

Progression of Primary Angle Closure Suspect to Primary Angle Closure and Associated Risk Factors: The Handan Eye Study

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PURPOSE. To investigate the progression of angle closure from primary angle closure suspect (PACS) and associated risk factors over five years in rural Chinese adults.

METHODS. In this population-based cohort study, subjects aged ≥ 30 years old with unilateral or bilateral PACS at baseline of the Handan Eye Study who participated in the follow-up and had undergone baseline and follow-up gonioscopic examinations were included. The progression of angle closure was defined as the presence of primary angle closure (PAC)/primary angle-closure glaucoma (PACG) during the follow-up in subjects with PACS at baseline. Ocular data from the right eye were used for cases with bilateral PACS and unilateral PACS in the right eye at baseline. For those with unilateral PACS in the left eye at baseline, ocular data from the left eye were used. Demographic information, ocular conditions, personal history, and systemic comorbidities were compared between the progression and nonprogression groups. Univariate and multivariate logistic regression was performed to identify the baseline risk factors for progression of angle closure.

RESULTS. In total, 526 subjects (111 male, 415 female) with baseline PACS were finally enrolled. The overall progression of PACS to angle closure was 32 cases (31 PAC, 1 PACG). Logistic regression analysis identified narrower mean angle width ($P < 0.001$) to be associated with the progression.

CONCLUSIONS. We report the progression from baseline PACS to PAC/PACG after five years. And baseline mean angle width was determined to be independent predictive risk factor for the progression of angle closure.

Keywords: progression of angle closure, primary angle closure suspect, primary angle closure, primary angle closure glaucoma, risk factors

Glaucoma is the leading cause of irreversible blindness, a pressing public health challenge and is responsible for 14% of blindness all over the world.^{1,2} Because of increased life expectancy and demographic expansion, the number of glaucoma cases worldwide is estimated to reach 76 million by 2020, of which 23 million will be primary angle-closure glaucoma (PACG).³ PACG is more prevalent in Asians, especially Chinese who have about half of the global number.⁴ Population-based studies show that PACG on average carries a threefold increased risk of severe, bilateral visual impairment, compared with primary open-angle glaucoma.^{1,3,5}

According to the classification developed by the International Society of Geographic and Epidemiologic Ophthalmology (ISGEO), primary angle-closure disease (PACD) is classified into three categories: (1) primary angle-closure suspect (PACS): eyes with appositional contact between the peripheral iris and posterior trabecular meshwork for at least

180°, intraocular pressure (IOP) ≤ 21 mm Hg, no peripheral anterior synechiae (PAS) and healthy optic nerves; (2) primary angle closure (PAC): eyes with raised IOP (> 21 mm Hg), or PAS in a PACS; and (3) PACG: PAC together with the evidence of glaucomatous optic neuropathy (GON)/visual field loss.⁶

PACS is considered a risk factor for PAC and PACG, but there are limited data on the natural history of PACD so far, especially large population-based data on the disease progression.^{7,8} A better understanding of the natural history of PACD would assist in identifying persons at risk of progression and deciding the most appropriate population who need intervention such as iridotomy or surgical removal of lens.⁹

Additionally, exploring the risk factors for the progression of PACD could provide guidelines for targeting at-risk groups to improve early detection and intervention, which

are currently the most powerful tools for preventing blindness and low vision in this predominantly asymptomatic disease in its early stages.⁷

The objective of our study was to investigate the progression of PACS and the associated risk factors in a rural Chinese population on the basis of a longitudinal study—the Handan Eye Study.

METHODS

Subjects

The Handan Eye Study was a population-based cohort study conducted on a sample of rural Chinese adults.¹⁰ The baseline research (2006–2007) included 6830 subjects aged 30 years or older from 13 villages in Yongnian County, Handan City, Hebei Province, Northern China, using a clustered random sampling method.¹⁰ The follow-up research (2012–2013) included 5394 subjects (85.3% of survivors) who returned for the repeat examinations, following the same protocol.¹¹ Details of the study were described elsewhere.¹¹

Subjects enrolled in our study were participants who received both baseline and follow-up gonioscopic examinations and were diagnosed with baseline unilateral or bilateral PACS. The exclusion criteria were subjects with bilateral open angles, PAC, PACG, primary open-angle glaucoma, or secondary glaucoma, history of ocular surgery, or those presenting with other diseases that could have influenced the results of examinations. Subjects who underwent cataract surgery or laser peripheral iridotomy (LPI) in the studied eye during the five-year follow-up were also excluded from the analysis.

The study was approved by the Beijing Tongren Hospital Ethics Committee and performed in accordance with the tenets of the Declaration of Helsinki. Verbal and written informed consent was obtained from all subjects.

Examinations

Similar questionnaire and examination procedures were used for both baseline and follow-up studies. To overcome any language barriers or trust issues, all interviewers and coordinators were employed from local hospital or medical schools.

The ophthalmic examination consisted of measuring the presenting visual acuity (PVA) and best-corrected visual acuity (BCVA), objective and subjective refraction, slit-lamp biomicroscopy, visual field examination, IOP measurement, gonioscopy, A-scan ultrasound biometry, and fundus examination.

PVA and BCVA were tested using a Logarithmic Visual Acuity Chart at a distance of 4 m. Objective refraction and corneal curvature radius were measured by a KR-8800 auto refractor-Keratometer (Topcon, Tokyo, Japan) with the readings being used for subjective refraction on subjects with PVA worse than 1.0 in either eye. The limbal anterior chamber depth (LACD) was graded using slit-lamp biomicroscopy and recorded according to the modified van Herick system as a percentage fraction of the thickness of the adjacent cornea in the following seven categories: 0%, 5%, 15%, 25%, 40%, 75%, and $\geq 100\%$ (Fig. 1A). IOP was measured using the Kowa applanation tonometer (HA-2; Kowa Company Ltd. Tokyo, Japan). The visual field was tested using the Swedish interactive threshold algorithm program 24-2 on a visual

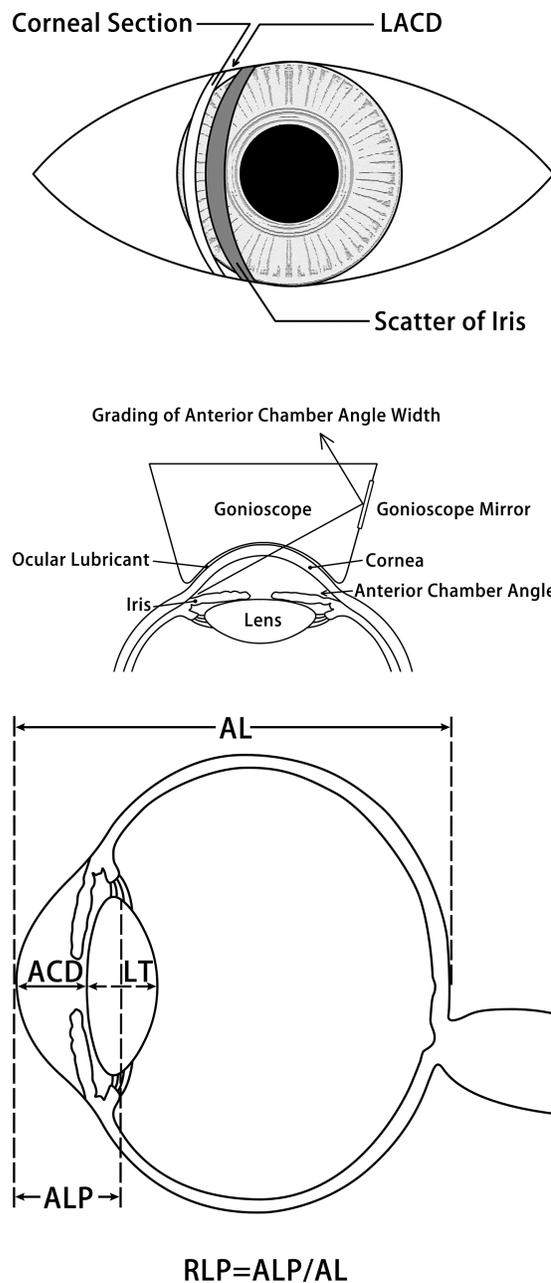


FIGURE 1. Diagrammatic representations. (A) LACD graded by van Herick system using slit-lamp biomicroscopy. (B) Anterior chamber angle width assessed by gonioscopy. (C) Ocular biometry measured by ultrasound device. RLP, relative lens position.

field analyzer (Humphrey Visual Field Analyzer 740i or 750i; Carl Zeiss, Jena, Germany).

Gonioscopy was performed on one in 10 subjects consecutively, as well as who were found to have $LACD \leq 40\%$, $IOP > 21$ mm Hg, and those with a history of glaucoma or suspect, using a handheld gonioscopic lens (Goldmann) at magnification $\times 25$ by experienced ophthalmologists at baseline (a single observer) and follow-up (two observers with a kappa score of 0.76) on the basis of the same standard. Static gonioscopy was performed with the minimum possible ambient illumination with the eye in the primary gaze position and indentation gonioscopy was then performed

using the same lens. The anterior chamber angle width was graded according to the Spaeth system and recorded as 0°, 10°, 20°, 30°, 40°, and 50° in all four quadrants of each eye (Fig. 1B). The mean angle width was calculated as the mean value of the angle widths in four quadrants.

Ocular biometry including anterior chamber depth (ACD), lens thickness (LT), and axial length (AL) were measured by a 10-MHz A/B-mode ultrasound device (CineScan; Quantel Medical, Clermont-Ferrand, France), using a hard-tipped, corneal contact probe mounted on a slit lamp at baseline and an OcuScan RxP (Alcon, Inc., Fort Worth, TX, USA) at the follow-up (Fig. 1C). And absolute lens position (ALP) was calculated as $ACD + 1/2 \times LT$ and relative lens position as ALP/AL (Fig. 1C).

Stereoscopic evaluation of the optic nerve head and retinal nerve fiber layer (RNFL) was performed using a +78 diopter lens and the slit-lamp. The vertical and horizontal cup-to-disc ratios and presence of any notching, splinter hemorrhages, peripapillary atrophy, or RNFL defect was documented.

Physical examinations including height, weight, waist-hip circumference and blood pressure were measured according to a standardized protocol. Body mass index (BMI) and waist/hip ratio (WHR) were calculated for each subject.

Demographic information, ocular conditions, personal history (smoking, drinking and diet), family history of eye diseases including glaucoma and systemic comorbidities such as diabetes mellitus, hypertension, and other conditions, as well as medical treatment with systemic and topical pressure-lowering drugs, laser peripheral iridotomy, or surgical peripheral iridectomy were obtained from questionnaires administered by trained staff. Cataract surgery, trabeculectomy, and other surgical interventions were also documented.

Diagnosis Definitions

PACS, PAC, and PACG were defined on the basis of the ISGEO classification as described before. The progression from PACS to PAC was defined as the presence of increased IOP or the presence of PAS on the basis of gonioscopic findings in baseline PACS subjects during the follow-up. Progression from PACS to PACG was defined as the presence of increased IOP or the presence of PAS plus GON or glaucomatous visual field defects in PACS subjects at baseline during the follow-up.

GON was diagnosed with definite and probable certainty by a consensus panel of five senior glaucoma specialists. The diagnostic flow was as follow. Firstly, stereoscopic optic disc photographs were divided into four sections and evaluated by four glaucoma specialists (Y.Z., Q.Z., J.H., and Z.G.) respectively. The status of the optic nerve was categorized as “definite glaucoma” (90%–100% probability), “probable glaucoma” (70%–89% probability), “possible glaucoma” (30%–69% probability), and “not glaucoma” (<30% probability). Those felt to have definite glaucoma, probable glaucoma, and possible glaucoma by either of the specialists were presented to a panel of three senior glaucoma specialists to review.

Second, three senior glaucoma specialists (T.R., B.S.W., and Y.B.L.) reviewed disc photographs of subjects who were classified as definite glaucoma, probable glaucoma or possible glaucoma in the first step again and categorized these subjects as having definite, probable, possible, or no glaucoma on the basis of consensus. If the results differed among

three specialists, a third independent reading was carried out by another senior glaucoma specialist (D.S.F.), who also classified the patients according to the same definitions. The final diagnosis was determined by another glaucoma specialist (N.L.W.) on the basis of disc photographs, clinical records for vertical cup/disc ratios, and visual fields if some confused diagnosis still existed in the third step.

Statistical Analysis

We used ocular data from the right eye for cases where either both eyes or only the right eye had PACS at baseline. For those with PACS only in the left eye at baseline, ocular data from the left eye was used. Statistical analysis was performed using SPSS statistical software (Version 25.0; SPSS, Inc., Chicago, IL, USA). All *P* values reported were two-tailed, and statistical significance was considered as $P < 0.05$.

For the purpose of analysis, the recruited subjects were divided into progression and nonprogression groups. The one-sample Kolmogorov-Smirnov test was used to assess normality of the continuous variables. Comparison of variables between the non-progression and progression groups was done using the independent *t*-test (normally distributed variables) or Mann-Whitney U test (non-normally distributed variables) for continuous variables and the χ^2 test or Fisher's exact test for qualitative variables.

Univariate and backward multivariate logistic regression analyses were conducted to determine the predictive risk factors that affect the progression of PACS, such as age, sex, IOP, biometric parameters, BMI, WHR, socioeconomic status, education level, and personal history. Variables with a *P* value < 0.1 from the univariate logistic regression were included in the multivariate logistic regression and variables with a *P* value > 0.05 were excluded from the final multivariate model.

Receiver operating characteristic curves and area under the curve (AUC) with 95% confidence intervals (CIs) were used as an index of testing the performance of baseline demographic characteristics and ocular parameters on predictive detecting the progression of PACS.

RESULTS

A total of 2046 participants underwent gonioscopic examination in the baseline study. Among them, 1102 participants received the follow-up gonioscopic examinations, and 534 subjects with baseline PACS were included in our study. Figure 2 shows the enrollment of participants.

At baseline, there were 795 PACS subjects in total. During the follow-up, 69 of them had died, leaving 726 PACS subjects to be re-examined. Of them 534 returned for follow-up and underwent gonioscopic examination; the other 192 subjects did not undergo follow-up gonioscopic examination for different reasons. Compared to those who did not undergo gonioscopy on follow-up, PACS subjects who underwent gonioscopy both at baseline and follow-up were younger ($P < 0.001$), had shallower central ACD ($P = 0.023$), thicker lens ($P = 0.029$), and shorter AL ($P = 0.003$); the differences were statistically significant. There was no difference in gender, BMI, spherical equivalence, corneal curvature radius, IOP, and mean angle width between the two groups (Table 1).

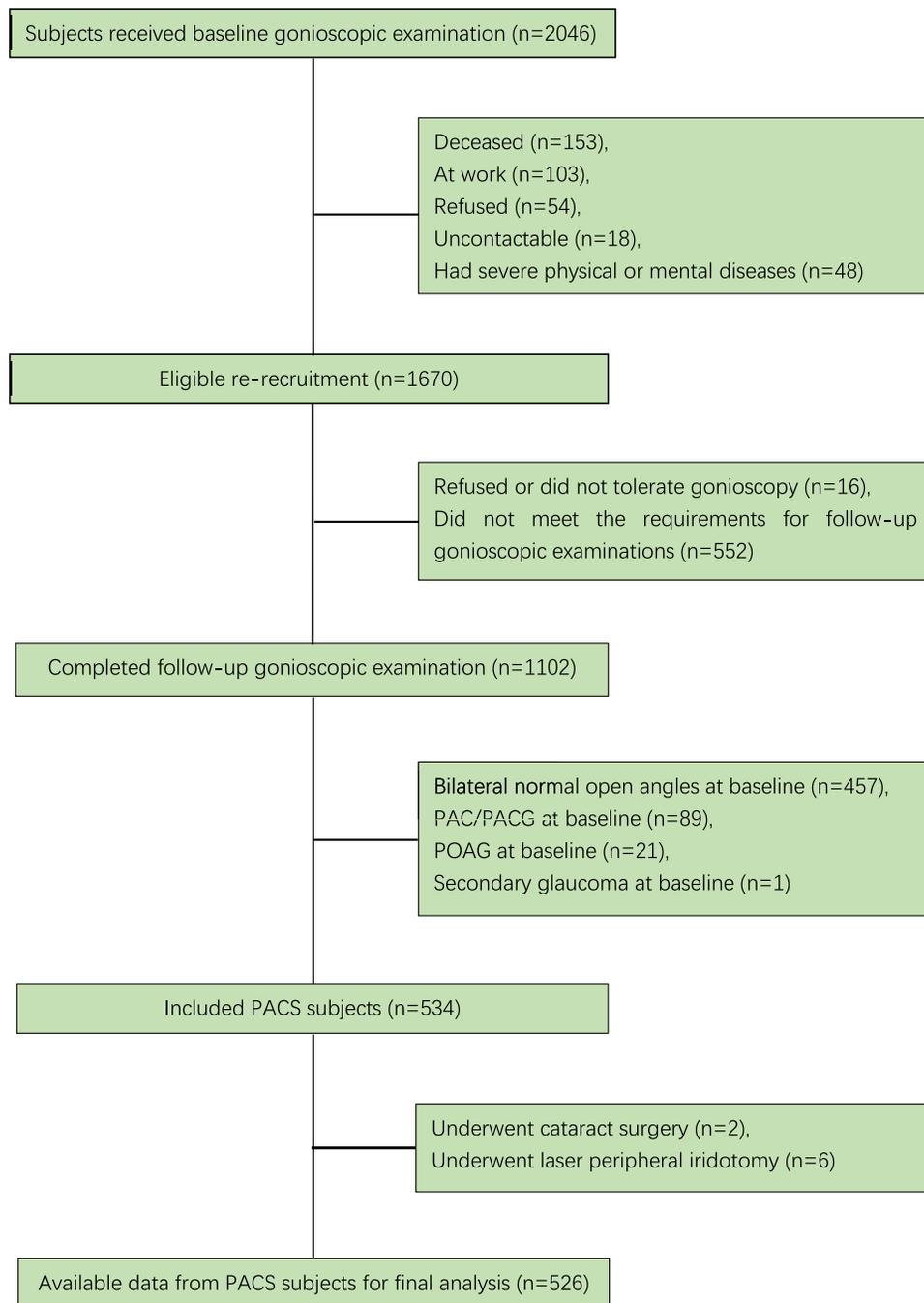


FIGURE 2. Flow chart showing the enrolment of participants in this study. POAG, primary open angle glaucoma.

Among the 534 subjects diagnosed with PACS at baseline, 402 subjects were bilateral and 132 were unilateral (73 subjects with PACS in the right eye and 59 subjects with PACS in the left eye). Five of the 402 bilateral PACS subjects were excluded because they underwent LPI in the both eyes during follow-up. And 3 of the 132 unilateral PACS subjects were excluded because they underwent cataract surgery (two case) or LPI (one case) in that PACS eye during follow-up. The data from 526 eyes of 526 subjects with PACS at baseline (397 bilateral and 129 unilateral) was available for the final analysis. Among all the included subjects, 111 were male, and 415 were female.

Progression from PACS to PAC/PACG occurred in 32 cases. Twenty-seven cases with bilateral PACS progressed to PAC, including 11 in both eyes (two cases showed presence of PAS with increased IOP higher than 21 mmHg in the right eye and PAS with normal IOP in the left; nine cases showed presence of PAS with normal IOP in both eyes) and 16 in the right eye (presence of PAS with normal IOP). One case with bilateral PACS had progressed to PACG in the right eye with presence of PAS with an IOP higher than 21 mm Hg and GON. Four cases with unilateral PACS progressed to PAC, including 2 in the right eye (presence of PAS with increased IOP higher than 21 mm Hg) and two in the left eye

TABLE 1. Baseline Characteristics of PACS Subjects Who Did and Did Not Undergo Follow-Up Gonioscopic Examinations

Parameter	Non-Examinees (n = 192)	Examinees (n = 534)	P Value
Age (IR), years	60.0 (54.0, 67.3)	57.0 (53.0, 63.0)	<0.001*
Gender			0.230†
Male (%)	142 (74.0)	418 (78.3)	
Female (%)	50 (26.0)	116 (21.7)	
BMI (IR), kg/m ²	23.38 (21.40, 26.25)	24.00 (22.03, 26.62)	0.109*
SE (IR), diopter	0.50 (−0.25, 1.00)	0.50 (0.00, 1.25)	0.058*
CCR (Mean ± SD), mm	7.60 ± 0.25	7.58 ± 0.27	0.202‡
IOP (IR), mm Hg	15.0 (13.5, 16.8)	15.0 (12.8, 16.8)	0.675*
Mean angle width (IR)	17.5° (12.5°, 20.0°)	17.5° (10.0°, 20.0°)	0.226*
Central ACD (IR), mm	2.38 (2.15, 2.58)	2.33 (2.07, 2.52)	0.023*
LT (IR), mm	4.91 (4.65, 5.21)	4.98 (4.73, 5.26)	0.029*
AL (Mean ± SD), mm	22.38 ± 0.67	22.20 ± 0.71	0.003‡

SE, spherical equivalent; CCR, corneal curvature radius; IR, interquartile range; SD, standard deviation.

*Mann-Whitney U test.

† χ^2 test.

‡Independent t-test.

TABLE 2. Demographic and Biometric Characteristics of PACS Participants

Parameter	PACS Participants Who Progressed to Angle Closure (n = 32)	PACS Participants Who Did Not Progress to Angle Closure (n = 494)	P Value
Age (IR), years	59.0 (52.3, 69.0)	57.0 (52.0, 63.0)	0.185*
Female (%)	22 (68.8)	393 (79.6)	0.147†
Education, none (%)	10 (31.3)	118 (23.9)	0.347†
Low income, < ¥1800/year (%)	16 (64.0)	264 (64.1)	0.994†
Hypertension, present (%)	19 (59.4)	296 (59.9)	0.951†
Diabetes, present (%)	1 (3.1)	43 (9.3)	0.343‡
BMI (IR), kg/m ²	23.38 (20.69, 27.06)	24.01 (22.04, 26.61)	0.609*
WHR (IR)	0.90 (0.86, 0.93)	0.90 (0.87, 0.92)	0.849*
PVA (IR), logMAR	0.23 (0.11, 0.39)	0.20 (0.10, 0.32)	0.252*
BCVA (IR), logMAR	0.08 (0.00, 0.20)	0.10 (0.00, 0.11)	0.465*
SE (IR), diopter	1.00 (0.34, 1.25)	0.75 (0.13, 1.38)	0.409*
CCR (mean ± SD), mm	7.52 ± 0.28	7.58 ± 0.27	0.238§
IOP (IR), mm Hg	14.9 (13.2, 17.1)	15.0 (12.8, 16.8)	0.800*
Limbal ACD, ≤ 25% (%)	27 (84.4)	331 (67.1)	0.043†
Mean angle width (IR), °	10.0 (7.5, 16.9)	17.5 (12.5, 20.0)	<0.001*
Central ACD (IR), mm	2.19 (1.94, 2.40)	2.36 (2.11, 2.55)	0.017*
LT (IR), mm	5.03 (4.82, 5.38)	4.96 (4.71, 5.21)	0.125*
ALP (mean ± SD), mm	4.74 ± 0.22	4.81 ± 0.24	0.112§
RLP (mean ± SD)	0.22 ± 0.01	0.22 ± 0.10	0.459§
AL (Mean ± SD), mm	22.03 ± 0.86	22.20 ± 0.71	0.212§

logMAR, logarithm of minimum angle of resolution; SE, spherical equivalent; CCR, corneal curvature radius; RLP, relative lens position; IR, interquartile range; SD, standard deviation.

*Mann-Whitney U test.

† χ^2 test.

‡Fisher's exact test.

§Independent t-test.

(presence of PAS with normal IOP). In total, 494 PACS cases did not show progression after five-year follow-up. None had developed an acute attack, visual impairment or blindness at the five-year follow-up.

Compared to those who did not progress to PAC/PACG over the 5-year period, the cases with progression had shallower LACD ($P = 0.043$) and central ACD ($P = 0.017$), had narrower mean angle width ($P < 0.001$) at baseline; all differences were statistically significant (Table 2).

The univariate logistic regression model identified baseline LACD ($P = 0.050$), mean angle width ($P < 0.001$), central ACD ($P = 0.033$) as significant predictors associated with progression of PACS. On multivariate logistic regression, significant risk factors for the progression of PAC/PACG

from baseline PACS were found to be narrower mean angle width ($P < 0.001$) (Table 3).

Receiver operating characteristic analysis was used to assess the potential performance of mean angle width as a predictive determinant of progression of PAC/PACG from baseline PACS (Fig. 3). The AUC was 0.698 (95% CI, 0.657–0.737).

DISCUSSION

Cross-sectional studies have reported that the risk factors for developing angle closure include Asian ethnicity (e.g., Chinese), female gender, and advanced age.⁷ Anatomic features predisposing to angle closure include small cornea,

TABLE 3. Factors Associated With Five-Year Progression of PACS to PAC/PACG in the Handan Eye Study

Variable	Univariate Logistic Regression		Multivariate Logistic Regression			
	OR (95% CI)	P Value	Estimated Regression Coefficient	χ^2	OR (95% CI)	P Value
Age, years	1.039 (0.995, 1.085)	0.101				
Female	0.568 (0.261, 1.239)	0.151				
Education, none	0.688 (0.317, 1.495)	0.349				
Low income, < ¥1800/year	1.002 (0.432, 2.325)	0.994				
Hypertension, present	0.993 (0.479, 2.057)	0.951				
Diabetes, present	0.309 (0.041, 2.320)	0.261				
BMI, kg/m ²	0.967 (0.867, 1.078)	0.550				
WHR	0.178 (< 0.001, 103.139)	0.588				
BCVA, logMAR	2.036 (0.173, 23.987)	0.608				
SE, diopter	1.116 (0.800, 1.558)	0.483				
CCR, mm	0.436 (0.111, 1.717)	0.238				
IOP, mm Hg	1.016 (0.884, 1.167)	0.822				
Limbal ACD, ≤ 25%	0.370 (0.140, 0.980)	0.050				
Mean angle width, °	0.895° (0.843°, 0.950°)	<0.001	-0.115	13.390	0.891 (0.838, 0.948)	<0.001
Central ACD, mm	0.274 (0.083, 0.901)	0.033				
LT, mm	2.042 (0.809, 5.155)	0.129				
ALP, mm	0.301 (0.069, 1.306)	0.111				
RLP	<0.001 (< 0.001, 2302996286)	0.458				
AL, mm	0.718 (0.428, 1.206)	0.211				

logMAR, logarithm of minimum angle of resolution; SE, spherical equivalent; CCR, corneal curvature radius; RLP, Relative lens position; OR, odds ratio.

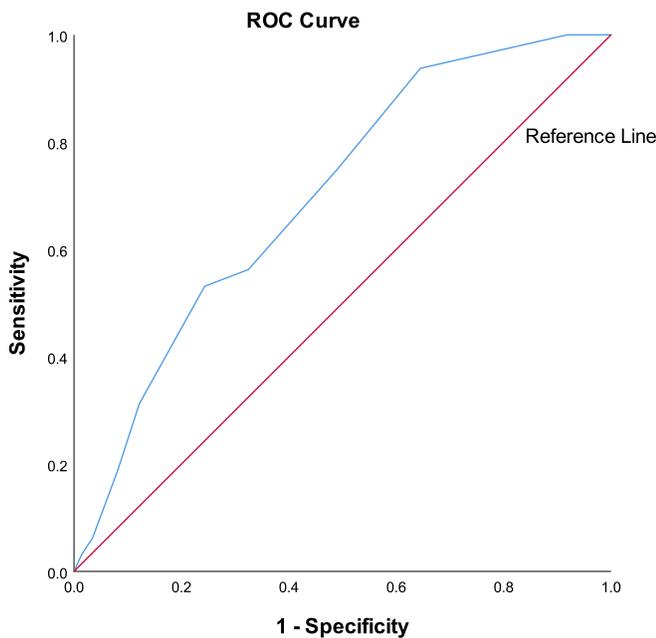


FIGURE 3. Receiver operating characteristics curve of mean angle width as a determinant of progression of PACS to PAC/PACG.

shallow anterior chamber, smaller anterior chamber width, area and volume, thick lens, anterior lens position, thicker irides with greater iris curvature, a greater lens vault and short axial length of the eye.¹²⁻¹⁴

To date, few prospective studies have reported the natural history of PACD and risk factors related to the progression of the disease. Our study was based on a cohort of a rural population with a large sample size from northern China. However, because not all subjects received both baseline

and follow-up gonioscopic examinations, we were unable to provide the incidence of PAC/PACG in PACS population.

Among the 526 PACS subjects at baseline with complete data, 32 subjects (6.08%) progressed to PAC/PACG during the five-year follow-up. Most of the subjects who progressed had bilateral PACS (27 cases, 84.38% of the total). Over five years 31 PACS subjects (96.87%) progressed to PAC whereas one (3.13%) progressed to PACG. A shallower LACD, shallower central ACD, and narrower mean angle width at baseline were found in the progression group compared to the nonprogression group. Although all differences were statistically significant, only baseline narrower mean angle width was demonstrated to be predictive factors for progression from PACS to PAC/PACG. This parameter as a determinant failed to show enough predictive ability in deciding who will progress to PAC/PACG in PACS subjects with an AUC of 0.698.

Alsbrink et al.¹⁵ reported that among a high-risk cohort of Greenland Eskimos, 35% (95% CI, 14%–55%) of PACS progressed to the ISGEO equivalent of PAC (synechial PAC) or PACG (including acute or chronic), while only 8% of open angles progressed to PAC/PACG over 10 years; the differences were statistically significant. They reported that LACD and central ACD could effectively select a subgroup at risk of developing PACG over a 10-year period.¹⁵ Only the gonioscopic classification of suspect occludable versus nonoccludable angles showed a significant association with PACG rates 10 years later.¹⁵

A clinic-based report from Wishart and Batterbury¹⁶ followed up 25 patients with ocular hypertension and narrow angle for an average of six years with what would most likely be classified as PAC in modern nomenclature. Nine patients (36%) in the narrow angle group developed PACG over an average four-year follow-up.¹⁶ Among them two patients developed PACG (8%), PAS was detected in an additional five patients (20%), and symptoms suggestive of subacute angle closure were elicited in three (12%).¹⁶ They

found that a shallow axial ACD and a narrow anterior chamber angle (van Herick grade 2 or less) was associated with the development of PACG.¹⁶

In a population-based study from South India, Thomas et al.^{17,18} reported that 22% (95% CI, 9.8%–34.2%) of PACS progressed to PAC and 28.5% (95% CI, 12%–45%) of PAC progressed to PACG over five years. They too found that bilateral PACS was a clinical risk factor for progression to PAC.¹⁷ There were no significant differences in AL, ACD, or LT between those who progressed and those who did not (Thomas et al.^{17,18}). No biometric features were identified as predictive factors of progression from PAC to PACG.¹⁸ None of the patients followed up in their study developed acute angle closure or blindness attributable to incident PACG.¹⁸

Liza-Sharmini et al.¹⁹ conducted a study exploring the progression of primary angle closure in Malays based on clinical data of 100 PACD patients (200 eyes) and found that after at least five years of follow-up, a total of 112 eyes (56.0%) progressed from PACS to PAC, PAC to PACG, and mild to moderate PACG to advanced PACG.¹⁹ The incidence of progression from PACS to PAC in that study was found to be 14%.¹⁹ Of PACS cases, 11.5% developed PACG during follow-up.¹⁹ They also reported that baseline age, initial diagnosis, IOP, mean deviation of Humphrey visual field, visual acuity, and peripheral iridotomy or iridectomy were significant clinical predictors associated with progression of the disease.¹⁹

Shao et al.²⁰ reported that among 252 PACS eyes of 126 enrolled Chinese patients, 35 eyes developed PAC after five years of follow-up, an incidence of 13.9%. The following features were associated with progression: narrow-angle width with Shaffer's grading of grade I or less, shallowing of the ACD, or narrowing of the angle during follow-up, positive dark room test, family history of PACG, history of previous angle closure attacks, need for repeated pupillary dilation, hyperopia with senile cataract, and lack of medical care.²⁰

As can be seen, the progression of PACD differs significantly among the reported studies, which may be attributed to different populations and inconsistent definitions of PACD in those studies. Also, no unified risk factors of progression of PACD were reported by these studies. More prospective studies with standardized definitions are required to further determine the progression of PACD and the related predictive factors.

It has also been demonstrated that the pathogenesis of angle closure in Asians (especially Chinese) is more complicated than in Caucasians.^{19,21} Multiple mechanisms that include pupillary block and nonpupillary block such as iris crowding, anteriorly positioned ciliary body, and more are believed to increase the susceptibility to chronic angle closure in Asians.²¹ PAS plays a more significant role in the progression of PACD.¹⁹ Asian eyes are more susceptible to the development of PAS because of ocular morphology and thicker iris.²¹ In our study, we also found that all the 32 cases with progression from PACS to PAC/PACG presented with PAS during the follow-up.

There are several limitations of our study. The main limitation is loss to follow-up gonioscopic examination. We compared the baseline parameters between the two groups of PACS subjects who did and did not receive gonioscopic examination. PACS subjects who received follow-up gonioscopic examinations tended to be younger and have shallower central ACD, thicker lens, and shorter AL. Given that older, shallower central ACD, thicker lens, and shorter

AL were risk factors for angle closure, the progression of PACS to PAC/PACG in our study might be overestimated. Second, the baseline and follow-up gonioscopic examinations in our study were performed by different observers. Although using the same standardized grading system, the interobserver and physiological variation might still affect the results. Last but not least, the study population was solely Chinese, and future population-based studies in other racial ethnic groups and in other geographic areas are needed to determine the generalizability.

CONCLUSIONS

This study reported the progression from baseline PACS to PAC/PACG after a five-year follow up. Baseline narrower mean angle width was found to be predictive factor for the progression of PAC/PACG in PACS eyes.

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