Prevalence of Angle-Closure Disease in a Rural Southern Indian Population

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Objective: To estimate the prevalence of primary angle-closure glaucoma, primary angle closure (PAC), and primary angle-closure suspect (PACS) and its associated risk factors in a rural population in southern India.

Methods: Three thousand and nine hundred thirty-four (81.95%) of 4800 enumerated subjects aged 40 years or older underwent a complete ophthalmic examination, including compression gonioscopy. Glaucoma was diagnosed using International Society of Geographical and Epidemiological Ophthalmology classification.

Results: Data were analyzed for 3924 subjects (81.75%). Primary angle-closure glaucoma was diagnosed in 34 subjects (0.87%; 95% confidence interval [CI], 0.58 to 1.16) (27 women, 7 men). The mean intraocular pressure was 20.71±9.24 mm Hg. One subject (2.94%) was blind. Twenty-eight subjects (0.71%; 95% CI, 0.45 to 0.98) were diagnosed to have PAC (21 women, 7 men). Eleven subjects (39.3%) had an intraocular pressure greater than 21 mm Hg, 13 subjects (46.43%) had peripheral anterior synechiae, and 4 subjects (14.29%) had both. Two hundred forty-six subjects (6.27%; 95% CI, 5.51 to 7.03) had PACS (168 women, 78 men). Primary angle closure and primary angle-closure glaucoma were more common in women (age-adjusted odds ratio, 3.02; 95% CI, 1.66 to 5.51) with an increasing prevalence with age. Increasing intraocular pressure was associated with the disease (odds ratio, 1.14; 95% CI, 1.09 to 1.19). There was no association with hypertension and hyperopia. Axial length and anterior chamber depth were longer in the normal group than in the 3 groups with angle closure (P<.05). Women had shorter axial lengths than men (P<.001) in the angle closure groups.

Conclusions: The overall prevalence of primary angle closures (PAC and primary angle-closure glaucoma) in a rural population of southern India was 1.58%. There was a female preponderance, and the disease tends to be asymptomatic.

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HERE IS A GROWING ACCEPTANCE that the prevalence and predominant type of glaucoma show racial variability. Population-based surveys in the age group 40 years and older in different races have shown large variations in primary angle-closure glaucoma (PACG). The prevalence rates are highest for the Eskimo population (2.6%-5.0%)1-3 and lowest for the white population.4 In between these come the Mongol (1.4%),4 Chinese,5 and Thai populations (0.9%).6 In India, 3 studies conducted in southern states have shown varied prevalence of PACG (0.5%-4.3%).7-9 This is probably due to the different definitions used by the studies for occludable angles and angle-closure glaucoma. We adopted the definitions suggested by the International Society of Geographical and Epidemiological Ophthalmology (ISGEO)10 in this study and report our data on prevalence of PACG and its associated factors in a rural population in southern India.

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The Chennai Glaucoma Study is a population-based study. The aim of the study is to estimate the prevalence of glaucoma in rural and urban populations of the southern Indian state of Tamil Nadu. The study was started in June 2001 and the rural arm was completed in January 2003. The present study deals only with the prevalence of primary angle-closure disease in the rural population. This study was approved by the institutional ethics review board. The methods and design of the Chennai Glaucoma Study are described in detail elsewhere.11 The details of the study design relevant to this paper are given here.

STUDY POPULATION AND FIELD WORK

A cluster of 32 villages in Thiruvallur and Kancheepuram districts of Tamil Nadu with an estimated population of 22,000 persons was identified. These villages had an estimated 4840 persons who were 40 years or older (Government of India census, 1991).11 Trained social work-

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ers then performed the enumeration by door-to-door survey in these villages and identified 4800 eligible subjects aged 40 years or older from 27 contiguous villages. During enumeration, demographic information was collected using a household questionnaire. All eligible subjects were motivated by the social workers to come to the base hospital for detailed examinations.

EXAMINATION

All the responding subjects underwent detailed ophthalmic examinations at a dedicated facility in the base hospital. Written informed consent was obtained from all the subjects (left thumb impressions from illiterate persons). The consent form was given in English to those who can read the language. For those who cannot read English, the same form was available in the vernacular language. For illiterate subjects, the consent form was read out in the vernacular language in the presence of either a relative or the village volunteer. Two ophthalmologists (glaucoma specialists) and 2 optometrists who received additional training in the study procedures performed the ophthalmic examinations. The optometrists tested visual acuity, performed pachymetry, and conducted visual field testing; ophthalmologists carried out all other examinations.

We measured the presenting visual acuity and the best-corrected visual acuity using 4-m logarithm of minimum angle of resolution (logMAR) charts (Light House Low Vision Products, New York, NY). Automated visual fields were performed for every subject with a best-corrected visual acuity of 4/16 (logMAR 0.6) or better using Frequency Doubling Perimetry (Zeiss Humphrey Systems, Dublin, Calif). All eligible subjects underwent the screening C-20-1 (if unreliable or abnormal, the test was repeated) and the N-30 threshold test once. For the screening C-20-1 test, the reliability criteria were no fixation or false-negative errors. Visual fields with no depressed points to any level of sensitivity were considered to be normal.

External examination and pupillary evaluation were done using a flashlight. Slitlamp biomicroscopy was done and any abnormalities in the anterior segment were noted. Using a narrow slit beam, peripheral anterior chamber depth was graded according to van Herick’s technique.12 However, we did not use the grading by van Herick et al12 to diagnose angle-closure disease. Intracocular pressure (IOP) was recorded with a Goldmann applanation tonometer (Zeiss AT 030 Applanation Tonometer, Carl Zeiss, Jena, Germany) under topical anesthesia using 0.5% proparacaine and fluorescein staining of the tear film. The right eye was measured first and 1 reliable measurement was recorded for each eye. Gonioscopy was performed on all subjects in dim ambient illumination with a shortened slit that did not fall on the pupil. A 4-mirror Sussmann lens (Volk Optical Inc, Mentor, Ohio) was used. The angle was graded according to the Shaffer system2 and the peripheral iris contour, the degree of trabecular meshwork pigmentation, and other angle abnormalities were recorded. An angle was considered occludable if the pigmented trabecular meshwork was not visible in more than 180° of the angle in dim illumination (primary angle-closure suspect [PACS]). If the angle was occludable, indentation gonioscopy was performed and the presence or absence of peripheral anterior synchiae was recorded. Laser iridotomy was performed in subjects with occludable angles after obtaining their consent. The rest of the examination was deferred to another convenient date following laser iridotomy.

All subjects with open angles on gonioscopy had pupillary dilation using 1% tropicamide and 5% phenylephrine hydrochloride (Unimed Technologies, Halol, Gujarat, India). If phenylephrine was contraindicated, 1% homatropine (Warren Pharr- maceticals, Mumbai, India) was used. Subjects diagnosed as having PACS underwent pupillary dilatation after laser iridotomy. Grading of lens opacification was done at the slit-lamp using the Lens Opacities Classification System13 with a minimum pupillary dilation of 6 mm. Lenticular opacities were graded by comparison with the standard set of photographs. Stereoscopic evaluation of the optic nerve head was performed using a +78 diopter (D) lens at slitlamp. The vertical and horizontal cup-disc ratios (CDRs) were measured and recorded. Presence of any notching, splinter hemorrhages, and peripapillary atrophy was documented. The detailed retinal examination was done with binocular indirect ophthalmoscope using the +20-D lens. The agreement between the 2 ophthalmologists was high for grading the occludability (κ=0.87) and determining the vertical CDR (VCDR) (κ=0.87).

Ocular biometry was performed using the Alcon ultrasonic biometer (OcuScan; Alcon Laboratories Inc, Fort Worth, Tex) on every fifth subject, the first subject having been selected at random. The axial length, anterior chamber depth, and lens thickness were measured. In addition to the randomized subset, all subjects with PACS, PAC, and PAGC underwent biomicroscopy measurements prior to laser iridotomy.

A provisional diagnosis of suspected glaucoma was made when the subject had 1 or more of the following conditions: IOP of 21 mm Hg or greater in either eye, vertical CDR of 0.7 or greater in either eye or CDR asymmetry of 0.2 or greater, focal thinning, notching of neuroretinal rim, or splinter hemorrhage. All these subjects were advised about a threshold visual field test using the SITA standard 30-2 program (Model 750, Humphrey Instruments, San Leandro, Calif).

DIAGNOSTIC DEFINITIONS

The distribution of VCDR and IOP was obtained from those subjects with reliable and normal suprathreshold visual field testing using Frequency Doubling Perimetry. Cases of glaucoma were defined using the ISGEO classification.10 Glaucoma was classified according to 3 levels of evidence. In category 1, diagnosis was based on structural and functional evidence. It required CDR or CDR asymmetry equal to or greater than the 97.5th percentile for the normal population or a neuroretinal rim width reduced to 0.1 CDR (between 10 and 1 o’clock or 5 and 7 o’clock) with definite visual field defect consistent with glaucoma. A glaucomatous field defect was diagnosed on threshold visual field examination (SITA standard 30-2) of the central 30°, if the glaucoma hemi field test was outside normal limits and 3 or more abnormal contiguous nonedge points (except nasal horizontal meridian) were depressed to the P<0.05 level.13 Reliability criteria were as recommended by the instrument’s algorithm (fixation losses, <20%; false positive and false negative, <33%).

Category 2 was based on advanced structural damage with unproved field loss. This included those subjects in whom visual fields could not be done or were unreliable, with CDR or CDR asymmetry equal to or greater than the 97.5th percentile for the normal population or a neuroretinal rim width reduced to 0.1 CDR (between 10 and 1 o’clock or 5 and 7 o’clock) with definite visual field defect consistent with glaucoma. A glaucomatous field defect was defined using the SITA standard 30-2 program of the central 30°, if the glaucoma hemi field test was outside normal limits and 3 or more abnormal contiguous nonedge points (except nasal horizontal meridian) were depressed to the P<0.05 level.13 Reliability criteria were as recommended by the instrument’s algorithm (fixation losses, <20%; false positive and false negative, <33%).

Category 3 consisted of persons with an IOP greater than the 99.5th percentile for the normal population, whose optic discs could not be examined because of media opacities.

The definitions of occludable angle and manifest PACG were again based on definitions suggested by ISGEO.10 Primary angle-closure suspect is an eye in which the posterior trabecular meshwork was not seen for greater than 180° on gonioscopy; PAC is an eye with PACS and peripheral anterior synchiae and/or elevated IOP without glaucomatous damage of the optic disc; PACG is PAC with evidence of glaucoma as defined.
Blindness was defined as a best-corrected logMAR visual acuity of less than 0.4/0.2 (logMAR 1.3) and/or constriction of the visual field of less than 10° from fixation in the better eye. Hyperopia was defined as spherical equivalent greater than 0.50 D in a phakic eye. Diabetes mellitus was detected based on current use of antidiabetic medication and/or a random blood glucose level greater than 200 mg/dL. We defined systemic hypertension as current use of systemic antihypertensive medications or a measured systolic blood pressure of 140 mm Hg or greater and/or a diastolic blood pressure of 90 mm Hg or greater.

Categorical variables were compared using a χ2 test, a t test was used for continuous variables, and continuous variables for multiple groups were compared using ANOVA. Independent effects of age group, hyperopia, systemic hypertension, VCDR, IOP, and ocular biometry were assessed using logistic regression. Data analysis was carried out using Windows-based statistical software. Odds for PACG were presented with 95% confidence intervals.

RESULTS

A total of 3934 subjects were examined (1767 men, 2167 women; response rate, 81.95%). Of these, complete data were available for 3924 subjects (1761 men, 2163 women; response rate, 81.75%). The mean age was 57.21±9.8 years. Eleven (39.3%) of 28 subjects (46.4%) had synechiae in the angle, 19 (67.8%) had peripheral anterior synechiae, and 4 subjects (14.29%) had both. On gonioscopy, 13 subjects (46.4%) had synechiae in the angle, 19 (67.8%) had moderate amounts of pigmentation, and 9 (32.1%) had a heavily pigmented trabecular meshwork.

PRIMARY ANGLE-CLOSURE SUSPECT

There were 28 subjects (21 women, 7 men) with PAC (0.71%; 95% CI, 0.45 to 0.98). The mean IOP was 17.96±3.02 mm Hg, the mean VCDR was 0.38±0.46, and the mean age was 57.21±9.8 years. Eighteen (64.3%) of 28 subjects had a presenting IOP of 21 mm Hg or less, and the remaining 16 (47.06%) had an IOP greater than 21 mm Hg at presentation. On gonioscopy, 14 subjects (41.2%) had synechiae in the angle, 12 (36.4%) had a lightly pigmented angle, 24 (70.6%) had moderate amounts of pigmentation, and 9 (26.4%) had a heavily pigmented trabecular meshwork.

PRIMARY ANGLE-CLOSURE

There were 246 subjects (168 women, 78 men) with PACS (6.27%; 95% CI, 5.51 to 7.03) as defined. The mean IOP was 15.28±4.23 mm Hg, and the mean VCDR was 0.38±0.46, and the mean age was 57.21±9.8 years. Eighteen (56.3%) of 28 subjects had a presenting IOP of 21 mm Hg or greater, and 13 subjects (46.4%) had peripheral anterior synechiae, and 4 subjects (14.29%) had both. On gonioscopy, 13 subjects (46.4%) had synechiae in the angle, 19 (67.8%) had moderate amounts of pigmentation, and 9 (32.1%) had a heavily pigmented trabecular meshwork.

Table 1. Distribution of Age and Sex for PACG, PAC, and PACS

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Men, No. (%)</th>
<th>Women, No. (%)</th>
<th>Total, No. (%)</th>
<th>95% CI</th>
<th>Men, No. (%)</th>
<th>Women, No. (%)</th>
<th>Total, No. (%)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-49</td>
<td>2 (0.3)</td>
<td>5 (0.54)</td>
<td>7 (0.44, 0.11 to 0.77)</td>
<td>1 (0.15)</td>
<td>5 (0.54)</td>
<td>6 (0.38, 0.08 to 0.68)</td>
<td>18 (2.70)</td>
<td>50 (5.46)</td>
</tr>
<tr>
<td>50-59</td>
<td>3 (0.66)</td>
<td>7 (1.31)</td>
<td>10 (1.01, 0.39 to 1.64)</td>
<td>2 (0.44)</td>
<td>6 (1.12)</td>
<td>8 (0.61, 0.25 to 1.37)</td>
<td>18 (2.40)</td>
<td>54 (10.13)</td>
</tr>
<tr>
<td>60-69</td>
<td>0</td>
<td>9 (1.8)</td>
<td>9 (1.01, 0.35 to 1.66)</td>
<td>2 (0.51)</td>
<td>7 (1.40)</td>
<td>9 (1.01, 0.35 to 1.66)</td>
<td>26 (6.61)</td>
<td>45 (9.02)</td>
</tr>
<tr>
<td>70-79</td>
<td>1 (0.48)</td>
<td>6 (3.08)</td>
<td>7 (1.73, 0.46 to 3.00)</td>
<td>2 (0.96)</td>
<td>3 (1.54)</td>
<td>5 (1.23, 0.16 to 2.32)</td>
<td>13 (6.22)</td>
<td>17 (8.72)</td>
</tr>
<tr>
<td>80-89</td>
<td>1 (0.48)</td>
<td>2 (0.42)</td>
<td>1 (1.72, 0.62 to 2.80)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3 (7.70)</td>
<td>2 (10.53)</td>
</tr>
</tbody>
</table>

Total | 7 (0.40)     | 27 (1.25)     | 34 (0.87, 0.58 to 1.16) | 7 (0.40) | 21 (0.97)     | 28 (0.71, 0.45 to 0.98) | 78 (4.43) | 168 (7.77) | 246 (6.27, 5.51 to 7.03) |

Abbreviations: CI, confidence interval; PAC, primary angle closure; PACG, primary angle-closure glaucoma; PACS, primary angle-closure suspect.
The ocular biometry details of the normal group and 3 groups of angle closure are given in Table 4. Axial length and anterior chamber (AC) depth were significantly different between the groups (1-way analysis of variance, \( P<.001 \)) whereas lens thickness was found to be similar in all groups (\( P=.70 \)). When comparing the groups in pairs, the axial length and AC depth were significantly more in the normal group than in each of the 3 groups of angle closure (Tukey test, \( P<.05 \)). Biometric data of both sexes in the normal group were compared (Table 5). Women had significantly shorter axial lengths (\( P<.001 \)), shallower AC depths (\( P<.001 \)), and thicker lenses (\( P=.008 \)) than men. On comparing biometry between men and women for each age group, no significant difference was noted for the age group of 70 years and older, but axial length and AC depth were significantly (\( P<.001 \)) shorter among women in all other age groups. Within all 3 groups of angle closure, women had significantly shorter axial length (\( P<.001 \)) than men. However, there was no difference in AC depth and lens thickness between the sexes (Table 6).

Subjects with pseudoexfoliation were excluded from the analysis for PAC and PACG because it is an independent risk factor for ocular hypertension and glaucoma. As reported earlier, pseudoexfoliation was significantly associated with PACS as compared with the normal population. 19

In this study, we classified angle closure on the grounds of both structural and functional evidence of glaucomatous damage as recommended by the ISGEO. 10 To the best of our knowledge, this is the first study from India to classify angle closure according to the ISGEO criteria. According to the ISGEO recommendations, the suggested definition for PACS is nonvisualization of the posterior trabecular meshwork for 270° or greater. However, we used 180° as the cutoff for differentiating the occludable from the nonoccludable angles based on our usual clinical practice. In a recent publication, Foster et al classified angle closure according to the ISGEO criteria. 19

### Table 2. Comparison of IOP, VCDR, Age, and Sex

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>PACG (n = 34)</th>
<th>PAC (n = 28)</th>
<th>PACS (n = 246)</th>
<th>Normal (n = 1696)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOP, mm Hg*</td>
<td>20.70 ± 9.24</td>
<td>17.96 ± 5.02</td>
<td>15.28 ± 4.23</td>
<td>14.18 ± 3.27</td>
<td>(&lt;.0011 )</td>
</tr>
<tr>
<td>VCDR†</td>
<td>0.76 ± 0.14</td>
<td>0.38 ± 0.14</td>
<td>0.43 ± 0.16</td>
<td>0.39 ± 0.17</td>
<td>(&lt;.001 )</td>
</tr>
<tr>
<td>Age, y§</td>
<td>58.41 ± 10.67</td>
<td>57.21 ± 9.8</td>
<td>56.19 ± 10.45</td>
<td>49.25 ± 8.60</td>
<td>(&lt;.001 )</td>
</tr>
<tr>
<td>Sex, M/F, No.</td>
<td>7/27</td>
<td>7/21</td>
<td>78/168</td>
<td>1747/2115</td>
<td>(&lt;.001 )</td>
</tr>
</tbody>
</table>

**Abbreviations:** IOP, intraocular pressure; PAC, primary angle closure; PACG, primary angle-closure glaucoma; PACS, primary angle-closure suspect; VCDR, vertical cup-disc ratio.

**Footnotes:**
*\( P<.05 \); all pairwise comparison Tukey test.
†One-way analysis of variance.
‡\( P<.05 \); all pairwise comparison Tukey test except PAC vs normal group and PAC vs PACS.
§\( P<.05 \); all pairwise comparison Tukey test only for normal group vs PACG, PAC, and PACS groups.
||\( \chi^2 \) test.

### Table 3. Multivariate Analysis for Risk Factors for PACG and PAC

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No.</th>
<th>Adjusted Odds (95% Confidence Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40-49</td>
<td>1585</td>
<td>1.00</td>
</tr>
<tr>
<td>50-59</td>
<td>985</td>
<td>2.34 (1.41 to 4.79)</td>
</tr>
<tr>
<td>60-69</td>
<td>892</td>
<td>2.54 (1.24 to 5.22)</td>
</tr>
<tr>
<td>70-90</td>
<td>462</td>
<td>3.95 (1.81 to 8.61)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1761</td>
<td>1.00</td>
</tr>
<tr>
<td>Female</td>
<td>2163</td>
<td>3.02 (1.66 to 5.51)</td>
</tr>
<tr>
<td>IOP</td>
<td>3864</td>
<td>1.14 (1.09 to 1.19)</td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
<td></td>
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<tr>
<td>Absent</td>
<td>3578</td>
<td>1.00</td>
</tr>
<tr>
<td>Present</td>
<td>286</td>
<td>2.24 (0.88 to 5.72)</td>
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<tr>
<td>Hypertension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>2617</td>
<td>1.00</td>
</tr>
<tr>
<td>Present</td>
<td>1247</td>
<td>0.50 (0.23 to 1.08)</td>
</tr>
<tr>
<td>Hyperopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>3191</td>
<td>1.00</td>
</tr>
<tr>
<td>Present</td>
<td>673</td>
<td>1.19 (0.51 to 2.60)</td>
</tr>
<tr>
<td>Axial length</td>
<td>800</td>
<td>0.99 (0.38 to 2.63)</td>
</tr>
<tr>
<td>AC depth</td>
<td>800</td>
<td>0.21 (0.04 to 1.93)</td>
</tr>
<tr>
<td>Lens thickness</td>
<td>800</td>
<td>1.08 (0.43 to 2.68)</td>
</tr>
</tbody>
</table>

**Abbreviations:** AC, anterior chamber; IOP, intraocular pressure; PAC, primary angle closure; PACG, primary angle-closure glaucoma.

**Footnotes:**
*\( P<.05 \) whereas lens thickness was found to be similar in all groups (\( P=.70 \)). When comparing the groups in pairs, the axial length and AC depth were significantly more in the normal group than in each of the 3 groups of angle closure (Tukey test, \( P<.05 \)). Biometric data of both sexes in the normal group were compared (Table 5). Women had significantly shorter axial lengths (\( P<.001 \)), shallower AC depths (\( P<.001 \)), and thicker lenses (\( P=.008 \)) than men. On comparing biometry between men and women for each age group, no significant difference was noted for the age group of 70 years and older, but axial length and AC depth were significantly (\( P<.001 \)) shorter among women in all other age groups. Within all 3 groups of angle closure, women had significantly shorter axial length (\( P<.001 \)) than men. However, there was no difference in AC depth and lens thickness between the sexes (Table 6).

###COMMENT
In this study, we classified angle closure on the grounds of both structural and functional evidence of glaucomatous damage as recommended by the ISGEO. 10 To the best of our knowledge, this is the first study from India to classify angle closure according to the ISGEO criteria. According to the ISGEO recommendations, the suggested definition for PACS is nonvisualization of the posterior trabecular meshwork for 270° or greater. However, we used 180° as the cutoff for differentiating the occludable from the nonoccludable angles based on our usual clinical practice. In a recent publication, Foster et al classified angle closure according to the ISGEO criteria. 19

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‡\( P<.05 \); all pairwise comparison Tukey test except PAC vs normal group and PAC vs PACS.
§\( P<.05 \); all pairwise comparison Tukey test only for normal group vs PACG, PAC, and PACS groups.
||\( \chi^2 \) test.
al admitted that the definition of ISGEO is too stringent and suggested reconsideration because a significant proportion of those classified as “open” with between 180° and 270° of the angle closed had synechiae in the angle. The authors also felt that the “gold standard” for diagnosis of angle closure is gonioscopy by an experienced ophthalmologist. In the current study, gonioscopy was done by 2 glaucoma specialists using a well-defined and strict protocol. We therefore believe that our results reflect true angle-closure prevalence rates in this population.

In this study, we report the prevalence rates of PACG (0.87%; 95% CI, 0.58 to 1.16); PAC (0.71%; 95% CI, 0.43 to 0.98); and PACS (6.27%; 95% CI, 5.51 to 7.03) from a rural south Indian population. Our prevalence rates are similar to those reported from a Mongolian population4 (PACG, 1.4%; 95% CI, 0.11 to 2.22, and occludable angle, 6.4%; 95% CI, 4.3 to 8.5). A recent study from Thailand reported a prevalence rate for PACG (0.9%; 95 CI, 0.3 to 1.9) using the ISGEO recommendations in the population aged 50 years and older.6 Our PACG prevalence rate is similar to theirs, but they had a higher prevalence of occludable angles (10.13%; 95% CI, 7.91 to 12.98), which may be explained by the older age group studied.

Table 7 illustrates the comparison of our angle-closure prevalence rates with those of the other 3 studies from southern India.7-9 There is very wide variation of the prevalence rates between the 4 studies. The Aravind Comprehensive Eye Survey7 reported a prevalence of 0.5% (95% CI, 0.3 to 0.7) for PACG in a rural population in southern India, which is lower than the current study rate. However, they neither defined nor reported the prevalence of occludable angles in their population. Their definition of PACG is different from ours. These differences may be responsible for the observed variations in prevalence rates between these 2 studies. The prevalence of PACG in those aged 40 years and older in the urban population of the Andhra Pradesh Eye Disease Study8 was 1.08% (95% CI, 0.34 to 1.31). This
In conclusion, the overall prevalence of primary angle closure (PAC and PACG) in this rural population of southern India is 1.58%. Women are at higher risk, and the disease is silent and chronic.

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Table 7. Prevalence Rates of Angle Closure in All Population-Based Studies in India

<table>
<thead>
<tr>
<th>Study (Ages Studied, y)</th>
<th>PACS, % (95% CI)</th>
<th>PAC and PACG, % (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VES (30-60)</td>
<td>10.35 (8.44 to 12.25)</td>
<td>4.32 (3.01 to 5.63)</td>
</tr>
<tr>
<td>APEDS (≥40)</td>
<td>2.21 (1.15 to 3.27)</td>
<td>1.08 (0.36 to 1.80)</td>
</tr>
<tr>
<td>ACES (≥40)</td>
<td>NA</td>
<td>0.5 (0.3 to 0.7)</td>
</tr>
<tr>
<td>CGS, the current study</td>
<td>6.27 (5.51 to 7.03)</td>
<td>1.58 (1.19 to 1.97)</td>
</tr>
</tbody>
</table>

Abbreviations: ACES, Aravind Comprehensive Eye Survey; APEDS, Andhra Pradesh Eye Disease Study; CGS, Chennai Glaucoma Study; CI, confidence interval; NA, not available; PAC, primary angle closure; PACG, primary angle-closure glaucoma; PACS, primary angle-closure suspect; VES, Vellore Eye Survey.

is closer to our results. However, our PACS prevalence is greater than the prevalence of occludable angles without PACG in the Andhra Pradesh Eye Disease Study (2.21%; 95% CI, 1.15 to 3.27). This may either be due to the more stringent definition of the occludable angle they used (trabecular meshwork not visible for ≥270°), inherent differences in the study population, or a combination of both. The Vellore Eye Survey reported a prevalence rate of 4.32% (95% CI, 3.01 to 5.63) for PACG that includes PAC with or without evidence of glaucomatous damage. This is higher than our combined prevalence of PAC and PACG (1.58%; 95% CI, 1.19 to 1.97). Because Vellore is a town situated only about 130 km southwest of our study area, one would expect similar results for the 2 populations. Their smaller sample size and lower response rate may be responsible for the discrepancies observed. The reported prevalence for PACS in the Vellore Eye Survey (10.35%; 95% CI, 8.44 to 12.25) is higher than our PACS rate, although the confidence intervals overlap.

In our study, the prevalence of PACS was much higher than that of PAC or PACG. Similar findings have been reported by other studies. This clearly suggests that not all people with PAC naturally progress to develop PAC or PACG. Thomas et al report that only 22% of persons with untreated PACS progressed to PAC over a period of 5 years. With this relatively low rate of progression such a difference in the prevalence of PACS and PAC would be expected.

Previous reports have shown a higher prevalence of PACG and occludable angles with increasing age. Similar findings were noted in our study: the normal study population was significantly younger than the 3 groups of angle closure. However, we did not see any difference in mean age among persons with PACS, PAC, and PACG. The prevalence of angle closure and angle-closure glaucoma is known to be higher among women. We also noted a female preponderance in all 3 groups of angle closure. Women were 3 times more likely to have PAC and PACG than men. Women in our study had significantly shorter eyes, shallower anterior chambers, and thicker lenses. Even within the 3 groups of angle closure, women had shorter axial lengths compared with men. Quigley et al reported that shorter axial lengths are associated with decreased ocular volumes, both of which are possible risk factors for angle-closure glaucoma. Anterior lens contour is one of the important factors determining iris contour: a thicker lens in a shorter eye with shallow anterior chambers would be one of the risk factors for a narrow angle. This could explain the increased prevalence of angle closure among women.

In the Andhra Pradesh Eye Disease Study, the prevalence of PACG (vs 7.4% for primary open-angle glaucoma [POAG]) were previously diagnosed as having glaucoma, and 16.7% gave a history suggestive of acute or intermittent angle closure. Bourne et al from Thailand reported that 50% of persons with PACG (vs 25% of POAG) had been previously diagnosed to have the disease. In these reports, the authors felt that PACG is more likely to be symptomatic than POAG, which results in the subject seeking medical advice. In contrast to these reports, none of our PACG subjects were aware of their disease. None of them gave a history suggestive of a past acute attack, which is similar to reports from the Vellore Eye Survey. It is possible that in our study population, the disease is more chronic and silent in nature.

The association of PACG with hyperopia has been suggested previously. However, we did not find an association of hyperopia (more than +0.5 spherical equivalent) with angle closure. Primary angle-closure glaucoma (34.69%) comprised approximately a third of all primary glaucoma. This finding is similar to hospital-based data from India that suggested that PACG was at least as common as POAG. In addition, a significant proportion of the adult population was diagnosed to be PACS. These persons were largely undiagnosed. These numbers are likely to rise as India’s aging population increases. In the absence of an appropriate screening test, they will have to be diagnosed with a routine eye examination that includes gonioscopy. The average practicing Indian ophthalmologist is likely to see an almost equal number of POAG and PACG patients. Unless one does gonioscopy routinely, the chances of missing the diagnosis are likely to be very high. Fremont et al estimated that only 50% of newly diagnosed POAG patients in the United States undergo gonioscopy at the time of diagnosis. These rates are likely to be lower in India as unfortunately gonioscopy does not form a part of routine ophthalmic practice in the country. Unless the ophthalmic community in the country is sensitized to the routine use of gonioscopy, angle-closure glaucoma will continue to be misdiagnosed.

In conclusion, the overall prevalence of primary angle closure (PAC and PACG) in this rural population of southern India is 1.58%. Women are at higher risk, and the disease is silent and chronic.
REFERENCES


Announcement

Clinical Trials Registration Required. In concert with the International Committee of Medical Journal Editors, Archives of Ophthalmology will require, as a condition of consideration for publication, registration of clinical trials in a public trials registry (such as http://ClinicalTrials.gov). Trials must be registered at or before the onset of patient enrollment. This policy applies to any clinical trial starting enrollment after March 1, 2006. For trials that began enrollment before this date, registration will be required by June 1, 2006. The trial registration number should be supplied at the time of submission.