The ocular biometry characteristics of young patients with primary angle-closure glaucoma

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Abstract

Background: Although primary angle-closure glaucoma (PACG) mainly occurs in elderly people, diagnosis of PACG in young patients is not uncommon. So far, there is no article specialized on the ocular anatomical characteristics in these patients. In this study, ocular anatomical characteristics in young PACG patients are analyzed.

Methods: In this retrospective, comparative study, patients diagnosed with PACG and received ultrasound biomicroscopy (UBM) examination in our department were included. Patients were divided into two groups: a young group composed of patients ≤ 45 years and an old group composed of patients > 45 years. A-scan ultrasonography and ultrasound biomicroscopy (UBM) were used to measure ocular biometric parameters of patients in the two groups including axial length (AL), lens thickness (LT), central anterior chamber depth (ACD), anterior chamber width (ACW), angle opening distance 500 (AOD500), anterior chamber angle 500 (ACA500), iris thickness 1000 μm from the iris root (IT1000), iris thickness 500 μm from the iris root (IT500), trabecular-ciliary process angle (TCPA), trabecular-ciliary process distance (TCPD), scleral–ciliary process angle (SCPA), lens vault (LV), and pupil diameter (PD). Plateau iris (PI) and basal iris insertion were determined from UBM images, and the prevalence of PI and basal iris insertion were compared between the two groups. The incidence of postoperative malignant glaucoma (MG) was also determined in both groups and ocular anatomical predictors for the development of MG were evaluated in young PACG patients.

Results: One hundred fifteen patients were included into young group and 480 patients were included into old group. The young group had shorter TCPD, shorter AL, narrower TCPA, narrower SCPA thinner Lens compared to the old group. There were no significant differences in ACD, AOD 500, ACA500, LV, IT500, IT1000, PD or ACW between the two groups. The prevalence of PI was 22.6% in old group and 66.1% in young group (P < 0.001). More young PACG patients displayed basal iris insertion compared to old PACG patients (P < 0.001). 87 patients in the young group and 201 patients in the old group underwent trabeculectomy in our study. Among these patients, 21 young patients and 11 old patients developed MG after trabeculectomy (P < 0.001).

Conclusions: Shorter AL, more anteriorly positioned ciliary body, higher prevalence of PI may be responsible for the etiology of young PACG patients. Our results suggest that shorter AL, shorter TCPD and narrower TCPA may be predictors for development of MG in young PACG patients after trabeculectomy.

Keywords: Ocular biometric characteristics, Young patients, Primary angle-closure glaucoma

Introduction

Primary angle-closure glaucoma (PACG) is a major form of glaucoma in Asia, affecting approximately 0.75% Asian adults. Although the disease mainly occurs in elderly people, diagnosis of PACG in young patients is not uncommon [1, 2].
Material and methods
Patients and data collection
This study was a retrospective, comparative study. We searched our database for patients who were diagnosed with acute or chronic PACG and received UBM examination in Xiangya Hospital, Central South University from January 1, 2016, to January 1, 2020. The study was conducted in accordance with the ethical principles specified in the Declaration of Helsinki and was approved by the Xiangya Ethics Committee.
iris root. TCPD was measured as a line extending from a point 500 μm anterior to the scleral spur along the corneal endothelium and dropped perpendicularly through the iris to the most anterior ciliary process seen while scanning in that meridian. SCPA were measured between the line tangent to the scleral surface and the axis of the ciliary process and TCPA was measured with the apex in the scleral spur and the arms of the angle passing through the apex of ciliary process and tangent to the inner surface of cornea. Iris insertion was determined by the location of

![Ultrasound biomicroscopy image showing the measurements of ocular biometric parameters.](image)

A The measurements of central anterior chamber depth (ACD), pupil diameter (PD), anterior chamber width (ACW), and lens vault (LV). B The measurements of anterior chamber angle 500 (ACA500), angle opening distance 500 (AOD500). C The measurements of iris thickness at 1000 μm from iris root (IT1000) and iris thickness at 500 μm from iris root (IT500). D The measurements of trabecular meshwork-ciliary process distance (TCPD). E The measurement of scleral–ciliary process angle (SCPA). F The measurement of trabecular meshwork-ciliary process angle (TCPA). G Image of a quadrant depicting basal iris insertion.
iris insertion on the ciliary body, and basal iris insertion refers to iris insertion that is located at the base of the ciliary body near the scleral spur (Fig. 1). A-scan ultrasound biometry (Model KN-3000A; Quatel Co Ltd., France) and UBM (Model SW-3200L; Tianjin Suowei Electronic Technology Co Ltd., China) examinations and measurements were performed by the same well-trained physician.

PI was defined based on UBM images using standardized qualitative criteria as described by Kumar et al., that is, anteriorly directed ciliary process, absent ciliary sulcus, steep iris root from the point of insertion followed by a downward angulation, flat iris plane, and irido-angle contact (above the level of the scleral spur) in the same quadrant. At least 2 quadrants had to fulfill these UBM criteria to be defined as having PI [11].

We observed the incidence of MG after trabeculectomy surgery in the two groups. Patients who received cataract surgery and trabeculectomy at the same time were excluded. The diagnosis of MG was established based on the following: i) presence of a central and peripheral shallow or flat anterior chamber with a patent iridectomy; and ii) elevated IOP (≥21 mmHg). Eyes with suprachoroidal hemorrhage and postoperative bleb leakage were not considered as MG in our study. To confirm whether patients had postoperative MG, all medical records for each patients were checked, and follow-up visits were conducted.

Only one eye per patient was analyzed in this study. If both eyes were eligible for study, data from the the eye with more serious glaucoma was chosen for analysis. Mean deviation (MD) in visual field was used to evaluate the progress of glaucoma.

**Statistical analysis**

Statistical analyses were performed using SPSS statistics software 24 (International Business Machines Corporation, USA). The numerical variables are described as mean ± standard deviation (SD) while the categorical variables are described as numbers and percentages.

Differences in mean values between young and old PACG eyes were examined using the unpaired t-test. To determine the possible factors affecting the occurrence of malignant glaucoma in young PACG patients, all the variables measured by A-scan and UBM were assessed using univariate logistic regression analysis. Variables with $P<0.1$ in univariate logistic regression analysis were included in the multivariate logistic regression model. Consequently, insignificant factors were removed using a stepwise approach. $P<0.05$ was considered statistically significant.

**Results**

From January 1, 2016 to January 1, 2020, 1220 patients were diagnosed with acute or chronic PACG in our department and met our inclusion criteria, of which, 115 patients (9.43%) younger than 45 years old were included into the young group and 480 patients older than 45 years old were included into the old group. The clinical data of young and old PACG patients were shown in Table 1. There were 83 (72.2%) female patients in the young group and 287 (59.8%) female patients in the old group ($P=0.02$). No significant difference in visual field MD or PSD was found between the two groups ($P>0.05$).

A-scan and UBM parameters in the young and the old group were shown in Table 2. TCPD and AL were significantly shorter, TCPA and SCPA were significantly narrower, and LT was significantly thinner in the young group compared to those in the old group. However, there were no significant differences in ACD, AOD 500, ACA500, LV, IT500, IT1000, PD and ACW between the two groups. The prevalence of PI was 22.5% in the old group while was 66.1% in the young group ($P<0.001$). Basal iris insertion was found in 72 (62.6%) patients in the young group and 96 (20.0%) patients in the old group ($P<0.001$).

Besides, 24 young patients and 164 old patients received medical treatment, 4 young patients and 115 old patients received combined surgery with glaucoma and cataract. There were 87 young patients and 201 old patients underwent trabeculectomy in our study. Among these patients, 21 young patients (24.1%) and 11 old patients (5.5%) developed MG after trabeculectomy ($P<0.001$). Table 3 listed the relevant variables that predict the occurrence of MG in young patients with PACG using multivariate regression with the Generalized Estimation Equation. TCPD, TCPA and AL were associated with the occurrence of MG in young patients ($P<0.05$).

**Table 1** Comparison of the demographic and clinical characteristics of the young and old PACG patients

| Characteristic | Young group | Old group | $P$ |
|---------------|-------------|-----------|-----|
| No. of patients | 115 | 480 | |
| Female/male | 83/32 | 287/193 | 0.02 |
| Age | 39.2 ± 6.7 | 61.8 ± 8.2 | <0.001 |
| MD of VF (dB) | −140 ± 6.5 | −15.5 ± 5.3 | 0.78 |
| PSD of VF (dB) | 6.9 ± 4.1 | 7.0 ± 3.1 | 0.67 |

PACG primary angle-closure glaucoma, MD mean deviation, PSD pattern SD, VF visual field

**Discussion**

In the present study, ocular biometric parameters including AL, LT, ACD, LV, PD, ACW, TCPA, TCPD, SCPA, LT, IT500, IT1000, AOD500, and ACA 500 were quantitatively compared between young and old PACG patients. Among these ocular biometric parameters, shorter TCPD and AL, narrower SCPA and TCPA, thinner LT were found in young PACG patients when
Several previous studies have suggested that the iris play an important role in the pathogenesis of angle closure [8, 20, 21]. A thicker peripheral iris and a more basal iris insertion were associated with an increased risk of angle closure. In our study, peripheral iris thickness was similar between the old and young PACG patients, but basal iris insertion was more common in the young PACG patients than in the old PACG patients.

The thicker and more anteriorly located lens, as well as a shorter AL, are thought to be predisposing factors for angle-closure [22–25]. In our study, we also found that higher LV and thicker LT in the old patients. LT and LV will increase with age, and this factor may contribute to the increase in incidence of angle closure with age [21]. Compared to the old patients with PACG, young PACG patients displayed shorter AL, we hypothesised that the natural anatomical abnormality with short AL was a cause of angle closure in these patients.

Pathogenesis of angle closure glaucoma can be divided into pupillary block mechanism and non-pupillary block mechanism. Although pupillary block mechanisms are the main cause of angle closure in PACG patients [7], non-pupillary block, especially PI, is an important pathogenesis of angle closure in young patients. Ritch et al. [5] systematically examined the demographics and clinical appearance of young individuals with angle closure and found that PI was the most common diagnosis (52.2%) in a relatively inhomogeneous sample of 67 patients with angle closure symptoms. Previous studies also showed that the prevalence of PI in primary angle-closure suspect (PACS) eyes was about 30% in Asian people, and patients with PI tend to be younger [10, 12]. In PI, large and anteriorly inserted ciliary processes hold the iris root in apposition to the trabecular meshwork, resulting in spontaneous or provoked acute or intermittent angle closure. In this study, we specifically compared the incidence of PI between young and old PACG patients and found that the prevalence of PI in primary angle-closure suspect was about 66.1% in the young patients with PACG, which was significantly higher than that in the old patients. Our results indicated that in contrast to old PACG patients, PI was the most common underlying etiology in young PACG patients.

### Table 2
Comparison of ocular biometric parameters in young and old PACG patients

| Parameter          | Young group  | Old group  | p   |
|--------------------|--------------|------------|-----|
| AL (mm)            | 21.78±1.00   | 22.68±0.87 | <0.001 |
| LT (mm)            | 4.22±0.69    | 4.56±0.64  | 0.03 |
| AOD500 (mm)        | 0.02±0.04    | 0.02±0.03  | 0.87 |
| ACA500 (Deg.)      | 2.70±4.84    | 2.82±2.4   | 0.76 |
| TCPA (Deg.)        | 52.87±11.34  | 63.28±18.41| <0.001 |
| TCPD (μm)          | 0.44±0.08    | 0.51±0.09  | <0.001 |
| SCPA (Deg.)        | 61.32±11.68  | 73.59±11.85| <0.001 |
| IT500 (μm)         | 0.36±0.06    | 0.37±0.06  | 0.50 |
| IT1000 (μm)        | 0.43±0.07    | 0.44±0.06  | 0.58 |
| ACD (μm)           | 2.01±0.40    | 1.91±0.23  | 0.16 |
| LV (mm)            | 3.19±0.89    | 3.41±0.95  | 0.17 |
| PD                 | 11.55±0.74   | 11.33±0.73 | 0.20 |
| PI (No)            | 76 (66.1%)   | 108 (22.5%)| <0.001 |
| BII (No)           | 72 (62.6%)   | 96 (20.0%) | <0.001 |
| PMG (No)           | 21 (24.1%)   | 11 (5.5%)  | <0.001 |

AL, axial length; LT, lens thickness; AOD500, angle opening distance 500; ACA500, angle chamber angle 500; TCPA, trabecular-ciliary process angle; TCPD, trabecular-ciliary process distance; SCPA, scleral-ciliary process angle; IT500, iris thickness at 500 μm from iris root; IT1000, iris thickness at 1000 μm from iris root; ACD, central anterior chamber depth; LV, lens vault; PD, pupil diameter; ACW, anterior chamber width; PI, plateau iris; BII, basal iris insertion; PMG, postoperative malignant glaucoma.

### Table 3
Factors predicting the development of PMG in young patients with PACG

| Factor | β     | SE    | 95% CI Lower | 95% CI Upper | Hypothesis Test | df | p   |
|--------|-------|-------|--------------|--------------|----------------|----|-----|
| TCPA   | −1.12 | 0.54  | 0.11         | 0.88         | 4.80           | 1  | 0.03|
| TCPD   | 168.85| 74.93 | 3,586,933,959| 1.28E+137    | 5.08           | 1  | 0.02|
| AL     | −2.36 | 0.86  | 0.02         | 0.54         | 7.63           | 1  | 0.006|

AL, axial length; CI, confidence interval; PMG, postoperative malignant glaucoma; PACG, chronic primary angle-closure glaucoma; SE, standard error; TCPA, trabecular-ciliary process angle; TCPD, trabecular-ciliary process distance; PMG, postoperative malignant glaucoma; PACG, chronic primary angle-closure glaucoma.
MG is typically known to occur after glaucoma filtration surgery in eyes with PACG and the incidence of MG has been reported to be approximately 0.6% to 4% [12]. Young age is an important risk factor for the development of MG. In our study, the incidence of postoperative MG was 24.1% in young patients with PACG (Table 3), which was much higher than that in the old patients, and higher than those reported in previous studies [12]. To our knowledge, this was the first time that reported the incidence of MG in young patients with PACG after glaucoma filtration surgery. Moreover, we found that shorter AL and more anteriorly rotated ciliary bodies might be predictors for the development of MG in young patients with PACG.

Our study was limited by its retrospective design, which may have affected the selection of patients. Another limitation of this study was that the gonioscopic and quantitative measurements of UBM images were performed by the same examiner, which could cause observational bias. The third limitation of this study was lack of normative data since the ocular parameters such as LT and LV will change with age. All the patients in our study were Chinese, so the results may not be generalizable to other ethnicities.

In conclusion, compared to old patients with PACG, young patients with PACG had shorter ALs, more anterior position of ciliary processes, more cases of basal iris insertion, higher prevalence of PI and higher incidence of MG. These anatomic abnormalities could be the reason that young patients develop angle closure at much earlier age and develop MG more easily after trabeculectomy. In contrast to old PACG patients, non-pupil block mechanisms are the main cause of angle closure in young patients with PACG, thus iridectomy may not be an effective treatment for angle closure in these patients [26]. Therefore, in young patients with glaucoma, gonioscopy and UBM should be used to examine the angle structure, to determine the pathogenesis of glaucoma and provide corresponding treatment.

Authors’ contributions
Research design: Dan Liu, Qian Tan, UBM and A-scan examination: Yi Xu, acquisition of data: Yi Xu, data analysis and manuscript writing: Dan Liu, Chunyan Li. All the authors have read and approved of the final version of the manuscript.

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Availability of data and materials
The datasets used during the current study are available from the corresponding author on reasonable request.

Declarations
Ethics approval and consent to participate
The study was conducted in compliance with informed consent regulation and the Declaration of Helsinki. Oral informed consent was obtained from all the participants and the oral informed consent procedure was approved by Xiangya Hospital Ethics Committee. The study protocol was approved by Xiangya Hospital Ethics Committee.

Consent for publication
Not applicable.

Competing interests
The authors declare that there is no competing interest.

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