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Ocular biometry in occludable angles and angle closure glaucoma: a population based survey

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Aim: To compare ocular biometric values in a population based sample of eyes with occludable angles, angle closure glaucoma, and normal subjects.

Method: 2850 subjects from a population based glaucoma prevalence study underwent complete ocular examination including indentation gonioscopy. Ocular biometry was performed in all subjects classified to have occludable angles (n = 143); angle closure glaucoma (n = 22), and a random subgroup of 419 normal subjects. Ocular biometry readings between the groups were compared and statistically analysed using "t," "z," and Mann-Whitney U tests.

Results: The mean age among subjects with occludable angles (54.43 (SD 9.53) years) and angle closure glaucoma (57.45 (8.5) years) was significantly higher (p<0.001) than normal subjects (49.95 (9.95) years). Axial length was shorter (p<0.001) in the occludable angle group (22.07 (0.69) mm) compared to the normal group (22.76 (0.78) mm). Anterior chamber depth (ACD) was shallower (p<0.001) among subjects with occludable angles (2.53 (0.26) mm) than normal subjects (3.00 (0.30) mm). Lens thickness (LT) was greater (p<0.001) in people with occludable angles (4.40 (0.53) mm) compared to normal subjects (4.31 (0.31) mm). No significant difference was noted in axial length, ACD (p = 0.451), and LT (p = 0.302) between angle closure glaucoma and occludable eyes.

Conclusion: South Indian eyes with angle closure glaucoma and occludable angles seem to have significantly shorter axial lengths, shallower anterior chambers and greater lens thickness compared to the normal group.

Quigley has estimated that 66.8 million people are affected by primary glaucoma worldwide, with 6.7 million people being bilaterally blind due to the disease.¹ The prevalence of primary open angle glaucoma (POAG) versus primary angle closure glaucoma (PACG) varies with race and region; India has higher prevalence of PACG compared with Western populations.¹ An estimated eight million Asian Indians were projected to have glaucoma by the year 2000 with equal numbers of open angle and angle closure glaucoma.¹ Population based studies from India have suggested that angle closure glaucoma is at least as common as open angle glaucoma.^{2,3} A significant percentage of the population (10.35%) has been reported to have occludable angles.³ The reasons for the relatively high prevalence of occludable angles and angle closure glaucoma are, however, not known.

Clinic based studies have suggested that eyes with occludable angles and angle closure glaucoma have a shorter axial length, shallower anterior chamber, and a thicker lens.^{4–8} The shallower anterior chambers are in part because of the thicker and more anterior position of the crystalline lens.⁷ Progressive increase in lens thickness with age results in greater shallowing of the anterior chamber.⁹

In a hospital based study from India, Saxena *et al* found shallower anterior chambers and thicker lenses in their clinic based comparison between angle closure glaucoma and normal subjects⁴ and Sihota *et al* have reported comparable results.⁵

It has been a general clinical impression that Asian Indian eyes have shorter axial lengths than Western eyes. However, there are few population based data available from India.¹⁰ Hence, this study was planned to report biometric data from a population based sample of Indian subjects.

METHODS

A total of 2850 subjects from rural Tamil Nadu in southern India participating in an ongoing population based glaucoma

prevalence survey underwent a complete ocular examination. Subjects were from a previously selected cluster of villages in Tiruvallur and Kanchipuram districts 80 km from Chennai city. Adults aged 40 years or more were eligible for examination. The study was carried out after approval from the institutional review board and informed consent was obtained from all the participants.

All subjects underwent a complete ocular examination in the base hospital including visual acuity measurement on the ETDRS chart, slit lamp examination, Goldmann applanation tonometry, indentation gonioscopy, post-dilatation lens classification on the LOCS II system,¹¹ stereobiomicroscopic examination of the optic disc using a 78D lens, and optic disc photography.

Gonioscopy was performed with a Sussman indentation gonioscope (Volk Optical Inc, Mentor, OH, USA) in dim illumination using a shortened slit beam that did not fall upon the pupil. The modified Shaffer grading system¹² was used and the angle grade and degree of pigmentation recorded in clock hours. Angles were indented open to look for synechiae and extent of closure in eyes where angle structures were not visualised. An occludable angle was defined as an eye where less than 180 degrees of the filtering trabecular meshwork was visible before indentation. Angle closure glaucoma was defined as occludable angles with intraocular pressure more than 21 mm Hg. Cases with raised intraocular pressure or glaucomatous optic disc changes were advised to have visual field testing on the Humphrey field analyser. Field and optic disc changes were not mandatory for the diagnosis of angle closure glaucoma.

Cases classified to have occludable angles and angle closure glaucoma underwent ocular biometry. A random subgroup of normal subjects, selected by systematic random sampling, also underwent biometry. Subjects who reported for testing were assigned consecutive registration numbers and based on the registration number, every fifth subject underwent ocular

Table 1 Demographic data for normal subjects, occludable angles, and angle closure glaucoma

	Normal subjects (n=419)	Occludable angle group (n=143)	Angle closure glaucoma group (n=22)
Age	49.95 (9.95)	54.4 (9.53)*	57.45 (8.50)*
Sex (male:female)	210:209	40:103*	2:20*

*p<0.001.

Table 2 Ocular biometry values of normals compared with occludable angles and angle closure glaucoma eyes

	Normal subjects (n=419)	Occludable angle group (n=143)		Angle closure glaucoma group (n=22)	
	Mean (SD)	Mean (SD)	95% CI difference in means	Mean (SD)	95% CI difference in means
Axial length (mm)	22.76 (0.78)	22.07 (0.69)*	-0.83 to -0.054	21.92 (0.7)*	-1.17 to -0.50
Anterior chamber depth (mm)	3.00 (0.3)	2.53 (0.26)*	-0.052 to -0.41	2.63 (0.39)*	-0.23 to -0.51
Lens thickness (mm)	4.31 (0.31)	4.40 (0.53)*	-0.51 to -0.41	4.23 (0.69)†	-0.06 to 0.22
Lens thickness/axial length ratio	0.192 (0.01)	0.199 (0.02)*	-0.01 to -0.003	0.191 (0.03)‡	-0.005 to 0.007

*p<0.001; †p=0.77; ‡p=0.66.

Table 3 Comparison of ocular biometric data in the normal group between males and females

	Males (n=210)	Females (n=209)	95% CI difference in means
	Mean (SD)	Mean (SD)	
Axial length (mm)	22.88 (0.70)	22.38 (0.74)*	-0.63 to -0.36
Anterior chamber depth (mm)	3.06 (0.3)	2.91 (0.28)†	-0.20 to -0.09
Lens thickness (mm)	4.39 (0.30)	4.30 (0.31)‡	-0.14 to -0.03

*p<0.001; †p=0.003; ‡p=0.03.

biometry if the inclusion criteria were fulfilled. In case the subject was ineligible, the next eligible subject on the list underwent biometry.

Biometry was performed by an optometrist after anterior segment examination and gonioscopy was completed by an ophthalmologist. The ocular surface was anaesthetised with 0.5% oxybuprocaine (proparacaine) hydrochloride eye drops and biometry was performed using the Alcon ultrasonic biometer (Ocuscan, Alcon Laboratories Inc, Fort Worth, TX, USA). The axial length, anterior chamber depth, and the lens thickness were measured for each eye. Biometry was performed in all subjects before the use of any mydriatics or pilocarpine.

Subjects with a normal ocular examination, intraocular pressure less than 22 mm Hg, open angle on gonioscopy, and no history of intraocular surgery were included in the normal group.

Subjects giving a history of previously diagnosed glaucoma, intraocular surgery, laser iridotomy or refractive surgery, use of antiglaucoma medication, or evidence of active keratitis or anterior segment pathology precluding examination were excluded. We also excluded subjects who were unable to undergo biometry for any specific reason.

The eyes that fulfilled the eligibility criteria were included for the study. If both eyes of a subject were eligible one eye was randomly selected for analysis. Similarly, in cases with bilateral angle closure glaucoma or occludable angles, one eye was randomly selected for analysis. Ocular biometry data in people with occludable angles was compared to a subset of age-matched normal subjects. Data were entered in a computerised database and the two groups compared using "t," "z," and Mann-Whitney U tests.

RESULTS

Of the 2850 subjects examined 143 (5.01%) were diagnosed to have occludable angles and 22 subjects (0.77%) had angle closure glaucoma as defined. The control group comprised 419 randomly selected normal subjects. Demographic details of the study groups are given in Table 1.

The mean age among subjects with occludable angles was 54.43 years (95% CI: 52.83 to 55.96), significantly higher (p<0.001) than the 49.95 years (95% CI: 49.00 to 50.90) among normal subjects. Those with angle closure glaucoma were older (57.95 (8.50) years) than the occludable group but the difference was not significant (p=0.149). There were a significantly larger proportion of females in both the occludable angle (40 males: 103 females) and angle closure glaucoma (two males: 20 females) groups compared to the normal group (210 males: 209 females).

Ocular biometric values were significantly different between the groups (Table 2). Mean axial length was significantly (p<0.001) less in the occludable (22.07 (0.69) mm) and angle closure glaucoma (21.92 (0.70) mm) groups compared to the normal group (22.76 (0.78) mm). Those with occludable angles (2.53 (0.26) mm) and angle closure glaucoma (2.63 (0.39) mm) had shallower (p<0.001) anterior chamber depths than normal eyes (3.00 (0.300) mm). Eyes with occludable angles (4.40 (0.53) mm) had significantly thicker lenses (p<0.001) compared to normal eyes (4.31 (0.31) mm).

Although eyes with angle closure glaucoma showed thinner lenses (4.23 (0.69) mm) than the other groups, the difference was not significant (p=0.066) and the 95% confidence intervals overlapped zero.

Biometric data of both sexes in the normal group were compared (Table 3). Females had significantly shorter axial lengths (p<0.001), shallower anterior chamber depths (p<0.001), and thicker lenses (p=0.003) than males.

Table 4 Comparison of ocular biometric data in the occludable group between males and females

	Males (n=40)	Females (n=103)	95% CI difference in means
Axial length (mm), mean (SD)	22.40 (0.51)	21.93 (0.70)*	0.22 to 0.71
Anterior chamber depth (mm), mean (SD)	2.62 (0.21)	2.50 (0.27)†	0.02 to 0.21
Lens thickness (mm), mean (SD)	4.41 (0.61)	4.39 (0.51)‡	-0.17 to 0.21

*p<0.001; †p=0.013; ‡p=0.843

Table 5 Occludable angle group compared to an age matched subset of normals

	Age matched normal group (n=143)	Occludable angle group (n=143)	95% CI difference in means
	Mean (SD)	Mean (SD)	
Axial length (mm)	22.58 (0.78)	22.07 (0.69)*	-0.68 to -0.33
Anterior chamber depth (mm)	2.96 (0.28)	2.53 (0.26)*	-0.46 to -0.34
Lens thickness (mm)	4.38 (0.28)	4.40 (0.53)†	-0.11 to 0.08

*p<0.001; †p=0.82.

Table 6 Comparison of ocular biometric data between different populations

	South Indian (n=419)	Chinese ¹³ (n=531)	White Americans ¹³ (n=170)	African-Americans ¹³ (n=188)
Sex (M:F)	210:209	236:295	82:88	55:133
Axial length (mm), mean (SD)	22.76 (0.78)	23.32 (1.38)*	23.35 (1.38)*	23.14 (0.87)*
95% CI difference in means		-0.68 to -0.43	-0.76 to -0.41	-0.519 to -0.24

*p < 0.001.

Within the occludable angle group females had significantly shorter axial lengths ($p < 0.001$) than males. There was no difference between anterior chamber depth and lens thickness between sexes in this group (Table 4).

Eyes with angle closure glaucoma had shorter axial lengths compared to occludable angles but the difference was not significant ($p = 0.345$). No significant difference was noted in anterior chamber depth ($p = 0.451$) and lens thickness ($p = 0.302$) between the groups.

The mean lens thickness to axial length ratio was significantly ($p < 0.001$) larger among the occludable group (0.199 (0.02)) compared to the normal group (0.192 (0.015)).

On comparing the occludable angle group with a set of age matched normal subjects, the group had significantly ($p < 0.001$) smaller mean axial lengths (22.58 (0.815) mm) and shallower anterior chambers (2.93 (0.28) mm). Lens thickness (4.389 (0.28) mm) was, however, not significantly different ($p = 0.827$) between the two groups. There was no significant difference ($p = 0.13$) in the lens thickness/axial length ratio between the groups (Table 5).

Biometric data for the normal population were compared to data reported for other populations.¹³ Axial lengths in the normal group were significantly shorter ($p < 0.001$) than reported for Chinese, white, and African-American populations (Table 6).

DISCUSSION

There is evidence in the literature that eyes with angle closure glaucoma or occludable angles have shorter axial lengths, shallower anterior chamber depths, and thicker crystalline lenses.⁴⁻⁸ This report from an Asian Indian population based study seems to suggest similar results.

Angle closure glaucoma is commoner in India^{2,3} than in the West, the reasons for which are not clearly understood. On

comparing mean axial lengths among our normal population to other racial subgroups,¹³ the south Indian eyes appear to be significantly shorter than the Chinese, white, or African-American populations. The shorter axial lengths among the occludable angles in our study suggests an anatomical predisposition to occludable angles and angle closure glaucoma.

As we have used non-visualisation of the filtering trabecular meshwork in more than 180 degrees of the angle to define occludable angles, our definitions of occludable angles and angle closure glaucoma may appear lenient. This reflects our usual clinical practice. A more stringent definition might result in a larger discrepancy between the two groups.

It is known that women are more susceptible to angle closure glaucoma than men.⁹ We also found a significantly larger proportion of women in the groups with occludable angles and angle closure glaucoma than the normal population. Females in our study had significantly shorter eyes, shallower anterior chambers, and thicker lenses. Additionally, within the occludable angle group females had shorter axial lengths compared to males. This could explain the increased prevalence of occludable angles among females.

The occludable group was almost 5 years older than the normal group and also had significantly thicker crystalline lenses. The increase in lens thickness with age could have resulted in a narrow angle configuration in an eye with a shorter axial length. In order to correct for the potential increase in lens thickness with age we age matched people with occludable angles to a subset of the normal group. On age matching the two groups the lens thickness was similar in both groups. However, the anterior chamber depth and axial length were shorter in the occludable angle group. The lens thickness/axial length ratio was, however, increased in these eyes, suggesting that a disproportionately thick lens or a normal sized lens in an eye with a shorter axial length may predispose to occludable angles.

The eyes with angle closure glaucoma did not have shallower anterior chambers or thicker lenses than the occludable group. Since both are stages in the progression of the disease it would seem logical to assume that angle closure glaucoma would be associated with a shallower anterior chamber and a thicker lens than an eye with occludable angles. The small sample size of angle closure eyes may account for the lack of a significant difference. Thomas *et al* in their paper on progression of angle closure glaucoma suspects report no significant difference in ocular biometry between those eyes that progressed to angle closure and those that did not.¹⁰ Perhaps some additional factor like configuration of the anterior chamber or differences in corneal curvature may also contribute to the development of angle closure glaucoma.

Occludable angles in this south Indian population seem to be associated with shallower anterior chambers, thicker crystalline lenses, and shorter axial lengths. However, we suggest that a larger sample size would be required to comment on the association of ocular biometric values and angle closure glaucoma in this population.

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