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Evaluation of Anterior Chamber Angle by Ultrasound Biomicroscopy and Gonioscopy in Glaucoma Patients and Glaucoma Suspects

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Abstract

Glaucoma is the second most common cause of blindness and the leading cause of irreversible type of blindness worldwide. *Objective:* To correlate the angles assessed and categorized by gonioscopy, with the quantified value of angles by the UBM. *Method:* Participants: Patients having open and closed angles coming to the glaucoma clinic were selected for this study. Grade 0 to Grade 4 were assigned to temporal quadrants of the angles of participants using Shaffer's classification. Quantification of angles was done by ultrasound biomicroscopy (UBM) using following biometric parameters namely- Angle opening distance at 500µ (AOD 500) from the scleral spur and trabecular meshwork-ciliary process distance (TCPD). Schaffer's Grade 0,1 and 2 were classified as "narrow angles" and Schaffer's Grade 3 and 4 as "open angles". *Outcome Measures:* Measurements of UBM were calculated and analyzed in relation to measurements of Gonioscopy. *Results:* Two hundred eyes of 100 patients were analyzed. 96 eyes had "narrow angles" and 104 eyes had "open angles" on gonioscopy. The difference of means calculated by UBM and angle grade estimated by Gonioscopy was significant ($p<0.001$). The Pearson correlation coefficient was calculated using all UBM parameters and gonioscopy grades which came out significant at the 0.01. *Conclusions:* The estimated of angle width done by gonioscopy significantly correlated with the angle dimensions those measured by the UBM. Gonioscopy, is thus a reliable method for estimation of the angle width, although it is a subjective test.

Keywords: Glaucoma; Ultrasound Bio-Microscopy; Gonioscopy; Aod; Tcpd.

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Introduction

Glaucoma is the second most common cause of blindness and the leading cause of irreversible type of blindness worldwide [1].

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The assessment of the anterior chamber angle (ACA) is critical in differentiating POAG from PACG. This can be done clinically by different methods like Van Herick's method, Smith method and gonioscopy [2]. Gonioscopy is considered the mainstay for assessment of the angle by directly visualising the anatomic relationships of iris, cornea and anterior chamber angle structures. There are three grading systems have been proposed for documenting angle findings seen in gonioscopy: Scheie, Schaffer and Spaeth classification [2].

Although gonioscopy is considered the gold standard for clinical evaluation of the angle, certain limitations are, subjective nature of this technique and so is limited by inter-observer variation in the assessment and diagnosis [3]. Secondly, there are no criteria which is universally accepted for determining the anatomic threshold that justifies treatment to prevent PACG.

The advancement in high resolution imaging techniques has made possible better and reproducible imaging of anterior chamber angle anatomy. High frequency Ultrasound Biomicroscopy (UBM) was the first method followed by Pentacam, Optical Coherence Tomography (OCT), Scheimpflug Photography and Scanning Peripheral Anterior Chamber Depth Analyzer (SPACS) [4].

The application of these technologies to the ACA has led to the definition of a variety of quantitative parameters. These parameters are- angle opening distance (AOD), the trabecular – iris space area (TISA), angle recess area (ARA) and the trabecular-ciliary process distance (TCPD). The location of measuring these parameters is 500 or 750 μm anterior to the scleral spur.

These parameters make the comparison of different imaging devices possible and also help in assessing correlations between the quantitative information and qualitative information that is available through imaging and semi quantitative and qualitative information derived from gonioscopy [4].

Agreement in the diagnosis of angle closure glaucoma between gonioscopy and UBM has not been well studied previously in India. Hence we undertook the present study to see if gonioscopy and UBM findings are in accordance with each other in known cases of glaucoma and glaucoma suspects in a tertiary care hospital of central India.

Objective

To correlate the angles assessed and categorized by gonioscopy, with the quantified value of angles by the UBM.

Methodology

This observational study was carried out at the Glaucoma clinic of a tertiary care referral institute March 2015- August 2016. A total of 100 patients fulfilling the following criteria were enrolled-

Inclusion criteria

1. Known cases of POAG
2. Patients with ocular hypertension
3. Those with spectrum of primary angle closure such as primary angle closure suspects (PACS), primary angle closure (PAC) and PACG

Ethical approval was obtained by the institute ethics committee. Informed consent was taken from all participants who were willing to participate in the study.

Patients underwent a series of baseline examination in including best corrected visual acuity (BCVA), intraocular pressure (IOP), anterior segment evaluation by slit lamp examination, clinical assessment of central and peripheral anterior chamber depth and optic nerve head evaluation by slit lamp biomicroscopy.

Subsequently, the subjects were assessed for their present status of angle of the anterior chamber by gonioscopy and UBM. For maintaining uniformity amongst the measurements, temporal quadrants of all angles were analyzed for both Gonioscopy and UBM.

Gonioscopy

Gonioscopy was done in a semi-darkened room with minimum-possible slit lamp illumination, using a Goldman single-mirror goniolens. A drop of topical anesthetic was instilled in the patient's eye and some lubricant gel was put over the concave part of the lens. After pulling down slightly on the lower lid the lens was placed on the surface of the eye. The inferior angle was examined first followed by superior, nasal and temporal and all the angle structures were identified in each quadrant. Similar procedure was repeated for the other eye. The angles were categorized as "narrow angles" (Shaffer's grade 2 or less) and "open angles" (Shaffer's grade 3 and 4) according to Shaffer's classification [16].

UBM (Ultrasound Biomicroscopy)

The UBM Model ReflexTM, Reichert Technologies, with a 50 MHz transducer probe was used to conduct all the examinations for the purpose of this study. It has a penetration depth of around 4-5mm and has a lateral and axial physical resolution of approximately 50μ and 25μ respectively

As done in gonioscopy, UBM is also performed in a semi darkened room for all patients. Instillation of 4% lignocaine drops was done and a plastic eyecup was used to gently part the lids, so as not to exert pressure on the globe. The probe was moved manually perpendicular to the structure to be scanned while keeping the patient supine. Patient was made to target on the ceiling by the fellow eye keep the fixation constant.

Blinding was ensured for the measurements obtained. Due to different echogenic properties,

the ciliary body and sclera could be readily differentiated on the UBM. On performing longitudinal scan across the limbus, the anterior-most point of the demarcation line between the ciliary body and sclera was identified as the scleral spur.

AOD 500 and TCPD of the patients were evaluated in the present study.

1. *The Angle-opening-distance (AOD):* This was defined as the perpendicular distance from the corneal endothelium to the anterior iris, at a given distance from the scleral spur. The calculation done at a distance of 250μ (AOD 250), consistently falls on trabecular meshwork. Similarly, at 500μ(AOD 500) measure the angle opening anterior to the trabecular meshwork.

2. *The Trabecular-ciliary process distance (TCPD):* This was measured 500μ anterior to the scleral spur from a point on the trabecular meshwork, extended perpendicularly through the iris to the ciliary process. The TCPD defines the port through which the iris must traverse and has implications as to the potential maximal angle opening. AOD-500 and TCPD were measured for individual patients. At the temporal quadrant, standard axial scans were obtained thrice. Mean calculation of three readings was done in each case.

Statistical analysis was done to compare the UBM measurements and gonioscopy findings. The Independent Samples t-test was applied for the comparison of UBM parameters and gonioscopy findings. For the co-relation analysis of the gonioscopic estimation of the angle width and the UBM quantification of the same angle grade, the Pearson Correlation coefficient was used.

Results

A total of 100 patients (200 eyes) who fulfilled the inclusion criteria for the present study were enrolled. The age of our patients ranged from 35 years to 76 years with a mean age of 57 ± 13.4 years. The maximum number of patients in our study were in the age group of 50-60 years (44%), followed by those >60 years (28%), 40-50 years (18%) and < 40 years (10%). The male: female ratio was 1.63:1 (males = 62%, females= 38%) and this difference was statistically insignificant (p=0.56).

The mean age of males and females and gender distribution according to type of glaucoma was calculated. In the narrow angle group, the mean age of women (51 ± 13.1) was less than men (55 ± 14.3), but the difference is statistically insignificant. Similarly in the open angle group mean age of women (62 ± 11.6) was less than men (63 ± 14.6), but statistically insignificance. Narrow angle was found in our study in 30 males and 18 females, 32 males and 20 females were categorized in open angle group (Table 1).

Table 1: Gender distribution of patients according to type of glaucoma

	Male	Female
Narrow angle (n=96)	30	18
Mean age ± SD (years)	55 ± 14.3	51 ± 13.1
Open angle (n=104)	32	20
Mean age ± SD (years)	63 ± 14.6	62 ± 11.6

Classifying the angles into narrow or open angle by gonioscopy, we found that 16 eyes (8%) had grade 0 angle, 34 eyes (17%) had grade 1 while 46 eyes (23%) had grade 2 angle, thus categorizing 96 eyes (48%) into the narrow angle group. Of the remaining 104 eyes with open angles, 68 eyes (34%) had grade 3 angle and 36 eyes (18%) had grade 4 angle (Table 2).

Table 2: Grading of angles by gonioscopy

Gonioscopy grade (n)	No. of Eyes (%)
Grade 0	16(8%)
Grade 1	34(17%)
Grade 2	46(23%)
Grade 3	68(34%)
Grade 4	36(18%)

In the comparison of angles graded by gonioscopy and UBM, 96 angles were graded narrow (Shaffer's grade 2 or less) by gonioscopy while 92 by UBM, and 104 angles were graded open (Shaffer's grade 3 and 4) by gonioscopy while the number of open angles measured by UBM was 108, but the difference was statistically insignificant (p value >0.05). The mean value of AOD 500 and TCPD in the narrow angle group was 112 ± 93μ and 623±120 μ respectively while in open angle group it was 342 ± 56μ and 956 ± 136μ respectively. The difference for both values in the two groups was found to be statistically significant. For AOD 500 p value is <0.00001 and for TCPD p value is <0.017126 (Table 3).

Table 3: Comparison of angles graded by gonioscopy and UBM

Angles	Gonioscopy	UBM	p value
Narrow	96	92	0.688625
Open	104	108	0.688625

The temporal angles of 16 eyes were categorized by gonioscopy as Grade 0, 34 angles were Grade 1, 46 angles were Grade 2, 68 angles were Grade 3 and 36 eyes had Grade 4 angles (Table 4). We observed

that both the AOD 500 and TCPD values increased successively with the increasing grade of the angle. The corresponding mean value of AOD 500 and TCPD for grade 0 angle was 16.7 ± 14.2μ and 567 ± 102.6 μ respectively, for grade 1 angle was 96 ± 36.4 μ and 665 ± 132.5 μ respectively, for grade 2 angle was 186 ± 80.7 μ and 736 ± 102.4 μ respectively, for grade 3 angle was 272 ± 50.6 μ and 874 ± 103.1 μ respectively and for grade 4 angle was 346 ± 30.6 μ and 972 ± 76.5 μ respectively (Table 5).

Table 4: Mean UBM measurements of temporal angles graded as Narrow VS Open by Gonioscopy

Angle parameters (mean ± SD)	Narrow angle (n = 96)	Open angle (n = 104)	p value
AOD 500	112 ± 93μ	342 ± 56μ	<0.00001
TCPD	623 ± 120μ	956 ± 136μ	<0.017126

Table 5: Mean UBM measurements of angles categorized by gonioscopy

Gonioscopy grade (n)	AOD 500 (μ) (mean ± SD)	TCPD (μ) (mean ± SD)
0 (n=16)	16.7 ± 14.2	567 ± 102.6
1 (n=34)	96 ± 36.4	665 ± 132.5
2 (n=46)	186 ± 80.7	736 ± 102.4
3 (n=68)	272 ± 50.6	874 ± 103.1
4 (n=36)	346 ± 30.6	972 ± 76.5

Discussion

For the diagnosis of narrow angles, Gonioscopy still remains the mainstay. Assessment of the risk of angle closure is done commonly by the Shaffer grading system. The cut-off between open and narrow angles is grade 2[19] and measurement is subjective, giving only approximate angle which are recorded in degrees. Thus, it provides only an estimation of the angle width[9]. There is disagreement between glaucoma subspecialists, as to the grading of the angle and its occludability[7]. Keeping this in mind, Congdon et al[20] developed biometric gonioscopy system so that inter-observer reliability improves and cut-off angles for screening may be defined.

Ultrasound Biomicroscopy has brought revolution by making possible the quantitative assessment of iris curvature and degree of angle opening. Clinicians can now determine the state of closure of the entire angle, even when it cannot be visualized by gonioscopy. The general configuration of the iris in normal patients is planar or has a gentle anterior convexity[21]. A relative pupillary block results in an anteriorly bowed iris, with a corresponding decrease in angle opening. The AOD 250 is a measure of the angle opening at the level of the posterior trabecular meshwork, while the AOD 500 is a measure of the angle opening at the level of the anterior Schwalbe's line. The AOD measured by the UBM may thus reflect the amount of relative pupillary block in eyes with narrow angles [22].

The TCPD, as reported by Pavlin et al is a particularly important parameter, since it defines the space available for the iris between the trabecular meshwork and ciliary process and is a main feature in an individual eye. The TCPD is the sum of three segments: the angle opening 500μ from the scleral spur; the thickness of the iris at that point and the width of the ciliary sulcus.

Out of a total of 100 patients the maximum number (44%) of patients was in the age group of 50-60 years with a mean age of 57 ± 13.4 years. Amongst patients with narrow angle glaucoma, the mean age was 53 ± 13.6 years while in open angle glaucoma patients, the mean age was 63 ± 12.8 years.

There was no significant gender predilection seen in our study (M:F = 1.63:1). Similar observation was made by Narayanaswami et al., (2004) [11] in their study on 500 patients which had 282 men and 218 women with a mean age of 57.32 ± 12.48 years.

In contrast**,** Kaushik S et al. (2006) [12] in their study on 163 patients had more females (71 males and 92 females). The mean age of males was higher in patients with narrow angle (58.3 ± 13.1 years v/s 53.2 ± 14.3years) while in patients with open angle females (64.4 ± 12.6 years) had a higher mean age compared to males (62.3 ± 14.6 years).

Our study revealed 96 eyes having narrow angles and 104 eyes with open angles. The maximum no. of eyes had a Schaffer's grading of grade 3 by gonioscopy (n=68; 34%) while the least common grading was grade 0 seen in 16 eyes (8%).

Kaushik S et al. (2006) [12] in their study had 106 eyes had narrow angles while 57 eyes had narrow angle by gonioscopy and in their study also the most common grading was grade 3 in 42 (25.7%) eyes. However, in contrast to our observation the least common grade in their study was grade 4 (n=15; 9.2%).

When we compared the grade of the angle by gonioscopy and UBM, we found good agreement between both techniques. Out of a total of 200 angles assessed grading of only 4 angles (2%) showed discrepancy. They were graded as narrow by gonioscopy, but UBM examination showed them as open angle. This difference was statistically

insignificant ($p > 0.6$).

Similar observations have been made by studies of Spaeth et al. (1995) [23], Narayanaswami et al. (2004) [11], Kaushik S et atl. (2006) [12], Barkana Y et al. (2007) [13] and Liu RJ et al. (2014) [17].

However the study by Wang N et al. (1999) [8] concluded that angles examined by gonioscopy were wider as compared to UBM especially when the angles were narrow.

Both the AOD 500 and TCPD values for narrow angles were less compared to those for non-occludable angles and the difference for both was statistically significant ($p < 0.00001$).

Similar findings were also documented by Kaushik S et al. (2006) [12] in their study

In our study we observed that the mean AOD 500 and TCPD values showed a gradual increase as the width of the angle increased from grade 0 to grade 4.

The mean AOD 500 values were smallest (16.7 ± 14.2) for grade 0 angles and highest (346 ± 30.6) for grade 4 angles. Similarly TCPD values were least (567 ± 102.6) for grade 0 and highest (972 ± 76.5) for grade 4.

Our findings are in accordance with those of Garudadri CS et al. (2002) [24] and Kaushik S et al. (2006) [12].

In a study conducted by Narayanaswami et al. (2004) [11], AOD 500 correlated well with angle width. All biometric parameters, except for lens thickness, were significantly lower in eyes with occludable angles in comparison with eyes with non-occludable angles.

According to published reports of UBM measurements in Indian eyes, the findings are as follows: Narayanaswamy et al. (2004) [11] found a tendency to overestimate the angle width by gonioscopy compared to the UBM, while in the study conducted by Kaushik S et al. (2006) [12], UBM measurements and gonioscopic assessments of the angle width were significantly correlated. Another study done by Garudadri et al. (2002) [24], used different method of estimating the AOD 500 and TCPD and thus the results are not comparable to the present study.

In the present study, UBM measurements and gonioscopic features of the angle width correlated significantly. This indicates that although being a subjective evaluation, gonioscopy appears to provide accurate information with regard to the angle width estimation. Angle closure is now being considered as a major problem in India. The Andhra Pradesh eye disease study25 reported that 2.21% of the population > 40. 0 years, had occludable angles at risk of angle closure and 1.08% had manifest PACG, a large proportion of who were undiagnosed and untreated. In the Vellore eye study26 manifest PACG was as high as 4.3%. As visual loss resulting from PACG is potentially preventable if peripheral iridotomy is performed at an early stage, strategies for the early detection of PAC could reduce the risk of blindness resulting from PACG.

Conclusion

In conclusion UBM is a new method of imaging the anterior segment of the eye at high resolution. Although histological assessment of various disease types is sometimes available from pathology specimens, this usually occurs at a late stage in the disease and is susceptible to the inevitable distortions of the preparation process. UBM, though lacking the resolution of optical microscopy, gives us images in living eyes without affecting the internal relationships of the structures being imaged. UBM has proven to be valuable in both clinical practice and ophthalmic research.

In spite of the advent of the UBM for quantitative estimation of the anterior chamber angle, gonioscopy remains the reference standard for differentiating appositional from synechial angle closure and quantifying the extent of peripheral anterior synechiae, in addition to characterizing the anatomic appearance of the anterior chamber angle. It is appropriate for use in Asian countries like India, where the angle closure glaucoma is highly prevalent and access to quantitative methods like the UBM is limited. Mandatory use of gonioscopy would probably help towards reducing the morbidity from PACG by earlier diagnosis and timely management of occludable angles.

From the present study we can conclude that gonioscopy appears to be equally effective in grading the anterior chamber angle as compared to UBM grading in Indian eyes.

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