

# Pentacam 眼前节分析系统在预防性激光虹膜周边切除评估中的应用

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## Evaluation the value of Pentacam segment analysis system in the study of eye anterior segment before and after prophylactic laser periphery iridotomy

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### Abstract

• **AIM:** To investigate the 3D morphology changes of anterior segment in the fellow eye of acute primary angle closure glaucoma (PACG) before and after neodymium: yttrium aluminum garnet (Nd: YAG) laser periphery iridotomy (LPI) by using Pentacam system and evaluate the safety and efficiency of LPI.

• **METHODS:** Fifty patients (50 eyes) with PACG were enrolled in the study. Before and 1 day, 6 months after LPI, comparison of intraocular pressure (IOP) was measured, comparison of anterior segment parameters such as central corneal thickness (CCT), central anterior chamber depth (CACD), peripheral anterior chamber depth (PACD), anterior chamber volume (ACV), anterior chamber angle (ACA), lens thickness (LT) and pupil diameter (PD) were analyzed by the Pentacam system. The axial length (AL) of eye was measured by IOL-Master, and then comparison of relative position of the lens (RPL) was estimated.

• **RESULTS:** There were no differences among the IOP before and 1 day, 6 months after LPI. The Pentacam system clearly showed the convex configuration of the iris was flattened and the peripheral AC depth was deepened after LPI. Before and 1 day, 6 months after LPI, no statistic changes of CCT were found ( $548.02 \pm 20.22$ mm,

$549.32 \pm 21.78$ mm,  $551.34 \pm 26.37$ mm, respectively); no statistic changes of CACD were found ( $1.65 \pm 0.28$ mm,  $1.72 \pm 0.31$ mm,  $1.71 \pm 0.23$ mm, respectively); no statistic changes of PD were found ( $2.32 \pm 0.55$ mm,  $2.20 \pm 0.39$ mm,  $2.38 \pm 0.40$ mm, respectively); no statistic changes of LT were found ( $1.90 \pm 0.55$ mm,  $1.82 \pm 0.39$ mm,  $1.98 \pm 0.40$ mm, respectively); no statistic changes of AL were found ( $23.08 \pm 1.05$ mm,  $22.91 \pm 1.12$ mm,  $22.94 \pm 0.96$ mm, respectively); no statistic changes of RPL were found ( $0.118 \pm 0.035$ ,  $0.126 \pm 0.041$ ,  $0.121 \pm 0.028$ , respectively). PACD was deepened, temporal from  $0.88 \pm 0.31$ mm to  $1.19 \pm 0.25$ mm (1 day),  $1.17 \pm 0.30$ mm (6 months), superior ( $0.83 \pm 0.32$ mm,  $1.01 \pm 0.42$ mm,  $1.02 \pm 0.36$ mm), nasal ( $0.80 \pm 0.42$ mm,  $0.95 \pm 0.21$ mm,  $0.94 \pm 0.24$ mm), inferior ( $0.83 \pm 0.34$ mm,  $1.13 \pm 0.14$ mm,  $1.12 \pm 0.25$ mm); ACV was increased from  $57.06 \pm 18.43$ mm<sup>3</sup> to  $80.65 \pm 20.02$ mm<sup>3</sup> (1 day),  $81.43 \pm 17.21$ mm<sup>3</sup> (6 months); ACA was widened from  $27.02^\circ \pm 6.65^\circ$  to  $30.41^\circ \pm 5.87^\circ$  (1 day),  $31.52^\circ \pm 6.98^\circ$  (6 months), which were increased significantly between before and after LPI, and no difference between 1 day and 6 months after LPI.

• **CONCLUSION:** LPI can induce dramatic changes of 3-D anterior segment morphology in the fellow eye of acute primary angle closure glaucoma (PACG). The changes of AC after LPI can be demonstrated by Pentacam qualitatively and quantitatively.

• **KEYWORDS:** primary angle closure glaucoma; eye anterior segment; laser therapy; iridotomy; Pentacam segment analysis system

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### 摘要

**目的:**以首次发作急性闭角型青光眼的对侧眼为研究对象,采用 Pentacam 眼前节分析系统观察预防性激光虹膜周边切除(laser peripheral iridotomy, LPI)前后眼前节结构变化,评估 LPI 的有效性和安全性。

**方法:**急性原发性闭角型青光眼 50 例 50 眼的对侧眼行氩激光联合 Nd:YAG 激光预防性激光周边虹膜切除,检查治疗前及治疗后 1d;6mo 的眼内压(intraocular pressure, IOP),以 Pentacam 测量中央角膜厚度(central corneal thickness, CCT)、中央前房深度(central anterior chamber depth, CACD)、周边前房深度(peripheral anterior chamber depth, PACD)、前房容积(anterior chamber volume, ACV)、前房角(anterior chamber angle, ACA)、瞳孔直径(pupil diameter,

PD)、晶状体厚度(lens thickness,LT),IOL-Master 测量眼轴长度(axial length,AL),并估算晶状体在眼内的相对位置(relative position of the lens,RPL)。

**结果:**Pentacam 图像清晰显示凸出的虹膜变平坦,前房角加深。治疗前与治疗后 1d;6mo 的眼压无显著变化。CCT 值分别为 548.02±20.22,549.32±21.78,551.34±26.37mm。CACD 值分别为 1.65±0.28,1.72±0.31,1.71±0.23mm。PD 值分别为 2.32±0.55,2.20±0.39,2.38±0.40mm。LT 值分别为 1.90±0.55,1.82±0.39,1.98±0.40mm。眼 AL 分别为 23.08±1.05,22.91±1.12,22.94±0.96。RPL 值分别为 0.118±0.035,0.126±0.041,0.121±0.028。治疗前后均无统计学差异。PACD 值分别为颞侧(0.88±0.31,1.19±0.25,1.17±0.30mm),上方(0.83±0.32,1.01±0.42,1.02±0.36mm),鼻侧(0.80±0.42,0.95±0.21,0.94±0.24mm),下方(0.83±0.34,1.13±0.14,1.12±0.25mm);ACV 值分别为 57.06±18.43,80.65±20.02,81.43±17.21mm<sup>3</sup>;ACA 值分别为 27.02°±6.65°,30.41°±5.87°,31.52°±6.98°,治疗前与治疗后均有统计学差异,治疗后 1d 与 6mo 无统计学差异。

**结论:**LPI 能明显增加急性闭角型青光眼对侧眼的周边前房深度和前房容积。Pentacam 眼前节分析系统能直观定量反映 LPI 对于急性闭角型青光眼对侧眼的眼前节三维结构变化。

**关键词:**闭角型青光眼;眼前节;激光治疗;虹膜周边切除;Pentacam 眼前节分析系统

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## 0 引言

原发性闭角型青光眼(primary angle closure glaucom, PACG)是主要的致盲眼病,有报道 2020 年前全球范围大约有 590 万人口因 PACG 致盲,而其中 60% 为东亚人<sup>[1]</sup>。慢性闭角型青光眼尤其多见,其中 1/3 有急性发作史<sup>[2]</sup>。有研究显示预防性虹膜周边切除(laser periphery iridotomy,LPI)可以预防对侧眼闭角型青光眼急性发作<sup>[3,4]</sup>。而在评估眼前节形态学改变的检查手段中,A 超、前节 OCT(AS-OCT)和 UBM 都曾用于观察 LPI 后的眼前节形态学变化<sup>[5-7]</sup>,然而 AS-OCT 和 UBM 只能得到横截面的前节部分,并不能提供眼球的 3-D 全面的信息,而且 A 超和 UBM 检查需要受检者仰卧位,不能真实反映正常立位状况下眼部的情况。大量的研究用以上技术评估了眼前节结构在 LPI 前后的变化,并发现凸出的虹膜变得平坦,前房角有显著的加宽,而中央前房深度没有明显改变<sup>[5,8-16]</sup>,但也有不同报道<sup>[7]</sup>。基于旋转 Scheimpflug 照相技术的 Pentacam 眼前节分析系统(德国 Oculus 公司)可以得到眼前节三维影像,并已广泛应用于研究角膜和屈光手术,有关青光眼方面的研究并不多,本文旨在以 Pentacam 进行 LPI 后眼前节 3-D 结构变化的量化研究。

## 1 对象和方法

**1.1 对象** 2008-01/2011-08 临床首次确诊急性原发性闭角型青光眼 50 例 50 眼,以其未发作对侧眼为研究对象,检查眼压正常,周边前房浅,不伴有青光眼性视神经损伤。

表 1 青光眼患者 50 例 50 眼对侧眼激光周边虹膜切除治疗前后眼前节结构参数比较  $\bar{x} \pm s$

眼前节结构参数	LPI 治疗前	LPI 治疗后 1d	LPI 治疗后 6mo
CCT (mm)	548.02±20.22	549.32±21.78	551.34±26.37
CACD (mm)	1.65±0.28	1.72±0.31	1.71±0.23
PACD (mm)			
(颞侧)	0.88±0.31	1.19±0.25 <sup>a</sup>	1.17±0.30 <sup>a</sup>
(上方)	0.83±0.32	1.01±0.42 <sup>a</sup>	1.02±0.36 <sup>a</sup>
(鼻侧)	0.80±0.42	0.95±0.21 <sup>a</sup>	0.94±0.24 <sup>a</sup>
(下方)	0.83±0.34	1.13±0.14 <sup>a</sup>	1.12±0.25 <sup>a</sup>
ACV (mm <sup>3</sup> )	57.06±18.43	80.65±20.02 <sup>a</sup>	81.43±17.21 <sup>a</sup>
ACA(°)	27.02±6.65	30.41±5.87 <sup>a</sup>	31.52±6.98 <sup>a</sup>
PD(mm)	2.32±0.55	2.20±0.39	2.38±0.40
LT(mm)	1.90±0.55	1.82±0.39	1.98±0.40
AL(mm)	23.08±1.05	22.91±1.12	22.94±0.96
RPL	0.118±0.035	0.126±0.041	0.121±0.028
IOP(mmHg)	15.30	14.70	13.00

<sup>a</sup>P<0.05 vs LPI 治疗前。

进行自身配对设计,其中男 22 例 22 眼,女 28 例 28 眼;年龄 42~80(平均 63.12±15.37)岁。

**1.2 方法** 检查治疗前及治疗后 1d;6mo 的眼压(Goldmann 压平眼压计),Pentacam(德国 Oculus 公司)测量中央角膜厚度(CCT)、中央前房深度(CACD)、周边前房深度(PACD)、前房容积(ACV)、前房角(ACA)、瞳孔直径(PD)、晶状体厚度(LT)。IOL-master 测量眼轴长度并估算晶状体在眼内的相对位置值(RPL)即 1/2 晶状体厚度与中央前房深度之和与眼轴长度的比值。Pentacam 检查时在暗室中进行,被检者坐位,将下颌置于下颌垫上,注视 Pentacam 旋转轴中心一蓝色光带中的固视目标。检查者使用操纵杆按屏幕提示进行瞄准和对焦。测量时尽量睁眼,眼球保持不动,Scheimpflug 三维成像系统在不到 2s 内完成 360°扫描,拍摄 25 张眼前节图像。按仪器说明要求,只接受成像质量(quality specification, QS)显示 OK 的检测结果。连续测量 3 次,取平均值。对每一位被检者的 Pentacam 三维眼前节分析诊断系统的检查均由熟练操作该系统的同一位医生完成。对比分析每位受检者行 LPI 治疗前后的 Pentacam 眼前节检测结果。CCT, CACD, ACV, ACA, PD, LT 均由 Pentacam 自动生成数据,而鼻侧,颞侧,上方,下方 PACD 分别测量,即距离瞳孔中心 5mm 的 3:00,6:00,9:00,12:00 位的 ACD 值。激光虹膜周边切除步骤:所有患者术前 3d 起至术后 7d 局部点用百利特眼药水,3 次/d。虹膜激光孔明显并有合适的大小,位置在上方虹膜,10:00~2:00 之间,瞳孔缘至虹膜根部 2/3 虹膜位置,隐窝更佳。单次 5~10mJ 脉冲能量,直至击穿。术前患者签署知情同意书。

**统计学分析:**采用 SPSS 15.0 统计学软件进行数据处理。对 LPI 前后 IOP, CCT, CACD, ACV, PACD, ACA, PD, LT, AL, RPL 进行方差分析等统计学处理。以 P<0.05 作为差异有统计学意义。

## 2 结果

**2.1 LPI 前及 LPI 后 1d 和 6mo Pentacam 三维前房分析仪测量数据比较** 采用随机区组设计的方差分析对术前及术后 1d;6mo 的 CCT, CACD, ACV, ACA, PD, LT, AL, RPL, IOP 及各象限的 PACD 值进行比较(表 1)。IOP, CCT, CACD, PD, LT, AL, RPL 值在 LPI 前后均无统计学差异。LPI 后 1d;6mo 各象限 PACD 均较之前增大,差别有

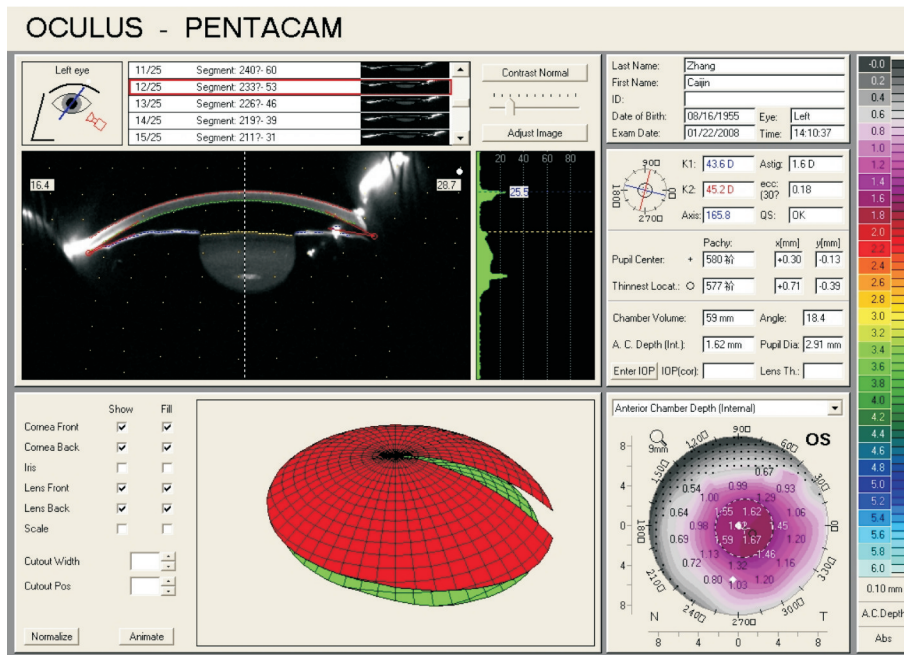


图1 LPI前 Pentacam 影像显示虹膜膨隆,狭窄的前房角。

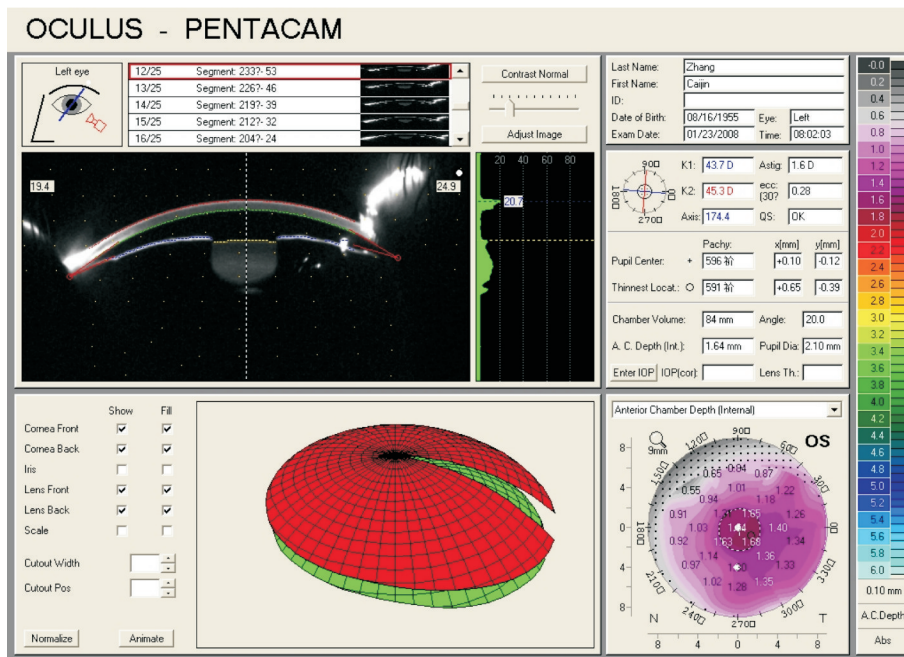


图2 LPI后1d Pentacam 影像显示周边前房深度加深,前房角变宽。

统计学意义( $P < 0.05$ ) ;LPI后1d和6mo之间比较,差别无统计学意义( $P > 0.05$ )。LPI后1d;6mo ACV均较之前增大,差别有统计学意义( $P < 0.05$ ) ;LPI后1d和6mo之间比较,差别无统计学意义( $P > 0.05$ )。LPI后1d;6mo平均ACA均较之前增大,差别有统计学意义( $P < 0.05$ ) ;LPI后6mo较1d仍有增大趋势,但差别无统计学意义( $P > 0.05$ )。这表明LPI后的前房深度、前房容积、前房角至术后1d基本达到稳定状态。

**2.2 图像显示眼前节结构变化** 激光周边虹膜切除治疗前的图像,可清晰地反映膨隆的虹膜,相对狭窄的前房等眼前节结构特征。在激光周边虹膜切除后,Pentacam系统提供的图像清晰显示凸出的虹膜变平坦,前房角加深。每种测量参数的所有测量数值都可以在图中标示,更可以直观地显示每个测量数值在激光周边虹膜切除治疗前后的

变化程度,其中周边前房深度和前房容积的治疗前后变化更明显(图1~3)。

### 3 讨论

在亚洲国家,PACG是主要的青光眼类型。Oh等<sup>[15]</sup>强调前房角的地域性差异-东亚人的虹膜附着于巩膜更靠前,而欧洲人更靠后。Kim等<sup>[16]</sup>同样指出亚洲人可闭的房角较普遍,晶状体位置靠前而不是明显的晶状体的增大可以解释亚洲人的闭角型青光眼。急性青光眼如果不及治疗,短期即可造成失明。在一个大样本研究中<sup>[17,18]</sup>认为,如果不治疗,5a内有22%的可疑房角关闭(primary angle-closure suspect,PACS)发展成原发性房角关闭(primary angle closure,PAC),28.5%的PAC发展成PACG。新加坡有一项基于调查问卷的研究<sup>[19]</sup>显示,84.9%的眼科医生认为对于无症状的PACS患者他们会常规进行LPI以

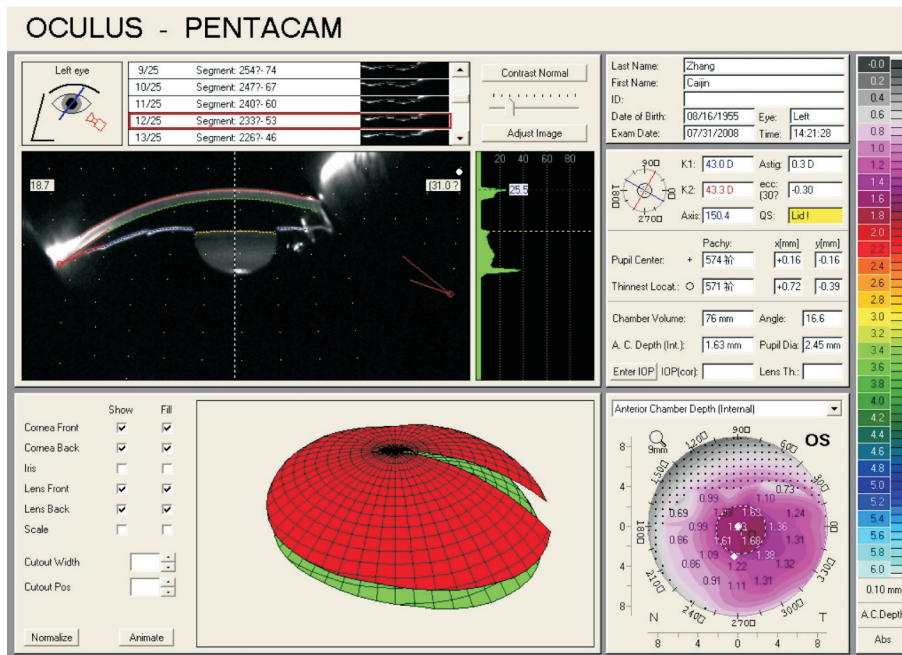


图3 LPI后6mo Pentacam影像显示周边前房深度加深,前房角变宽。

预防急性闭角发作。另一项研究报道只有9.3%的PAC患者在LPI治疗后5a发展为PACG,并认为LPI改变了房角关闭的自然进程<sup>[20]</sup>,LPI已经成为治疗PACS的标准治疗模式<sup>[21]</sup>。最近也有研究证实,可闭房角和原发性房角关闭(PAC)患者,LPI可以平衡升高的眼内压(IOP)<sup>[22]</sup>。LPI可以制造旁路通道缓解瞳孔阻滞,使凸出的虹膜变得平坦而加宽前房角<sup>[8,23]</sup>,从而逆转房角关闭,平衡前后房压力而加深ACA,稳定眼压,预防PAC发展为PACG<sup>[24,25]</sup>。而比起早期青光眼,一旦房角关闭粘连视神经有青光眼性损害,LPI并不能降低IOP保护视功能。本文选用首次确诊急性闭角型青光眼的未发作对侧眼即是LPI的最佳适应证。

有作者建议激光虹膜周边切除孔直径至少为200 $\mu\text{m}$ <sup>[26]</sup>,常见的并发症包括角膜灼伤、一过性前葡萄膜炎、眼压波动、周切口出血<sup>[27]</sup>。本研究中没有发生以上并发症,可能与病例选用急性闭角型青光眼的对侧眼,其相对安静的内眼环境有关。治疗后6mo随访未发现一例激光孔封闭。

本文以Pentacam研究了闭角型青光眼对侧眼在LPI治疗前后眼前节结构质和量的改变后发现,LPI前所有虹膜隆凸,而LPI后无一例隆凸,这和之前的研究一致<sup>[5,8-14]</sup>。绝大多数的PAC眼房角狭窄,而LPI造成的虹膜孔使房水从后房引流至前房,缓解瞳孔阻滞,从而平衡虹膜前后的压力梯度,使虹膜变平后退。很多研究已证实LPI后PACD加深,CACD是否加深并不确定,有报道CACD没有改变<sup>[8,11-13]</sup>。Gazzard等研究了55例急性闭角型青光眼对侧眼行LPI后光学测厚仪并未发现CACD的明显改变,而A超显示LPI后CACD显著增大。有学者将此归因于A超的探头压迫眼球。在我们的研究中LPI后CACD平均增加0.06mm,比之前增加4%,但并没有统计学意义。关于增加中央前房深度的确切机制并不十分明了。Dada等<sup>[28]</sup>提出猜测,被阻塞的房水可能进入玻璃体腔,并把晶状体向前推。LPI建立旁路使房水减压可能阻止这样的房水迷流,缓解使晶状体向前的压力,因而加深

中央前房角。Quigley等<sup>[29]</sup>认为晶状体后表面受到后房的压力并传至前表面,除了瞳孔部分,因其前房周围压力是等效的。虹膜周边切除可以消除作用于晶状体的压力差(瞳孔区和后房压力一致),从而造成轻微的后运动。本研究以几何中心即晶状体穹隆连线的中点来表示晶状体在眼球中的相对位置(relative position of lens,RPL),即1/2晶状体厚度与前房深度之和与眼轴长度比值,经计算发现LPI治疗后几何中心稍后移,但是没有统计学差异。从CACD加深的研究中推测,LPI治疗前晶状体主要受到三个力的作用,后房压力、前房压力和瞳孔阻滞产生的力,且前者等于后二者之和,合力为零故而晶状体稳定。LPI后虹膜上的通道使房水直接从后房进入前房,前房压力等于后房压力,然而瞳孔阻滞产生的力仍然存在,晶状体所受合力不再为零,平衡打破,瞳孔阻滞产生的力使晶状体向后,晶状体后退时被晶状体悬韧带牵引,后移到一定距离,晶状体停止并产生新的平衡,即悬韧带的牵引力等于瞳孔阻滞产生的力。我们假设晶状体后退的距离(即CACD加深的程度)大部分取决于两个力,即瞳孔阻滞产生的力和悬韧带的牵引力。除此,有3例CACD较之前减小,但其症状和体征检查并不能区分他们。其中1例晶状体厚度(LT)增加值与CACD减少值相同,LPI后1d瞳孔直径(PD)减小。我们推测可能是LPI时滴用pilocarpine,造成睫状体的收缩和晶状体的变厚。至今,我们没有发现报道LPI治疗后LT和PD变化的,本研究并未发现LT和PD变化有统计学意义。由于CACD的增加导致ACV的增加量很小,所以ACV的改变大部分是由于LPI后虹膜形态的变平<sup>[30]</sup>。

正如之前Van Herick等<sup>[31]</sup>的研究,对于闭角型青光眼,极周边ACD被认为是一个重要的危险因素之一。PACD是影响PACG急性发作眼预后的一个主要参数之一。这一定量化的周边前房深度变化,可对激光周边虹膜切除术的临床效果(即解除周边浅前房状态)提供可靠的量化证据。Pentacam将每种测量参数的所有测量数值分别在图中标出,可以直观地显示每个测量数值在激光周边

虹膜切除术前后的变化程度,其中周边前房深度和前房容积的前后变化更明显。

总之,本研究应用 Pentacam 眼前节分析系统定量检测急性原发性闭角型青光眼对侧眼行激光周边虹膜切除治疗前后眼前节形态结构变化参数,结合检测仪提供的图像信息进行分析,证实 Pentacam 眼前节分析系统能够客观评价周边虹膜切除的治疗效果。此系统估测 PACD 无创方便,所有眼前节参数通过计算机系统自动测量,因此,结果避免了检查者人为的偏倚,有高度的可靠性<sup>[12]</sup>。LPI 激光技术是否能阻止 PACS 眼进展为 PAC 或 PACG 有待于长期大样本的随访研究。

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