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Diagnostic Accuracy of Anterior Segment Optical Coherence Tomography for Detection of Anterior Chamber Angle Closure: A Comparison with Gonioscopy

Shingrif Shabbir, Abdul Rauf, Shabir Ahmed*, Muqaddas Noor, Teyyeb Azeem, Aqsa Zahid**

Department of Ophthalmology, Armed Forces Institute of Ophthalmology /National University of Medical Sciences (NUMS), Rawalpindi Pakistan,*Department of Ophthalmology,Poonch medical college, Rawalakot Pakistan,**Department of Ophthalmology, University of Lahore Teaching Hospital Pakistan

ABSTRACT

Objectives: To determine the diagnostic accuracy of anterior segment OCT in the assessment of anterior chamber angle closure, keeping gonioscopy as the gold standard.

Study design: Cross-sectional study

Place and Duration of Study: Armed Forces Institute of Ophthalmology, Pakistan Emirates Military Hospital, Rawalpindi, Pakistan, from Mar 23 to Feb 24.

Methodology: A total of 140 patients aged≥40 years diagnosed with or suspected of angle-closure glaucoma, having healthy corneas, were included in this study. Gonioscopy was conducted using a Goldmann 3-mirror lens under dim illumination. Anterior segment OCT imaging was conducted using a spectral-domain OCT device equipped with an anterior segment module lens. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of anterior segment OCT for determining anterior segment angle closure were calculated, keeping gonioscopy as the gold standard.

Results: The age range of patients in this study was 43-67 years, with a mean age of 56.61±6.8 years. Anterior segment OCT diagnosed 74(52.86%) of cases, while gonioscopy diagnosed 69(49.24%) of cases with anterior chamber angle closure. Anterior segment OCT showed sensitivity of 62.32%, specificity of 56.34%, positive predictive value of 58.12%, and negative predictive value of 60.61%. The diagnostic accuracy was 59.3% ($p = 0.03$).

Conclusion: The moderate performance of anterior chamber OCT suggests that this technique is a good non-invasive method for anterior chamber angle closure assessment, but relying on it alone poses risks of missed diagnoses and false positives. It should be used alongside gonioscopy for a more reliable evaluation.

Keywords: Angle closure glaucoma, Glaucoma, Gonioscopy, Optical Coherence Tomography, Sensitivity and specificity.

How to Cite This Article: *Shabbir S, Rauf A, Ahmed S, Noor M, Azeem T, Zahid A. Diagnostic Accuracy of Anterior Segment Optical Coherence Tomography for Detection of Anterior Chamber Angle Closure: A Comparison with Gonioscop. Pak Armed Forces Med J 2026; 76(6): 827-830. DOI: https://doi.org/10.51253/pafmj.v76i6.12952*

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INTRODUCTION

Global data show that approximately 3.5% of the population aged 40 to 80 years suffers from glaucoma, which makes it a leading cause of irreversible blindness. 1 Asia accounts for nearly 80% of primary angle-closure glaucoma, which is responsible for approximately 50% of glaucoma-related blindness.[1,2] The anterior chamber angle (ACA) has a key role in the pathogenesis of glaucoma, as narrowing or closure of the ACA can increase IOP, leading to the development of angle-closure glaucoma, a disease that needs early diagnosis and timely intervention.[3]

Gonioscopy has remained the gold standard for ACA evaluation, offering dynamic assessment of illumination and pressure effects on iris configuration.4 However, it is subjective, reliant on examiner skill and experience, requires direct eye contact, and results may be influenced by observation angle and corneal indentation, altering the true ACA configuration.[5,6]

Anterior segment optical coherence tomography (AS-OCT) is a reliable, contactless imaging technique using low-coherence interferometry to generate high-resolution, cross-sectional images of anterior segment structures, including the ACA. AS-OCT offers rapid image acquisition, reproducible results, quantification of angle parameters, and detailed angle characterization. Unlike gonioscopy, AS-OCT minimizes variability with standardized lighting and requires no patient cooperation, making it ideal for individuals with poor compliance.[7,8] The disadvantages of AS-OCT include that it takes still pictures, so it might miss changes you can notice while performing gonioscopy.[9] Also, it can be hard to find the scleral spur in some eyes using AS-OCT, which is an important point for measuring the angle, so it may provide less accurate results.[10]

Correspondence: Dr Shingrif Shabbir, Department of Ophthalmology, Armed Forces Institute of Ophthalmology Rawalpindi Pakistan

Received: 06 Dec 2024; revision received: 25 Apr 2025; accepted: 28 Apr 2025

This study was therefore conducted to compare the diagnostic accuracy of AS-OCT in determining the ACA-closure keeping gonioscopy as the gold standard. These results will help ophthalmologists to determine whether this contactless imaging technique effectively assesses ACA closure to surpass the limitations of gonioscopy.

METHODOLOGY

This cross-sectional study was conducted at the Armed Forces Institute of Ophthalmology, Pakistan Emirates Military Hospital, Rawalpindi, Pakistan, from Mar 23 to Feb 24. The hospital's ethical review committee (307/ERC/AFIO) granted prior approval for conducting the study. Informed consent was obtained from all patients.

The sample size was determined using the WHO sample size calculator, incorporating 73% sensitivity and 86.4% specificity of AS-OCT for detecting true cases of angle-closure as key assumptions. Given the observed prevalence of glaucoma as 55.5% in the target population, the calculated minimum sample size was n = 136.[11]

Inclusion Criteria: Patients of either gender, aged ≥40 years, reporting to the outpatient department of ophthalmology with any case or suspicion of Angle-closure Glaucoma and having healthy corneas (peripheral anterior chamber depth of grade ≤2 as assessed by Van Herick's technique) were included in this study through consecutive sampling. One eye from each study participant was selected for our analysis using MATLAB software.

Exclusion Criteria: Patients with a history of anterior segment surgery/laser treatment, active ocular inflammation or infection, or any inability to undergo gonioscopy or AS-OCT imaging.

All the ophthalmologic evaluations of the patients were done on the same day. For gonioscopy, topical anesthesia was administered by instilling one drop of 0.5% proparacaine in each eye. A small amount of 1% hydroxymethyl cellulose gel was then applied to the concave surface of the goniolens. Gonioscopy was performed by an experienced ophthalmologist using a Goldmann 3-mirror lens under dim illumination. The angle was graded in all four quadrants based on Shaffer's classification. Angle closure was defined as the posterior trabecular meshwork not being visible in ≥2 quadrants.[12]

AS-OCT imaging was done using a spectral-domain OCT device (Optos SLO OCT) equipped with an anterior segment module lens. The examination followed a standardized protocol in dark room conditions. Scans were obtained in both nasal and temporal quadrants (3 and 9 o'clock, as well as 1 and 7 o'clock meridians) while patients maintained a straight gaze using external fixation lights. To avoid pressure on the globe, the upper lid was gently elevated during imaging. The images were evaluated by measuring the Trabecular Iris Angle and AOD. This comprehensive approach ensured a thorough evaluation of the ACA structure. ACA closure was characterized by apposition of the peripheral iris to any portion of the angle wall proximal to the scleral spur, observed in at least one quadrant.

Statistical analysis was performed using Statistical Package for the Social Sciences version 25.0. Quantitative variables were summarized using mean and standard deviation, whereas qualitative variables were reported as frequency and percentage. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of AS-OCT for determining angle closure were calculated, with gonioscopy as the gold standard. A p-value≤0.05 was taken as statistically significant.

RESULTS

A total of 140 patients were included in this study. The age range of patients in this study was 43-67 years, with a mean age of 56.61±6.8 years. The details of demographics, clinical characteristics, and the eyes examined are shown in Table-I.

Table-I: Demographics, Clinical Characteristics, and Details of Eyes Examined (n=140)

Demographics		
Age (Mean±SD) years		56.61±6.8
Gender	Male n (%)	59 (42.14)
	Female n (%)	81 (57.86)
Clinical characteristics and details of eyes examined		
Eyes examined	Right eye n (%)	74 (52.86)
	Left eye n (%)	66 (47.14)
IOP (Mean±SD) mmHg		20.44±5.58

**IOP – Intra Ocular Pressure*

The diagnostic accuracy parameters of AS-OCT compared to gonioscopy for detecting ACA closure demonstrated moderate sensitivity and specificity, with comparable predictive values, as presented in Table-II. These findings indicate that AS-OCT serves as a valuable non-invasive assessment tool; however, it should complement rather than replace gonioscopy for optimal diagnosis.

Table-II: Diagnostic Accuracy of Anterior Segment Optical Coherence Tomography Compared to Gonioscopy (n=140)

Gonioscopy (Gold Standard)	Anterior segment optical coherence tomography (AS-OCT)	
	(Yes/Positive)	(No/Negative)
(Yes/Positive)	43 (True Positive)	26 (False Negative)
(No/Negative)	31 (False Positive)	40 (True Negative)

Sensitivity = TP / (TP + FN) = 43 / (43 + 26) = 62.32%
Specificity = TN / (TN + FP) = 40 / (40 + 31) = 56.34%
Positive Predictive Value (PPV) = TP / (TP + FP) = 43 / (43 + 31) = 58.11%
Negative Predictive Value (NPV) = TN / (TN + FN) = 40 / (40 + 26) = 60.61%
Diagnostic Accuracy = (TP + TN) / Total = (43 + 40) / 140 = 59.3%

DISCUSSION

The findings of the study highlighted the moderate performance of AS-OCT, suggesting that it is a good non-invasive, reproducible, and objective technique for assessment of ACA closure in ophthalmology. The utilization of AS-OCT as a preferable technique for determining ACA closure has been the subject of interest over the last few years, and its diagnostic accuracy has been compared with gonioscopy.[13] Studies comparing gonioscopy and AS-OCT for evaluating the eye's anterior chamber angle have shown inconsistent results, where some studies have shown a good level of sensitivity, specificity, and accuracy of AS-OCT, while others have shown medium levels in detecting ACA closure. This comparison of the literature has been described by Namba *et al*.[14]

A cross-sectional study conducted in a South Asian population by Shan *et al.,* evaluated the diagnostic accuracy of AS-OCT in detecting gonioscopically narrow angles in patients aged ≥60 years.[15] The angle opening distance at 750 µm from the scleral spur (AOD750) offered the best performance. At 90% specificity, AOD750 detected 65% of gonioscopically narrow angles. Though not suitable as a standalone screening tool, AS-OCT may provide added value in comprehensive OCT-based screening programs with minimal extra effort, especially when posterior segment OCT is already part of the protocol.[16]

Baskaran et al., compared AS-OCT and gonioscopy in predicting angle closure development over 4 years in patients aged 50 years or more. While gonioscopy initially showed open angles in all participants, AS-OCT detected varying degrees of angle closure at baseline. Notably, 17.3% of subjects with AS-OCT-detected closure developed gonioscopic closure in ≥2 quadrants, and 10.1% in ≥3 quadrants. The control group, open on both tests, showed no closure. The extent of AS-OCT-detected closure at baseline correlated with the chances of future gonioscopic closure, highlighting AS-OCT's potential predictive value over gonioscopy alone.[17]

Jaseena *et al.,* evaluated the inter-instrument agreement between gonioscopy and AS-OCT in the assessment of ACA closure. Among 70 participants, gonioscopy identified 15.15% of nasal angles and 12.12% of temporal angles as closed, while AS-OCT classified them as open. The results showed moderate agreement between the two methods. AS-OCT found moderate sensitivity (73%) and higher specificity (86.4%). The findings suggested that while AS-OCT can serve as a clinical diagnostic tool, its limited agreement with gonioscopy doesn't support its use as a screening test for ACA closure.[12]

A descriptive observational study of 102 participants aged over 30 years compared AS-OCT with gonioscopy for assessing the ACA in angle-closure glaucoma or suspected cases. AS-OCT detected angle closure more accurately than gonioscopy (60.8% vs 35.3%), suggesting greater effectiveness for early detection and treatment planning.[18]

A systematic review by Imran *et al.,* found that AS-OCT has good sensitivity for detecting ACA closure and may identify many undiagnosed cases, particularly in Asia. However, it cannot replace gonioscopy; clinicians should assess its suitability for their needs, and longitudinal studies should examine cases where AS-OCT and gonioscopy disagree.[19]

The age range of patients in our study was 43-67 years, with a mean age of 56.61±6.8 years. Females were 58.86%, while males were 42.14% of the total study population. AS-OCT diagnosed 52.86% of cases of ACA closure, while gonioscopy diagnosed 49.24% of cases. The results of the diagnostic accuracy of AS-OCT, keeping gonioscopy as the gold standard, suggested that AS-OCT has moderately good performance in detecting angle closure when compared to gonioscopy. It has slightly better sensitivity (62.32%) than specificity (56.34%), meaning that it is better at detecting positive cases than ruling out negative cases. PPV was 58.12%, and NPV was 60.61%, suggesting that it may be more effective in ruling out conditions rather than diagnosing them. The diagnostic accuracy was 59.3% with a *p*-value= 0.03. These results of our study are in accordance with results of studies discussed above and also highlighted by Desmond *et al.*[20] it was also suggested that AS-OCT is a valuable, non-invasive method for ACA

assessment in patients diagnosed with or suspected of angle-closure glaucoma.

LIMITATION OF STUDY

The primary limitation of this study is its small sample size based on a single center. Future studies with larger sample sizes and a multicenter design will add to this useful data regarding the utilization of OS-OCT.

CONCLUSION

AS-OCT offers utility in screening ACA when gonioscopy poses challenges. The method can be considered as a complementary technique in our ophthalmological units, particularly for initial screenings; however, relying on this method alone poses a risk of missed diagnoses and false positives and should be used alongside gonioscopy for a more reliable evaluation.

Conflict of Interest: None.

Funding Source: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

SS & AR: Data acquisition, data analysis, critical review, approval of the final version to be published.

SA & MN: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

TA & AZ: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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