Laser Peripheral Iridotomy in Eyes with Narrow Drainage Angles: Ultrasound Biomicroscopy Outcomes. The Liwan Eye Study

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Purpose: To assess the short-term effect of laser peripheral iridotomy (LPI) on anterior segment anatomy in angle-closure suspects using ultrasound biomicroscopy (UBM).

Design: Prospective intervention study.

Participants: Persons identified as angle-closure suspects aged 50–79 years from a population-based survey in Guangzhou, China.

Intervention: Laser peripheral iridotomy was performed on 1 randomly selected eye. Ultrasound biomicroscopy examination was carried out before and 2 weeks after the intervention.

Main Outcome Measures: Proportion of eyes with iridotrabecular contact (ITC), as well as changes in UBM parameters including angle opening distance (AOD), iris thickness (IT), iris curvature, iris ciliary process distance, trabecular–ciliary process distance (TCPD), and scleral spur to iris insertion distance (SS–IR).

Results: A total of 72 of 101 eligible subjects participated in the study. The proportion of people with UBM-identified ITC in ≥1 quadrant dropped from 95% (68/72) before to 59% (42/72) after LPI. After LPI, the mean AOD at 250 microns increased from 0.064 mm (standard deviation [SD], 0.052) to 0.085 (0.052) mm ($P<0.001$); angle recess area increased from 0.040 (0.030) to 0.070 (0.036) mm^2 ($P<0.0001$); TCPD increased from 0.537 to 0.561 mm ($P = 0.001$); IT at 750 microns increased from 0.440 to 0.459 mm ($P = 0.094$), and IT at 1000 microns increased from 0.471 to 0.488 mm ($P = 0.0001$). Eyes whose angles remained closed after LPI (pigmented trabecular meshwork not visible in ≥3 quadrants) tended to have shallower AOD both at 250 (0.071 vs. 0.049 mm; $P = 0.09$) and 500 microns (0.108 vs. 0.052 mm; $P = 0.001$), a thicker iris (IT at 750 microns, 0.447 vs. 0.415 mm; $P = 0.041$), a more anterior positioned ciliary body (TCPD, 0.514 vs. 0.562 mm; $P = 0.03$), and a statistically nonsignificant more anterior iris insertion (SS–IR: 0.085 vs. 0.125 mm; $P = 0.061$), before LPI.

Conclusions: Laser peripheral iridotomy results in a significant increase in the angle width in Chinese people with narrow angles. However, some iridotrabecular contact was found in 59% of eyes with a patent iridotomy. This was associated with smaller anterior chamber angle dimensions and a thicker iris, both of which may play a causative role in maintaining angle closure after LPI. *Ophthalmology 2007;114:1513–1519 © 2007 by the American Academy of Ophthalmology.*

Laser peripheral iridotomy (LPI) is a proven prophylactic treatment for the prevention of symptomatic angle closure.[1–3] It is believed to act by bypassing relative block at the pupil, which results in a significant increase in angle width in both Europeans and Asians with narrow angles.[4–6] However, the prophylactic efficacy of iridotomy in asymptomatic cases is not comprehensively proven and depends on both the mechanism causing angle closure and the stage of the disease at presentation.[7,8] In addition, LPI does not invariably result in opening of an apparently closed drainage angle. This "postiridotomy angle closure" has been suggested to be relatively common in East Asian eyes.[8–12] We recently reported in a population-based survey of Chinese persons ≥50 years

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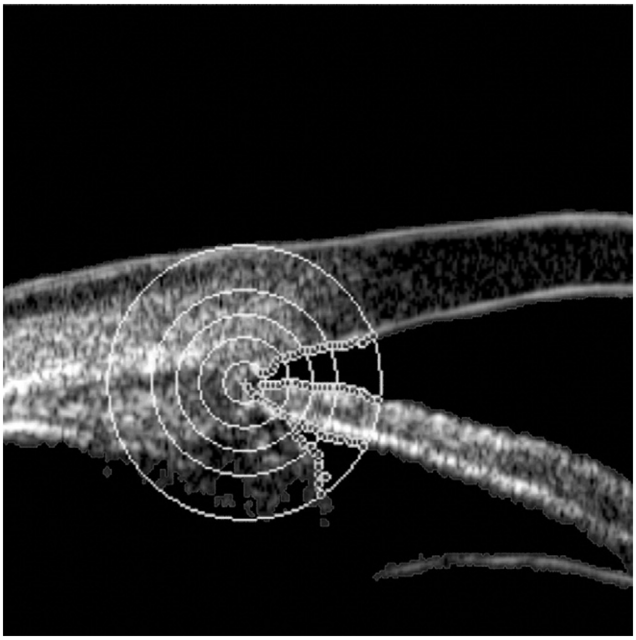

Figure 1. Screen image from the software illustrates the auttic identification of the border of corneal endothelium, the anterior and posterior surfaces of the iris, and anterior surface of the ciliary body.

of age that about 20% of narrow angle suspects remain gonioscopically "closed" even with a patent iridotomy.[13]

Ultrasound biomicroscopy (UBM) is a reproducible approach to measuring anterior chamber angle anatomy and allows quantitative analyses of angle relationships.[14–16] Ultrasound biomicroscopy examination is able to demonstrate angle changes after LPI in contralateral eyes of persons suffering symptomatic angle closure,[4] and is able to measure relatively small changes in response to other stimuli.[17] It is also commonly used for qualitative diagnosis, such as confirmation of appositional angle closure, identification of ciliary body rotation, and other abnormalities of the ciliary body and angle.

We report the qualitative and quantitative changes measured by UBM in the angle of Chinese people undergoing laser iridotomy for narrow angle suspects before developing pathologic angle closure. The biometric characteristics of those whose angles remained closed gonioscopically were compared with those whose angles opened after LPI.

Materials and Methods

Field Procedures

Ethical approval was obtained from the Zhongshan University Ethical Review Board, the Ethical Committee of Zhongshan Ophthalmic Center, and approval was granted by the Research Governance Committee of Moorfields Eye Hospital. The study was conducted in accordance with the tenets of the World Medical Association's Declaration of Helsinki. Examination of the subjects for the cross-sectional survey, laser iridotomy, and follow-up after treatment was carried out from September 2003 to February 2004.

The field procedures for the study have been reported previously elsewhere.[13] In brief, 1405 persons ≥50 years of age living in Liwan District, Guangzhou, were selected using cluster random sampling. People with narrow drainage angles—the study subjects—were identified as having ≥270 degrees of the posterior (usually pigmented) trabecular meshwork not visible on gonioscopy. We specifically enrolled subjects before the onset of pathologic angle closure, defined as intraocular pressure in the normal range (≤ 21 mmHg, the 97.5th percentile in people with normal fields) and no evidence of peripheral anterior synechiae. Slit lamp gonioscopy was carried out using a Goldmann-type 1-mirror lens (Model 902; Haag Streit, Bern, Switzerland) at ×25 magnification with low ambient illumination. A bright, narrow beam 1 mm in length was offset horizontally for superior and inferior quadrants, vertically for nasal and temporal quadrants. Care was taken to avoid light falling on the pupil. Small movements of the lens were allowed to visualize the drainage angle, but large movements were avoided because of the possibility of accidental indentation. Dynamic examination with the Goldmann lens was carried out after static gonioscopy of 4 quadrants was completed. A 4-mirror Zeiss lens was used if it was not possible to open an angle by dynamic gonioscopy using the Goldmann lens to identify the existence and extent of peripheral anterior synechiae. Cases with established primary angle closure (PAC) or PAC with glaucoma[18] were excluded. In this classification system, peripheral anterior synechiae

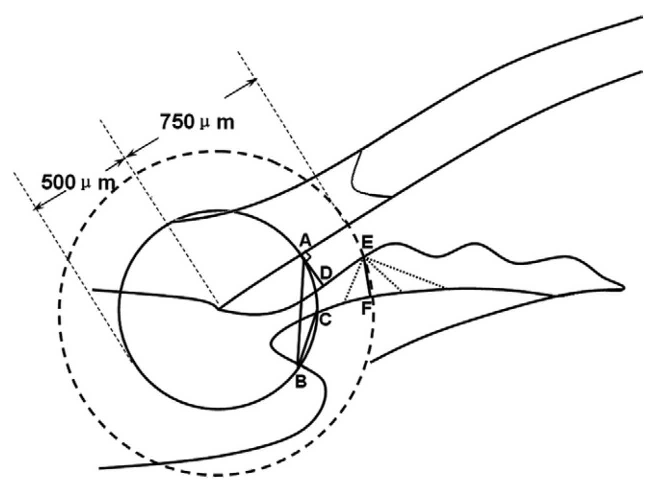

Figure 2. Principles used in our automated ultrasound biomicroscopy image analysis software. A circle with radius of 500 microns using the scleral spur as center was drawn by the computer (after the scleral spur was identified by the user). The points of intersection were identified by the software at the back of the cornea (A), back of the iris (C), and anterior surface of the ciliary body (B). Anterior opening distance, measured on a line perpendicular to the plane of the trabecular surface 500 μm anterior to the scleral spur and extended to meet the surface of the iris; trabecular–ciliary process distance, chord measured between A and B; iris–ciliary process distance, measured between C and B; iris thickness, distance from the intersection point (E) on the anterior surface of the iris at a given distance (750 or 1000 μm) to the intersection point (F) on the posterior surface with shortest distance to E automatically identified by the software; iris curvature displacement, measured relative to the posterior surface of the iris with an arc transecting 3 points: root of the iris, pupil margin, and point of maximal iris displacement between iris root and pupil margin; angle recess area, area bordered by the anterior surface of the iris surface, corneal endothelium, and a line perpendicular to the plane of the trabecular surface to the iris surface from a point 750 μm anterior to the scleral spur; area ratio of iris versus angle, cumulative area of the iris and drainage angle within the border to the circle with a 500-μm radius.

Table 1. Number of Quadrants with Ultrasound Biomicroscopy Appositional Angle Closure Before and After Laser Peripheral Iridotomy (LPI)*

	After LPI N (%)					
	0	*1*	*2*	*3*	*4*	**Total**
Before LPI						
0	2 (50.0)	1 (25.0)	1 (25.0)	0	0	4 (5.6)
1	9 (69.2)	4 (30.8)	0	0	0	13 (18.1)
2	11 (55.0)	2 (10.0)	5 (25.0)	2 (10.0)	0	20 (27.8)
3	6 (27.3)	5 (22.7)	7 (31.8)	3 (13.6)	1 (4.6)	22 (30.6)
4	2 (15.4)	2 (15.4)	2 (15.4)	5 (38.5)	2 (15.4)	13 (18.1)
Total	30 (41.7)	14 (19.4)	15 (20.8)	10 (13.9)	3 (4.2)	72 (100)

*UBM qualitative data were available for 72 eyes after PI.

is a defining feature of PAC. Hence, all subjects recruited in this study had gonioscopically verified appositional angle closure only. Subjects aged ≥80 years were also excluded from this prospective study because of concerns regarding follow-up over an extended time period. Any persons with conditions precluding follow-up (e.g., severe health problems) and clear visualization of the drainage angle (e.g., corneal opacity) were excluded. Written informed consent was obtained after carefully explaining the potential side effects and benefits of laser LPI in detail.

Laser peripheral iridotomy was performed using sequential argon and yttrium–aluminum–garnet laser technique in 1 randomly selected eye by the same ophthalmologist who has a specialist interest in glaucoma (MH). The LPI was placed in the superior region (between the 10 and 2 o'clock positions) in the peripheral third of the iris, wherever the iris appeared thinnest. An iridotomy of about 0.3 mm was the objective. Full-thickness perforation was confirmed by aqueous matter coming forth from the posterior to the anterior chamber with observed dispersion of pigment. All iridotomies were performed using an Abraham lens to focus the beam. At least 2 weeks after LPI (range, 14–17 days), the patients were asked to return for a postoperative examination.

Ultrasound Biomicroscopy Examination

Ultrasound biomicroscopy examination was performed before and 2 weeks after LPI by a technician (CX) with > 8 years of experience with UBM masked to the gonioscopic findings. The UBM examination was conducted in a dark room with illumination <5 Lux (P45 ultrasound workstation; Paradigm Med Ind., Salt Lake City, UT). Radial images of the 4 quadrants and 1 image centered on the anterior chamber were acquired while subjects fixated on ceiling targets using the fellow eye. Five target markers (fluorescent paper 5×5 cm in size) were set up on the ceiling to guide the patients to standardize the measurement of the superior, inferior, nasal, and lateral quadrants (keeping the viewing angle at about 20 degrees and controlling accommodation). Saline solution was used as a coupling agent after the application of topical anesthesia. The probe was orientated perpendicular to the ocular surface. The gain was set between 60 and 80 dB to maximize the view of the imaged structures and minimize "noise." Efforts were made to ensure images provided a clear view of the scleral spur, angle, ciliary body, and a half full chord of the iris.

Ultrasound Biomicroscopy: Qualitative and Quantitative Analysis

The UBM images were transferred to a personal computer for analysis. Self-designed software was used for the image analysis. Ultrasound biomicroscopy images were calibrated as 256×256 pixels and 5×5 mm in size. The software also calculates various parameters using automated identification of the borders of corneal endothelium, anterior and posterior surface of the iris, and anterior surface of the ciliary process (but the user identifies the scleral spur). The automatic identification on the borders of anterior and posterior chamber was based on the similarity of RGB values within these areas. The definitions of the angle opening distance at 250 microns from the scleral spur (AOD250) and the angle opening distance at 500 microns from the scleral spur (AOD500) were identical to Pavlin's. Custom software was used to measure trabecular–ciliary process distance and iris–ciliary process distance (ICPD) using modified methodology measurements related to the intersection of iris and ciliary body with a circle of a specified radius centered on the scleral spur instead of a straight line (Fig 1). This software allows for reproducible, standardized measurement of anterior chamber angle dimensions once the scleral spur is cor-

Table 2. Ultrasound Biomicroscopy Qualitative Characteristics in Eyes that Opened and Remained Closed after Laser Peripheral Ividotomy (LPI)* (Proportions)

	Open after LPI (%) N = 58	**Closed after LPI (%) N = 14**	**P Value†**
Anterior rotation of ciliary body			
Superior	65.5	78.6	0.35
Nasal	55.2	85.7	0.035
Inferior	46.6	71.4	0.095
Temporal	44.8	64.3	0.19
Thick basal iris insertion			
Superior	63.8	92.8	0.034
Nasal	72.4	85.7	0.30
Inferior	63.8	92.8	0.034
Temporal	63.8	78.6	0.29
Anterior iris insertion			
Superior	55.2	71.4	0.27
Nasal	41.4	50.0	0.56
Inferior	55.2	78.6	0.11
Temporal	34.5	42.9	0.56

Anterior insertion of the iris = it is insertion on the base of ciliary process; Anterior rotation of ciliary body = apex of ciliary body facing parallel to the iris plane; thick basal iris = iris at its point of attachment to the wall of the eye thicker than the cornea thickness at the limbus.
Data are presented as proportions.
*UBM data are available in 72 eyes after LPI.
†Chi-square test.

Table 3. Ultrasound Biomicroscopy Mean Angle Opening Distance before and after Laser Peripheral Iridotomy (LPI)*

	Before, Mean (SD)	After, Mean (SD)	Paired Difference, Mean (SD)	% Change	*P* Value†
AOD250					
Superior	0.037 (0.045)	0.058 (0.059)	0.021 (0.007)	+57	0.003
Nasal	0.081 (0.071)	0.106 (0.075)	0.025 (0.068)	+31	0.002
Inferior	0.040 (0.041)	0.057 (0.058)	0.017 (0.062)	+43	0.021
Temporal	0.096 (0.078)	0.122 (0.072)	0.025 (0.075)	+27	0.005
Mean	0.064 (0.052)	0.085 (0.052)	0.021 (0.037)	+33	<0.001
AOD500					
Superior	0.032 (0.040)	0.082 (0.068)	0.050 (0.066)	+156	<0.0001
Nasal	0.086 (0.076)	0.129 (0.079)	0.044 (0.065)	+50	<0.0001
Inferior	0.051 (0.059)	0.086 (0.066)	0.034 (0.067)	+69	<0.0001
Temporal	0.096 (0.062)	0.147 (0.071)	0.051 (0.066)	+53	<0.0001
Mean	0.067 (0.046)	0.111 (0.059)	0.044 (0.042)	+66	<0.0001
Angle recess area‡	0.040 (0.030)	0.070 (0.036)	0.029 (0.025)	+75	<0.0001

AOD250 = angle opening distance at 250 microns from the scleral spur; AOD500 = angle opening distance at 500 microns from the scleral spur; SD = standard deviation.
*UBM data are available in 72 eyes after LPI.
†Angle recess area average for all 4 quadrants.
‡Paired *t* test.

rectly identified, avoiding the need for manual measurement. Detailed methodology is illustrated in Figure 2.

The characteristics of ciliary body and iris in UBM images were also graded using the following definitions: anterior displacement of ciliary body was identified if the apex of ciliary body was parallel to the iris plane or more anterior; the basal iris was graded thick if, at its point of attachment to the wall of the eye, it was thicker than the adjacent limbal corneal thickness; and anterior insertion of the iris was diagnosed if the iris inserted into the base of the ciliary body without apparent synechiae.

Results

Seventy-two of 101 eligible subjects participated in this study; 72% were female and the mean age was 67.1 years. Participants and nonparticipants were similar in terms of age, gender, intraocular pressure, axial anterior chamber depth, and angle width. All the subjects who agreed to participate underwent UBM examination before and 2 weeks after LPI.

Qualitative Assessment

Before LPI, 95% of eyes (68/72) had appositional iridotrabecular contact identifiable on UBM in ≥ 1 quadrant. After LPI, the proportion dropped to 59% (42/72; Table 1). The superior quadrant was most frequently closed both before and after LPI, with more than half (33) of the 63 closed superior angles remaining closed after the procedure. The inferior angle was the second most commonly closed, and opened in a higher proportion of cases (48%, 26/54), whereas nasally 24 of 38 appositionally closed angles (63%) opened after LPI. The temporal angle was closed in 24% before LPI, and remained closed in only 4 persons (5%) after LPI.

Classifying the entire angle as either "open" or "closed" (based on the gonioscopic finding that the posterior, usually pigmented, trabecular meshwork being not visible in ≥3 quadrants using static gonioscopy), 58 eyes were open after LPI and 14 remained closed. Anterior ciliary body position was common in both open- and closed-angle eyes, although the proportion was higher in eyes whose angles remained closed after LPI. The iris adjacent to its point of attachment to the wall of the eye was thicker ("basal iris thickness") at baseline in eyes that remained closed after LPI: The proportion with an anterior insertion of the iris was also higher in eyes that remained closed after LPI (Table 2).

Quantitative Assessment

The mean values for AOD250, AOD 500, and angle recess area all increased significantly after LPI (Table 3), with the greatest increases seen in the superior quadrant. The mean AOD250 increased by 30% to 57% depending on the quadrant (superior had the greatest change). The AOD500 revealed even greater changes, increasing 156% in the superior quadrant, 50% nasally, and 60% temporally and inferiorly. The findings in ARA 750 were similar

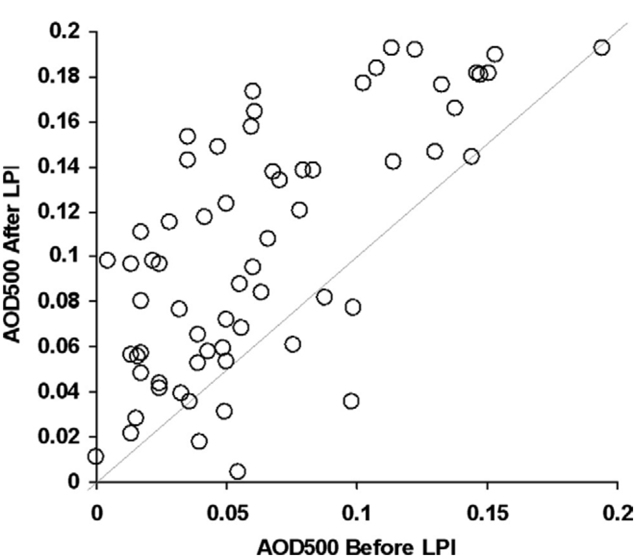

Figure 3. Anterior opening distance (AOD500) before (x-axis) and after (y-axis) laser peripheral iridotomy (LPI).

Table 4. Ultrasound Biomicroscopy Quantitative Findings Related to the Ciliary Body and the Iris Before and After Laser Peripheral Iridotomy*

	Before, Mean (SD)	After, Mean (SD)	Paired Difference, Mean (SD)	*P* Value†
TCPD	0.537 (0.060)	0.561 (0.060)	0.024 (0.046)	0.0001
ICPD	0.120 (0.063)	0.081 (0.034)	−0.039 (0.054)	<0.0001
SS-IR	0.105 (0.074)	0.118 (0.070)	0.013 (0.046)	0.017
IT 750	0.440 (0.047)	0.459 (0.102)	0.020 (0.012)	0.094
IT 1000	0.471 (0.054)	0.488 (0.006)	0.017 (0.034)	0.0001
Curvature				
Superior	4.80 (1.62)	13.72 (18.68)	8.92 (10.32)	0.0001
Nasal	4.79 (1.66)	12.54 (9.63)	7.75 (8.25)	<0.0001
Inferior	5.40 (2.10)	16.08 (11.80)	10.67 (11.96)	<0.0001
Temporal	5.02 (1.58)	10.87 (14.84)	5.84 (14.85)	0.0014
Mean	5.02 (1.26)	13.31 (7.71)	8.29 (7.59)	<0.0001

ICPD = iris ciliary process distance; IT = iris thickness at 750 and 1000 microns from the iris insertion; SD = standard deviation; SS-IR = scleral spur and iris root distance; TCPD = trabecular–ciliary process distance.
*UBM data are available in 72 eyes after laser peripheral iridotomy.
†Paired *t* test.

to those seen in AOD, with a 75% increase in the mean of all 4 quadrants.

Using the mean values from all 4 quadrants (available for 72 subjects), 53 (74.0%) eyes had an increase in the AOD250, with 19 eyes (26.0%) being unchanged or reduced after LPI. These proportions for the AOD500 were 88%, increasing and 12% unchanged or decreasing. Eyes with AOD500 > 0.1 mm at baseline all demonstrated increases in AOD500 after LPI. Eyes with more crowded angles (i.e., short AOD500) were less likely to open (Fig 3).

The radius of curvature of the posterior surface of the iris increased from 5.02 mm (before) to 13.31 mm (after), suggesting the trans-iris pressure gradient was reduced after LPI (Table 4). This flattening of iris was found in all 4 quadrants ($P<0.0001$). The distance between the back of the iris and the ciliary body (ICPD) decreased after LPI, a finding that also may be attributed to flattening of the peripheral iris (moving it closer to the ciliary body). Further supporting this is the finding that iris thickness at both 750 and 1000 microns from the scleral spur increased after LPI, suggesting that when pupil block is eliminated, the iris both flattens and increases in thickness. The distance between trabecular meshwork and ciliary body (trabecular–ciliary process distance) also increased significantly, from 0.537 to 0.561 mm ($P<0.0001$), suggesting that the ciliary body also moved backward after LPI.

Several biometric trends were identified in eyes in which angles remained closed on gonioscopy after LPI (pigmented trabecular meshwork not visible in ≥3 quadrants). These eyes tended to have shallower AOD both at 250 (0.049 vs. 0.071 mm; $P = 0.09$) and 500 microns (0.052 vs. 0.108 mm; $P = 0.001$) before LPI (Table 5), compared with those that did open after LPI. Furthermore, the iris insertion tended to be more anterior (the distance from iris insertion to scleral spur was one-third closer to the scleral spur) in angles that remained closed, although this finding was not statistically significant ($P = 0.06$; Fig 4). The iris was thicker at both 500 and 1000 microns from the scleral spur, but this difference was only statistically significant at 1000 microns (0.447 mm for those who remained closed vs. 0.415 mm for those who opened; $P = 0.041$). The distance between the scleral spur and the ciliary body was less at baseline in the eyes that did not open after LPI (0.514 vs. 0.562 mm; $P = 0.03$). However, the distance between the back of the iris and the ciliary body was not significantly different in these 2 groups (ICPD 0.075 vs. 0.078 mm; $P = 0.781$).

Discussion

Laser peripheral iridotomy leads to significant changes in the anterior segment anatomy of people with narrow drainage angles identified by gonioscopy, with clear widening of the chamber angle. The angle recess area was found to increase by 75% in this study, which is consistent with the findings from contralateral eyes of Chinese and European patients suffering symptomatic angle closure.[4,5] We documented that the narrowest angle on UBM at baseline was the superior quadrant, and it had the greatest proportionate amount of angle opening after LPI of the 4 quadrants (although the absolute amount of angle opening was similar across all angles). Patients are supine during UBM imaging; thus, gravity should not play a role in determining which quadrants appear most closed, indicating that the superior angle is likely the narrowest of the 4 and that this is not an artifact. It is likely that the higher

Table 5. Ultrasound Biomicroscopy Characteristics in Eyes with ≥ 270 Degrees of Appositional Closure After Laser Peripheral Iridotomy (LPI)* Compared with those Open after LPI

	Open after LPI (N = 58), Mean (SD)	Closed after LPI (N = 14), Mean (SD)	*P* Value†
AOD250 (mm)	0.071 (0.042)	0.049 (0.052)	0.099
AOD500 (mm)	0.108 (0.057)	0.052 (0.038)	0.001
Iris inse to SS (mm)	0.125 (0.069)	0.085 (0.069)	0.061
Angle recess area (mm)	0.076 (0.035)	0.042 (0.029)	0.002
Iris thickness 750	0.376 (0.045)	0.399 (0.043)	0.095
Iris thickness 1000	0.415 (0.052)	0.447 (0.035)	0.041
TCPD500	0.562 (0.068)	0.514 (0.046)	0.033
ICPD500	0.078 (0.032)	0.075 (0.035)	0.78

AOD250 = angle opening distance at 250 microns from the scleral spur; AOD500 = angle opening distance at 500 microns from the scleral spur; ICPD = iris ciliary process distance; SD = standard deviation; SS = scleral spur; TCPD = trabecular-ciliary process distance.
*UBM data are available in 72 eyes after LPI.

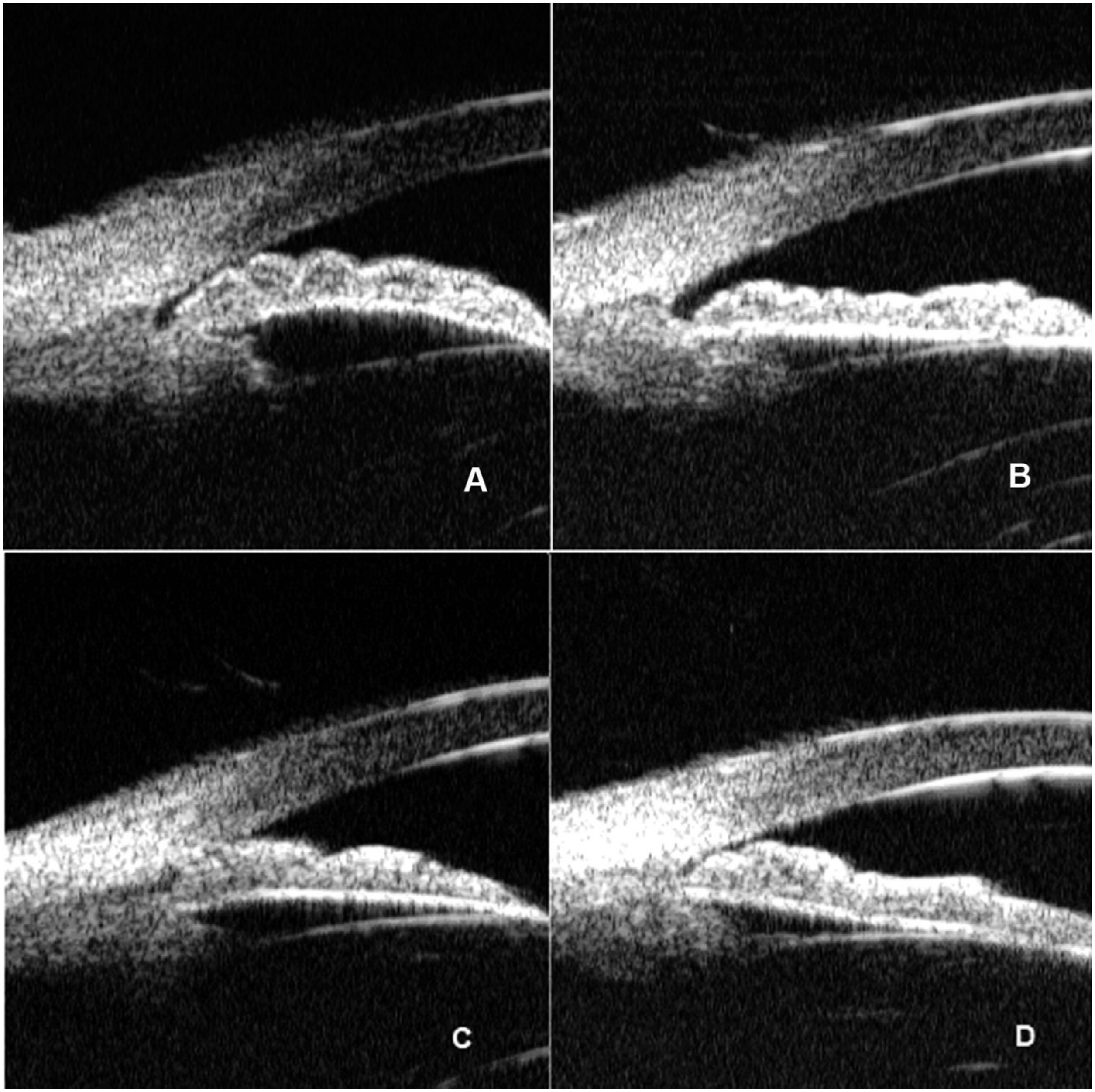

Figure 4. Ultrasound biomicroscopy montages showing characteristics of eyes with an angle that opened and remained close after laser peripheral iridotomy (LPI) determined by the location of iris insertion. **A**, Before LPI. **B**, After LPI. Changes after LPI when the iris inserts into the middle of the ciliary process. **C, D**, Change when the iris insertion is anteriorly located. The ciliary processes are horizontally orientated, with a relatively thick iris in both eyes.

proportionate widening in the superior angle is due to an overall posterior displacement of the iris after LPI, which yields a fixed amount of widening of each of the 4 quadrants. Because the superior angle is the narrowest to begin with, this degree of posterior movement yields a high proportionate increase in angle width.

An important, unique finding of this study is the posterior movement of the ciliary body after LPI. This may occur as tension on the lens–iris diaphragm is relaxed due to eradication of relative pupil block, allowing the entire diaphragm to subside slightly. This may, in part, explain why, even in persons with anteriorly positioned or plateaulike iris configurations, the angle still opened somewhat after iridotomy. Flattening of the iris contour after LPI (as reported previously)[4–6] was found to be nearly universal in the study population, as was an increase iris thickness, presumably due to relief of stretch forces placed on the iris by relative pupillary block causing an increased pressure in the posterior chamber.

Among our study cohort, about 60% of the eyes still had some appositional closure on UBM (in at least 1 quadrant) after LPI, although this proportion was 95% before LPI. Gazzard et al[4] reported that in the contralateral eyes of subjects who experienced symptomatic angle closure, 11 (20%) of 54 eyes ≥1 quadrant that remained fully closed (defined as ARA

= 0) after LPI. Using the same criteria, 10 of 72 eyes (13%) remained closed in ≥1 quadrant after LPI (as opposed to 43% before the procedure) in our subjects. This emphasizes the consistency of the findings with previous reports, and highlights the problems inherent in defining angle closure using UBM criteria. A UBM study in Indian eyes with primary angle-closure glaucoma, reported that 60% of eyes (with patent iridotomies) persisted in being narrow, although the definition of "narrow" in that study was arbitrarily selected as AOD ≤ 130 microns, based on AOD distribution.[19] The same authors also reported that anteriorly rotated ciliary processes were common, occurring both in eyes that opened after LPI (40.9%) and those that remained closed (66.6%). This is consistent with the findings of the present study, suggesting that this so-called plateau configuration may be seen in what has traditionally been called PAC. Certainly, the simultaneous presence of an anterior iris insertion with an anteriorly rotated ciliary process predisposes to closure. Prospective studies will help to determine which characteristics on UBM are predictive of clinical outcomes, and this will help to define the standards that should be used.

In summary, substantial changes in anterior segment configuration occur in response to LPI in eyes with narrow angles before the onset of pathologic angle closure. Although nearly 20% retain iridotrabecular contact in ≥3 quadrants and about 60% have ≥1 quadrant of appositional angle closure, there was a significant increase in UBM biometric indices of angle width after LPI. Factors associated with residual angle closure include an anteriorly positioned ciliary body, a thick iris, and a greater degree of closure on UBM at baseline. Further follow-up is needed to determine whether eyes with residual closure have a different outcome from those whose angles become open after LPI.

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