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Original Article

Role of Anterior Segment Optical Coherence Tomography in Angle Closure Glaucoma

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ABSTRACT

Objective: To evaluate the anterior chamber angles in acute angle closure glaucoma for early detection and prompt treatment.
Study Design: Prospective Analytical study
Place and Duration of Study: Armed Forces Institute of Ophthalmology Rawalpindi, Pakistan from Jan 2023 to Aug 2024.
Methodology: This study involved 34 participants of both genders between 42 to 59 years of age. Based on AS-OCT (DRI OCT Triton 2000), Posterior corneal surface, scleral spur and anterior iris surface were identified as key angle structures. The anterior chamber angles were graded according to Shaffer system and very narrow angles (≤10°) were included. Intraocular pressure (IOP) was measured on slit lamp mounted Goldmann tonometer. Both were measured before and after laser iridotomy. Zeiss slit lamp Q-switched Nd:YAG laser was used for the peripheral iridotomy. Data was analyzed using SPSS.
Results: A total of 34 participants were included in the study with a mean age of 51.8 years, ranging from 42 to 59 years. The intra ocular pressure was significantly reduced and anterior chamber angle were open within 34 patients, of whom 73.5% were female. Pre-operative mean IOP was 45.1 mmHg, and the AS-OCT angle increased from a mean of 6.7° to 42.8° post-operatively.
Conclusion: This study concludes that, AS-OCT aids in the diagnosis of acute angle closure glaucoma by measuring anterior chamber angles for early detection and treatment.

Keywords: Angle-Closure Glaucoma, Glaucoma, Intra Ocular Pressure, Angle Recovery, Anterior Chamber Angle

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INTRODUCTION

Chronic progressive optic neuropathy known as glaucoma is typified by alterations in the optic nerve head brought on by the gradual degeneration of retinal ganglion cells[1]. There are two main forms of glaucoma: acute and chronic. Primary angle closure glaucoma is more prevalent than open glaucoma, yet it still causes blindness to a greater extent[2]. An abrupt intraocular pressure (IOP) increase brought by impediment of the anterior chamber angle can result in acute angle-closure (AAC), a potentially blinding ocular emergency[3]. With a 2.7% incidence in 2003, glaucoma ranks as Pakistan's fourth most prevalent cause of blindness. Open angle glaucoma accounts for 47.3% of cases, while chronic angle closure glaucoma accounts for 16.2%[4].

Age is a significant risk factor for primary angle-closure glaucoma (PACG). Those over 60 are almost ten times more likely to have PACG[5] than those under 40. It is the most frequent cause of blindness in South Punjab, Pakistan. It is known as the "silent murderer" of eyesight because of the difficulties in treatment[6].

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AS-OCT is a contactless technique that provides angle parameter values, distinguishes between open and narrow/closed angles, and evaluates anterior chamber angle morphology[7]. For assessing anterior chamber angle width, gold standard for diagnosing angle closure is still gonioscopy. It is a contact procedure and can be uncomfortable for the patient and depends on the ophthalmologist's skill for accuracy[8].

In a clinical context, the anterior chamber angle can be evaluated by measuring several angle values using AS-OCT imaging[9]. AS-OCT images the anterior chamber angle using interferometry and light. For speedier scans, Spectral-Domain OCT (SD-OCT) employs a stationary mirror at 830 nm, while Time-Domain OCT uses a moving mirror at 1310 nm[10].

This study was planned to access the anterior chamber angles on AS-OCT in acute angle closure glaucoma for early detection and prompt treatment.

METHODOLOGY

This a prospective analytical study was conducted at a Armed Forces institute of Ophthalmology Rawalpindi, Pakistan from Jan 2023-August 2024. The ethical approval was taken from the hospital ethical approval committee (Reference no: 331/ERC/AFIO). Candidates of the study were taken

from those reporting in general out-patient department of the institute and were 42 years or older. Sample size estimation was done via WHO sample size calculator and came out to be 34 with 95% precision and 10% accuracy[11]. Systematic sampling was done taking every 5th patient reporting to the clinic. The research subjects gave their informed consent.

Inclusion Criteria: Patients of both genders between 42 to 59 years of age who were diagnosed with Acute Angle chamber angle on ASOCT≤ 10 degree and no previous iridotomy were included in the study.

Exclusion Criteria: Patients with steroid responder, open angle glaucoma, pigment dispersion glaucoma, phacomorphic glaucoma, previous iridotomy, plateau iris configuration and plateau iris syndrome were excluded from the study.

After the medical and ophthalmic history, each candidate went through the thorough examination on the same day including refraction (uncorrected and corrected distant vision), slit lamp examination of anterior and posterior segment including macula and optic disc, intraocular pressure via applanation tonometry, anterior segment optical coherence tomography (AS-OCT). A thorough ophthalmic examination was performed on all subjects, which included measurements of IOP using Goldmann applanation tonometry, anterior chamber angle tomograms using AS-OCT (DRI OCT Triton2000).

Intra ocular pressure was measured using slit lamp mounted Goldmann applanation tonometer. The force needed to flatten a 3.06 mm section of the central cornea was measured by GAT using the Imbert-Fick law. A drop of 0.5% Proparacaine was instilled into eye. A white light of illumination arm was set at 45 degree and perpendicular to the tonometer, doubling prism embedded inside divides the circular meniscus into two arcs. After an interlude of five-minute, Ophthalmic strips containing fluorescein sodium were inserted into the participant's eyes and slit lamp filter was set to cobalt blue light. IOP was measured by contacting inner edges of the semicircle mires. The force required to flatten the appropriate corneal surface is proportional to the intraocular pressure (IOP), which was measured straight from the measuring drum's scale and expressed in millimeters of mercury.

All candidates underwent AS- OCT via (DRI OCT Triton2000) executed by a single ophthalmologist who was blinded by the other ocular findings. With external fixation, the line 6 mm option was used for all AS-OCT scans. Anterior segment imaging was performed with anterior segment module lens mounted over imaging aperture in a dark room. Three readings at different clock hours were taken, at 3 and 9 o clock, 12 and 6 o clock hours. Upper lid was elevated gently to avoid in advertent pressure on globe to image superior angle. We identified the angle structure namely scleral spur, posterior corneal surface and anterior iris surface. After manually marking the apex of the angle, the anterior surface of the iris, and the posterior surface of the cornea, caliper software tool was employed to compute the ACA in degrees. Angles measured on AS_OCT were matched to Shaffer grading system as follows: Angle measured 0 on ASOCT were considered closed, Angles 1-10 were considered extremely narrow Grade-1, Angles from 11-20 degree considered narrow Grade-2. Angles 21-30 considered open Grade-3, angles from 31-40 or more considered open Grade-4. SS-OCT is a Fourier-domain non-contact imaging technique that was created especially for anterior segment imaging. High-resolution imaging of 10 m (axial) and 30 m (transverse) and high-speed scanning of 30,000 A-scans per second are both achieved by this technique.

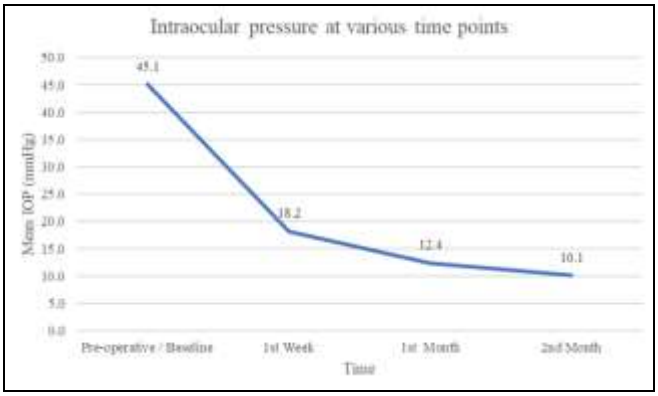

Figure: Intraocular Pressure At Various Time Points (n=34)

The participants were given 500ml of intravenous Mannitol infusion to reduce corneal edema. After 50 minutes peripheral laser iridotomy was performed. First the eye was anesthetized with 0.5% Proparacaine. Abraham irodotomy lens was applied with coupling gel. Zeiss slit lamp Q-switched Nd:YAG laser was used for the peripheral iridotomy at 1 o'clock in cornea. The average shot energy was 2.5 mJ (0.9-5.6 mJ), and the average number of laser shots was 20.5 (1-127 shots). The size of the iris hole was not smaller than 0.2 mm2.

Data was analyzed by using Statistical Package for Social Sciences (SPSS) 22.00. Normality of data was checked by using Kolmogorov-Smirnov test. Data were not distributed normally and were represented using median (IQR). Qualitative data was represented by using percentage and frequency. Chi square test (for qualitative variables), Wilcoxon signed rank test (for non-normally distributed quantitative data) were applied and p-value of ≤ 0.05 was considered as statistically significant.

RESULTS

A total of 34 patients were included in this study. Out of the total, 9(26.5%) were male with the mean age of 54.33±3.61 years and 25(73.5%) were female with the mean age of 50.92±4.64 years. 24 participants (70.6%) had laser peripheral iridotomy performed on their left eye, with the remaining 10 participants (29.4%) on their right eye as shown in Table-I.

Table-I: Demographics of Participants in the study (n=34)

Variable(s)		n(%)
Gender	Female	25(73.5%)
	Male	9(26.5%)
Eye	Left	24(70.6%)
	Right	10(29.4%)
Pre-Laser Shaffer Grading	Grade 1 (<10°)	34(100%)
Pre-Laser Shaffer Grading	Grade 4 (>35°)	34(100%)

The Table-II and Figure present a comparison of intraocular pressure (IOP) measurements at baseline and at various postoperative intervals, including the first week, first month, and second month. At baseline, the median IOP was 45.00 mmHg (IQR: 50.50-40.00). By the first week postoperatively, The IOP significantly decreased to a median of 18.00 mmHg (IQR: 22.50-13.50), with a *p*-value of <0.001. This decline continued in the first month, where the IOP further decreased to 12.00 mmHg (IQR: 14.00-10.00), also showing statistical significance with a *p*-value of <0.001. By the second month, the IOP stabilized at a median of 10.00 mmHg (IQR: 10.00-10.00), marking a consistent and significant reduction from baseline, with a *p*-value of <0.001 at each interval. These findings highlight the substantial and statistically significant reduction in IOP following the intervention.

The Table-III compares the anterior segment optical coherence tomography (AS-OCT) angle measurements both prior to and following peripheral iridotomy. Pre-operatively, the median AS-OCT angle was 8.70° (IQR: 9.30-2.60). After the procedure, the angle increased significantly to a median of 42.70° (IQR: 44.70-40.33). This change was statistically significant, with a *p*-value less than 0.001, indicating a substantial widening of the anterior chamber angle following peripheral iridotomy.

Table-II: Intraocular Pressure at Various Post-operative Intervals Compared to Baseline (n=34)

Intraocular pressure (Median, IQR)		
Baseline	**1st Week**	***p*-value**
45.00 (50.50-40.00)	18.00 (22.50-13.50)	<0.001
Baseline	1st Month	p-value
45.00 (50.50-40.00)	12.00 (14.00-10.00)	<0.001
Baseline	2nd Month	p-value
45.00 (50.50-40.00)	10.00 (10.00-10.00)	<0.001

Table –III: Comparison of AS-OCT Angle Measurements before and after Peripheral Iridotomy (n=34)

ASOCT Angle (Median, IQR)		*p*-value
Pre-Peripheral Iridotomy	**Post Peripheral Iridotomy**	
8.70 (9.30-2.60)	42.70 (44.70-40.33)	<0.001

DISCUSSION

This findings of this study show that, AS-OCT aids in the diagnosis of acute angle closure glaucoma by measuring anterior chamber angles for early detection and treatment. The evaluation of closure of the anterior chamber (AC) angle is done using three primary methods: ultrasound biomicroscopy (UBM), coherence tomography (AS-OCT), gonioscopy and anterior segment optical[12]. A non-contact method of acquiring and processing optical signals is optical coherence tomography (OCT), is capable of producing magnified and highlyresolute images of the ocular tissues. With the invention of anterior segment OCT (AS-OCT), which enables the investigation of anterior segment anatomy down to the iris plane, noninvasive testing and fine resolution are its benefits[13].The AS-OCT method has various benefits when it comes to figuring out the anterior chamber particle density. First off, even in situations when corneal opacities are present, a crisp tomographic image can be acquired because to AS-OCT's utilization of a long laser wavelength of 1310 µm[14]. Several research have evaluated the effectiveness of AS-OCT with gold standard gonioscopy. In contrast to gonioscopy, Kavitha *et al.,* found that AS-OCT showed a high sensitivity of 98% in identifying angle closure. Only 44.6% was the specificity, though[15].

The study had 34 individuals, whose age from 42 to 59 years and had a mean age of 51.8 years. Women

made up the bulk of the participants comprising 25 cases (73.5%), while there were 9 males (26.5%). According to the study by Zhang et al., among all age groups, women are more likely to have angle-closure glaucoma. The prevalence of ACG may differ between sexes for a variety of reasons, such as endocrinologic disorders and menopause16.A study was conducted by Shan *et al.,* among Chinese population which showed that 61.8 (± 10.7) years was the mean age (± standard deviation). Within the PACS and PAC/PACG groups, there were more female patients as compared to control group (0.84 vs. 0.72 vs. 0.52, $P < 0.001$)17. Out of 34 participants 24 participants (70.6%) had laser peripheral iridotomy performed on their left eye, with the remaining 10 participants (29.4%) on their right eye.

At the first week post-operatively, the IOP dropped significantly to a mean of 18.2 mmHg (±6.03), representing a 59.6% reduction from baseline. By the first month, the IOP further reduced to a mean of 12.4 mmHg (±2.9), showing a 72.5% reduction from baseline. By the second month, the IOP stabilized at a mean of 10.1 mmHg (±0.3), marking a 77.6% reduction from baseline. Our results coincide with the study of Shanet al., who state that IOP was found to have decreased significantly generally after LPI. During the first follow-up week, the mean IOP dropped to 19.25 ±9.35 mmHg, and a month after the treatment, it had further decreased to 18.83 ±9.47 mmHg[18]. It may appear perplexing that there is more glaucoma progression even with a lower IOP. It is possible to hypothesize that patients who underwent phacotrabeculectomy and those who underwent phacoemulsification will respond differently to the operation in terms of their vascular response in addition to differences in IOP[19].

Pre-operatively, the mean ASOCT angle was 6.7° (±3.2), with a median value of 8.7° (IQR: 2.6–9.2). Post-operatively, the ASOCT angle increased significantly to a mean of 42.8° (±2.4), with a median of 42.7° (IQR: 40.4–44.7). The prerequisites for anterior and posterior segment imaging are distinct. Initially, the goal is to picture the entire anterior segment, which calls for a wider and deeper scan than is usually employed in the posterior region. Longer light wavelengths, which are typically attenuated by the vitreous, can be employed since the anterior section is more optically accessible than the posterior segment. Following the laser iridotomy, it is reported that stromal damage and thicker Descemet's membrane may occur as procedure-related consequences visible on AS-OCT[20].

A study was conducted in Pakistan by Imran et al., their results show the comparison of AS-OCT and gonioscopy in angle closure glaucoma stating that the patients were 59.16 ± 6.03 years old on average, 34 (33.3%) were men and 63(66.7%) were women. Intraocular pressure was 17.80 ± 4.25 mmHg on average. Angle closure was detected with an accuracy of 35.3% by gonioscopy and 60.8% by anterior segment OCT. This study concludes that as compared to gonioscopy, anterior segment OCT is more effective in determining the anterior chamber angle.[21]

Even though gonioscopy is the gold standard for evaluating angles, AS-OCT offers a quick, non-contact, and quantitative approach. A study conducted by Jaseena *et al.,* compared the effect of AS-OCT with gonioscopy, they concluded that AS-OCT's diagnostic efficacy was moderate when compared to gonioscopy[22].Porporato *et al.* states that AS-OCT is well tolerated, rapid and easy-to-use technique for evaluating the anterior segment and angle in patients, and has a good correlation with the data obtained from gonioscopy[23].

Overall, these findings imply that the intervention not only reduced increased intraocular pressure but also enhanced anterior chamber angle geometry. These findings may have significant effects on the treatment and prognosis of angle-closure glaucoma patients in the long run. To ensure these results and assess the durability of these effects, more research with greater sample sizes and longer follow-up periods is required.

LIMITATION OF STUDY

Anterior chamber angle AS-OCT imaging has limitations, such as trouble scanning the superior and inferior quadrants and possible distortion during manipulation. With its cross-sectional images, pigmentation or neovascularization cannot be directly seen. There is no defined system for rating angles, and the measurements were made by a single investigator. Narrow angles were defined for this investigation using an ACA cutoff of less than 10 degrees or equal to 10 degrees.

CONCLUSION

This study concludes by measuring anterior chamber angles with AS-OCT greatly increases the accuracy of diagnosing acute angle closure glaucoma and paves the way for prompt treatment. This non-contact imaging technique helps with early identification, prompt treatment, and improved glaucoma outcomes.

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Authors' Contribution

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

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

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

SS & HUZ: 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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