Original Article
Pentacam could be a useful tool for evaluating and qualifying the anterior chamber morphology

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Abstract: Objective: This study aims to investigate the changes of anterior chamber morphology after laser peripheral iridotomy (LPI) in primary angle-closure (PAC) patients using Pentacam. Methods: 35 normal persons and 35 patients of PAC before and 1 week after neodymium: yttrium: aluminum garnet (Nd: YAG) LPI were evaluated with Pentacam. We measured the anterior chamber angle (ACA), central anterior chamber depth (CACD), peripheral anterior chamber depth (PACD), anterior chamber volume (ACV) and pupil diameter (PD). Paired t-test was used to investigate the differences in anterior segment parameters before and after LPI. Independent samples t-test was used to compare these parameters between PAC patients after LPI and normal persons. Results: There were significant differences between PAC patients and control in nasal and temporal ACA, PACD, ACV ($P < 0.05$) except for superior ($P = 0.053$) and inferior ACA ($P = 0.389$), CACD ($P = 0.453$) and PD ($P = 0.221$). ACV increased 56.5% in PAC patients after LPI whose ACV < 57 mm^3, which was more greatly than those patients whose ACV > 57 mm^3 ($P = 0.001$). Conclusions: The changes of anterior chamber parameters after LPI in PAC eyes can be demonstrated by Pentacam objectively and quantitatively. LPI seems more effective for PAC eyes with smaller ACV. The anterior chamber parameters in PAC eyes after LPI are still significantly smaller than those of normal persons.

Keywords: Laser peripheral iridotomy, primary angle-closure, Pentacam

Introduction

Primary angle-closure glaucoma (PACG) is one of the leading causes of blindness worldwide [1, 2]. It is the most frequent causes of glaucoma in China. PACG is also responsible for the majority of bilateral glaucoma blindness in China [3]. Screening, diagnosis, and management of PACG became a global concern [4]. Neodymium: yttrium: aluminum garnet (Nd: YAG) laser peripheral iridotomy (LPI) has proved to be beneficial in preventing the development of primary angle-closure (PAC) into PACG [5, 6]. The mechanism of LPI is that it creates an opening hole on the peripheral iris to eliminate the pupillary block. Thereby it makes the convex iris flattened which widening the anterior chamber angle [7]. However, quantification of changes in the anterior segment after LPI has been limited by lack of ideal instruments to assess them. Gonioscopy, anterior segment ocular coherence tomography (AS-OCT), and ultrasonic biomicroscopy (UBM) have been used to observe the morphological changes of the anterior chamber. However, Gonioscopy is not reproducible or accurate. UBM requires the contact and immersion in the solution of eyes and is inconvenient. These methods only obtain cross-sections of the anterior segment and can not provide full three-dimensional (3-D) information on the eye [7-9]. The Pentacam (Oculus Inc., Wetzlar, Germany) is a commercially available instrument comprised of a rotating Scheimpflug camera that captures images of the anterior segment of the eye. The device generates a complete image and 3-D virtual model of the anterior segment. Software allows evaluation and quantification of anterior segment parameters such as central anterior chamber depth (CACD), peripheral anterior chamber depth (PACD), anterior chamber volume (ACV), pupil diameter (PD), and anterior chamber angle (ACA) of cross-section photographs from 0° to 360°. This noncontact procedure takes approximately 2 seconds [10, 11].

The aim of the study is to use Pentacam to investigate the changes of anterior chamber

morphology after LPI in Chinese PAC patients and to compare these patients after LPI with normal Chinese persons. ACV by now is the unique parameter that can only be obtained by Pentacam with its 3-D virtual model. We firstly evaluate the relationship between ACV and the effect of LPI in this study which was never seen in previous literature.

Material and methods

Subjects

Patients eligible for this study were PAC, who were initially seen at Beijing Hospital, from February 2012 to September, 2013. PAC designate patients with an occludable drainage angle and features indicating that trabecular obstruction by the peripheral iris has occurred, such as peripheral anterior synechiae, elevated intraocular pressure, iris whirling(distortion of the radially orientated iris fibres), "glaucomfleken" lens opacities, or excessive pigment deposition on the trabecular surface. The optic disc does not have glaucomatous damage [12]. Patients were excluded if they met any of the following criteria: (1) secondary angle closure, such as lens dislocation or intumescence, neovascular glaucoma, uveitis; (2) prior laser treatment or intraocular surgery; (3) ocular trauma; (4) severe cornea diseases; (5) UBM showed PAC caused by forward rotation of ciliary body or iris thickening rather than pupil block.

The inclusion criteria of normal persons were as follows: (1) best-corrected visual acuity ≥ 20/20; (2) refractive error between +4.00 to -8.00 diopters; (D) of sphere and +3.00 to -3.00 D of cylinder and with anisometropia ≤ 2.00 D; (3) normal anterior chamber depth, clear refractive media and normal eye fundus; (4) intraocular pressure ≤ 21 mm Hg; (5) no history of retinal diseases, optic nerve diseases, uveitis, and no history of ocular trauma or intraocular surgeries or any kind of ocular laser therapy, including refractive surgery.

35 PAC patients and 35 normal persons were enrolled in our study. Only one eye was selected in each patient. When both eyes of the same patients were eligible, one eye was randomly selected. All subjects signed an informed consent form. This study was approved by the Ethics Committee of Beijing Hospital.

Methods

The following examinations were performed on PAC eyes and normal eyes: visual acuity, IOP by Goldmann applanation tonometry, slit-lamp biomicroscopy, ophthalmoscopy, refraction and Pentacam. All PAC patients went the examinations of Gonioscopy performed by a glaucoma specialist (Xy. Li) using a Goldmann-type 2-mirror indirect gonioscope (Haag-Streit AG, Koeniz, Switzerland), and UBM performed by one skillful technician Fang Tian. Pentacam was also done on PAC eyes 1 week after LPI. All patients provided written informed consent.

LPI: One hour before LPI, subjects received 1% pilocarpine 3 times. The YAG laser was used with a single 5-6mj pulse until patency was achieved.

After LPI, subjects received 0.1% dexamethasone for 3 days. Patients were seen 1 day and 1 week after LPI.

Anterior segment measurements: Pentacam enables evaluation and quantification of anterior segment parameters such as CACD, PACD, ACV, PD, and ACA. PACD is defined as 4 mm from the cornea apex. Pentacam examinations were performed in a room with a standard dim illumination by one skillful technician Lei Hu. Pentacam measurements were accepted only the quality score (QS) > 95%. Three measurements were obtained in each eye, and the best one was used for quantitative analysis.

Statistical analysis

Statistical analyses were performed using SPSS 19.0 statistics software (SPSS Inc, Chicago, IL, USA). Normal distribution of data was assessed using the Shapiro-Wilk test. Paired t-test was used to investigate the differences in anterior segment parameters before and after LPI. Independent samples t-test was used to compare these parameters between PAC eyes after LPI and normal persons. The $P < 0.05$ was considered statistically significant.

Results

35 eyes of 35 PAC patients (9 men and 26 women) and 35 eyes of 35 normal persons (19 men and 16 women) were included in the study. All subjects were Chinese. Mean age of PAC

Table 1. Anterior chamber values PAC patients before and after LPI and normal persons and their statistical significance

Parameter	Pre-LPI	Post-LPI	Normal	P-value 1	P-value 2
ACV (mm³)	58.20	83.66	135.80	0.000	0.000
ACA (degree)					
Superior	21.06	22.37	30.51	0.053	0.000
Inferior	24.02	24.54	31.59	0.389	0.000
Nasal	22.91	25.46	33.84	0.002	0.000
Temporal	25.67	27.22	37.12	0.033	0.000
CACD (mm)	1.77	1.79	2.77	0.453	0.000
PACD (mm)					
Superior	0.30	0.65	1.10	0.000	0.000
Inferior	0.58	0.95	1.51	0.000	0.000
Nasal	0.30	0.57	1.06	0.000	0.000
Temporal	0.73	1.08	1.67	0.000	0.000
PD (mm)	2.49	2.43	2.53	0.221	0.371

P-value 1 means statistically significant differences between PAC patients pre and post-LPI; P-value 2 means statistically significant differences between post-LPI patients and normal persons. LPI = laser peripheral iridotomy; ACV = anterior chamber volume; ACA = anterior chamber angle; CACD = central anterior chamber depth; PACD = peripheral anterior chamber depth; PD = pupil diameter.

was 66.1 years old (range 54-81), Mean age of normal persons was 67.1 years old (range 48-87). Mean spherical equivalent of PAC was 1.65 ± 2.38 diopters. Mean spherical equivalent of normal persons was -0.98 ± 2.13 diopters. There was no statistically different between these two groups either in age ($P = 0.618$) or in refraction ($P = 0.432$).

For PAC eyes, statistically significant differences were found before and 1 week after LPI in nasal and temporal ACA, PACD, ACV (all $P < 0.05$) except for superior ($P = 0.053$) and inferior ACA ($P = 0.389$), CACD ($P = 0.453$) and PD ($P = 0.221$) (**Table 1**). After LPI, We found ACV statistically increased from 58.20 mm³ to 83.26 mm³ ($P = 0.000$), and also superior, inferior, nasal and temporal PACD statistically increased from 0.30 mm, 0.58 mm, 0.30 mm, 0.73 mm to 0.65 mm, 0.95 mm, 0.57 mm and 1.08 mm respectively (all $P = 0.000$). PAC eyes were divided into two groups. After LPI for those whose ACV < 57 mm³, ACV increased 56.5%, which was much greater than those whose ACV > 57 mm³, which only increased 36.0% ($P = 0.001$).

Although after LPI, we found statistically increase in PACD and ACV for PAC patients, statistically significant differences were noted in

all analyzed parameters between PAC eyes after LPI and normal persons. ($P = 0.000$) except PD ($P = 0.371$) (**Table 1**). That is to say, for PAC patients, although after LPI, all of the anterior chamber parameters (ACA, CACD, PACD, ACV) were significantly smaller than normal persons.

Discussion

The first aim of our study was to investigate the efficacy of the LPI in the management of the subjects with PAC using Pentacam. LPI has proved to be successful in preventing the development of primary angle-closure (PAC) into PACG [5, 6]. Results obtained in our study confirmed the effectiveness of LPI, as there were significant increases in ACV and PACD after LPI. ACV increased greatly from 58.2 mm³ to 83.66 mm³. The increase was significant with 25.46 mm³. PACD increased significantly in all 4 quadrants with about 0.3mm. We assume that after LPI, the aqueous humor flow directly through the iridotomy site, so the convex iris flattened and the pupil block was eliminated, which greatly deepens the peripheral chamber and increases the ACV and PACD.

As Pentacam generates a 3-D virtual model of the anterior segment, ACV is by now the unique parameter which other anterior segment devices could not get. In our study, we firstly found after LPI, ACV smaller than 57 mm³ increased more greatly, thus we assume that LPI might be more effective in PAC patients with smaller ACV.

This study showed with LPI significant changes were found in nasal and temporal ACA, however, the changes in nasal and temporal ACA did not reach the significant level. Although Pentacam is an accurate method in anterior segment imaging, the inability of the Pentacam to visualize the most peripheral part of the iris and the base of the ACA might justify this observation that ACA measured by Pentacam, which is automatically calculated and critically dependent on the localization of the assumed apex of

the ACA, is thought to be unreliable and mostly overestimated in eyes with a narrow ACA [13, 14]. And also the eye lid shelter may also make the inaccuracy of the measurements of superior and inferior ACA.

The results of the present study showed increase in CACD after the LPI did not reach the significant level, agreeing with previous studies [10, 11]. The LPI moves the iris toward the posterior chamber, however, the location of the lens is not affected; thus may not affect the CACD.

Our results showed that the PD did not change significantly after the LPI. As is known to all, PD could affect the measurements of anterior chamber parameters [15]. In order to validate our experiment, we tried to control the lighting and fixation to ensure that PD remained the same in 2 sessions of the measurements.

The second aim of our study was to compare the changes of anterior chamber morphology after LPI in PAC patients with normal persons.

Our results showed statistically significant differences were noted in all analyzed parameters between PAC eyes after LPI and normal persons except PD.

We can see for PAC eyes, although after LPI, the PACD and ACV significantly increased, they were still much smaller than normal persons. The ACA in 4 quadrants, CACD were also significantly smaller than normal persons. Wang et al. stated that 55% of all angle-closure in China is caused by multiple mechanisms, with only 38% attributable to pure pupil block [16]. Hung and Chou reported that the dark-prone provocative test was positive in 60% of Taiwanese Chinese eyes after iridectomy, compared with 12.5% in normal eyes [17]. Our study also confirmed that even though pupil block was eliminated, PAC patients still had much smaller ACA, ACD and CV, which indicates multiple mechanisms for angle closure exist. So even after conventional YAG laser iridotomy, PAC patients need routine follow-up to prevent progression of angle closure. For some of these structural variations, other preventive treatments may need to be devised such as laser iridoplasty.

In conclusion, the present study confirmed previous reports on the increase in ACV and PACD for PAC patients after LPI. Pentacam could be a useful tool for evaluating and qualifying the anterior chamber morphology with the advantages of objectivity, good quantitative measurements, ease of handling, obtained with a rapid, non-contact method. For Chinese PAC patients, although after LPI, the anterior chamber measurements were still much smaller than normal persons, which indicating multiple mechanisms result in angle closure. Thus routine follow-up is recommended for those patients of PAC after LPI.

Disclosure of conflict of interest

None.

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References

[1]   Quigley HA and Broman AT. The number of people with glaucoma worldwide in 2010 and 2020. Br J Ophthalmol 2006; 90: 262-267.

[2]   Tarongoy P, Ho CL and Walton DS. Angle-closure glaucoma the role of the lens in the pathogenesis, prevention, and treatment. Surv Ophthalmol 2009; 54: 211-225.

[3]   Foster PJ and Johnson GJ. Glaucoma in China: how big is the problem? Br J Ophthalmol 2001; 85: 1277-1282.

[4]   See JL, Aquino MC, Aduan J and Chew PT. Management of angle closure glaucoma. Indian J Ophthalmol 2011; 59: S82-S87.

[5]   Johnson GJ and Foster PJ. Can we prevent angle-closure glaucoma. Eye 2005; 19: 1119-1124.

[6]   Pandav SS, Kaushik S, Jain R, Bansal R and Gupta A. Laser peripheral iridotomy across the spectrum of primary angle closure. Can J Ophthalmol 2007; 42: 233-237.

[7]   He M, Friedman DS, Ge J, Huang W, Jin C, Lee PS, Khaw PT and Foster PJ. Laser peripheral iridotomy in primary angle-closure suspects: biometric and gonioscopic outcomes: the Liwan Eye Study. Ophthalmology 2007; 114: 494-550.

[8]   Kim DY, Sung KR, Kang SY, Cho JW, Lee KS, Park SB, Kim ST and Kook MS. Characteristics and reproducibility of anterior chamber angle assessment by anterior-segment optical coherence tomography. Acta Ophthalmol 2011; 89: 435-441.

[9]   Radhakrishnan S, Goldsmith J, Huang D, Westphal V, Dueker DK, Rollins AM, Izatt JA

and Smith SD. Comparison of optical coherence tomography and ultrasound biomicroscopy for detection of narrow anterior chamber angles. Arc Ophthalmol 2005; 123: 1053-1059.

[10] Esmaeili A, Barazandeh B, Ahmadi S, Haghi A, Ahmadi Hosseini SM and Abolbashari F. Assessment of the anterior chamber parameters after laser iridotomy in primary angle close suspect using Pentacam and gonioscopy. Int J Ophthalmol 2013; 6: 680-684.

[11] Jain R, Grewal D and Grewal SP. Quantitative analysis of anterior chmber following peripheral laser iridotomy using Pentacam in eyes with primary angle closure. Eur J Ophthalmol 2013; 23: 55-60.

[12] Foster PJ, Buhrmann R, Quigley HA and Johnson GJ. The definition and classification of glaucoma in prevalence surveys. Br J Ophthalmol 2002; 86: 238-242.

[13] Shankar H, Taranath D, Santhirathelagan CT and Pesudovs K. Anterior segment biometry with the Pentacam: comprehensive assessment of repeatability of automated measurements. J Cataract Refract Surg 2008; 34: 103-113.

[14] Kurita N, Mayama C, Tomidokoro A, Aihara M and Araie M. Potential of the Pentacam in screening for primary angle closure and primary angle closure suspect. J Glaucoma 2009; 18: 506-512.

[15] Li S, Wang H, Mu D, Fu J, Wang X, Wang J, Wang N. Prospective evaluation of changes in anterior segment morphology after laser iridotomy in Chinese eyes by rotating Scheimpflug camera imaging. Clin Experiment Ophthalmol 2010; 38: 10-14.

[16] Wang N, Wu H and Fan Z. Primary angle closure glaucoma in Chinese and Western populations. Chin Med J 2002; 115: 1706-1715.

[17] He M, Foster PJ, Johnson GJ and Khaw PT. Angle-closure glaucoma in East Asian and European people: Different diseases? Eye 2006; 20: 3-12.