize and interpret the nasal and temporal quadrants using gonioscopy. The results of our study show that AS-OCT can be considered as a clinical diagnostic test for the confirmation of the ACA but may have limited use as a screening test. The significant proportion of subjects that have a mismatch in the categorization of open and closed ACA and the moderate agreement highlights the need to have better diagnostic classification systems for closed ACA that can be objectively assessed.

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Conflicts of interest

There are no conflicts of interest.

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