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Ultrasound Biomicroscopic Changes after Laser Iridotomy or Trabeculectomy in Angle-closure Glaucoma

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This study was performed to demonstrate the ultrasound, biomicroscopic and dimensional changes of angle structure after laser iridotomy (LI) and primary trabeculectomy (PT) in primary angle-closure glaucoma (PACG). Angle-opening distance at a point 500(m from the scleral spur (AOD500), trabecular-iris angle (Θ_1), trabecular ciliary process distance (TCPD), ciliary process-iris angle (CPI), iris thickness (ID1, ID3), length of iris-lens contact distance (ILCD) and anterior chamber depth (ACD) were assessed before and after each procedure. Thirteen patients with LI and 16 with PT were prospectively enrolled. There were statistically significant increases in AOD500, Θ_1, and ILCD in both groups. CPI was decreased in both groups. ACD, TCPD, and iris thickness were not changed significantly. The changes in angle configuration after LI or PT may result more from alterations in aqueous pressure gradients across the iris and the changes of configuration were greater in the iris roots without rotation of ciliary body. However, we didn't find any significant differences in the changes of parameters between the two procedures.

Key words: angle closure glaucoma, angle structure, laser iridotomy, trabeculectomy, ultrasound biomicroscopy

INTRODUCTION

Compared with normal eyes, eyes with primary angle-closure glaucoma (PACG) show an increased lens thickness and a more anteriorly situated lens, the latter of which may be associated with anteriorly situated ciliary process.[1-4] Relative pupillary block and iris crowding are involved in the development of angle closure in PACG. Ultrasound biomicroscopy (UBM) is usually able to determine the mechanism of elevated intraocular pressure (IOP) by showing the relationship between the peripheral iris and the trabecular meshwork. In our previous study of PACG by UBM, we demonstrated that there are two types of appositional angle-closure glaucoma (ACG) (types B and S) and showed the forward rotation of the ciliary process without changing the ciliary process-iris angle (CPI).[1]

As for the release of pupillary block of the eye or preventing the fellow eye from an acute glaucomatous attack, laser iridotomy (LI) can be tried. LI relieves the pupillary block and opens the angle of the anterior chamber. For the eyes of uncontrolled IOP by glaucoma medications and LI, we performed primary trabeculectomy (PT) or trabeculectomy combined with cataract surgery. Until now, many studies have reported on the configuration of the anterior segment after peripheral LI, but there have

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been few studies comparing quantitative changes on the anterior segment after LI and PT. So we tried to demonstrate the relative change of angle with the relationship of the peripheral iris to the lens and ciliary process after the release of pupillary block to further our understanding of the dynamics of angle-closure attack.

MATERIALS AND METHODS

We prospectively studied patients with acute PACG; the patients had no previous treatment with laser or incisional surgery. Patients of secondary ACG due to lens abnormalities, retinal surgery, or other causes were excluded. We classified the patients into the LI and PT groups. In the LI group, LI was only performed. In the PT group, PT was performed when IOP was uncontrolled by glaucoma medications and LI.

Indentation gonioscopy, UBM and IOP measurement were done. Topical instillation of 4% pilocarpine, beta-blockers, and carbonic anhydrase inhibitors were done before examination. The measurements were made at the time of arrival, and 2 weeks and 2 months after LI or PT.

The parameters of the UBM (Model 840, Zeiss-Humphrey Instruments Inc., San Leandro, California, USA) were set to 80 dB gains, 5 dB gains compensation with approximately 50 μm resolution. Each patient was examined in a supine position with illuminated conditions. We scanned 4 positions of the angle; at 3,6,9 and 12 o'clock positions. All measurements were made in the temporal meridian, through a typical ciliary process, and as vertically as possible, as determined by observing the screen image. The scleral spur is particularly useful as a constant reference point for measurement of the angle region. The details of the ocular measurements by UBM have been described in our previous study.[1] Angle-opening distance at a point 500 μm from the scleral spur (AOD500), trabecular-iris angle (Θ_1), trabecular ciliary process distance (TCPD), CPI, iris thickness (ID1, ID3), length of iris-lens contact distance (ILCD), and anterior chamber depth (ACD) were assessed before and after each procedure (Fig. 1).

Mann-Whitney *U* test was used to compare each parameter before and after each procedure, and to compare each parameter between the two procedure groups.

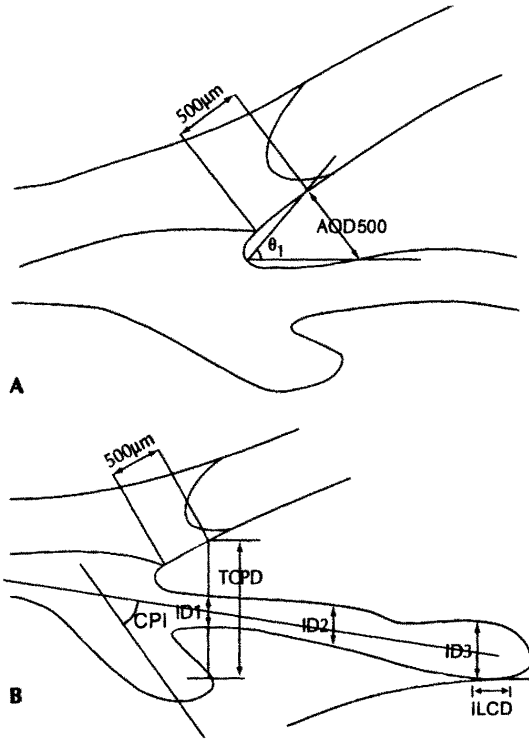

Fig. 1. Ultrasound biomicroscopic measurement positions displayed on a diagrammatic representation of the anterior segment of the eye. (A) Angle-opening distance (AOD 500) was measured on the line perpendicular to the trabecular meshwork at a point 500 μm from the scleral spur. The trabecular-iris angle (Θ_1) was measured with the apex in the iris recess and the arms of the angle passing through a point on the trabecular meshwork 500 μm from the scleral spur and through the point on the iris perpendicularly opposite. (B) Trabecular ciliary process distance (TCPD) was measured on the line extending from a point 500 μm from the scleral spur perpendicularly through the iris to the ciliary process. Iris thickness was measured 1mm from the iris root (ID1) and at its thickest point near the margins (ID3). Ciliary process-iris angle (CPI) and length of iris-lens contact distance (ILCD) are also indicated.

RESULTS

Thirteen patients with LI (mean age: 60.30 ± 8.17 years) and 16 with PT (mean age: 65.83 ± 5.91

Table 1. Patients demographics

	Angle-closure glaucoma patients	
	Laser iridotomy group	Trabeculectomy group
Gender (male/female, No. of patient)	2/11	3/13
Age (years)		
Mean ± SD	60.30 ± 8.17	65.83 ± 5.91
(Range)	(47-70)	(59-74)

Table 2. Mean preoperative and postoperative intraocular pressures(mmHg) in the laser iridotomy and trabeculectomy groups.

	Laser iridotomy group	Trabeculectomy group
Preoperative	42.1 ± 15.9	43.7 ± 15.6
Postoperative		
2 weeks	14.8 ± 2.2	19.0 ± 2.4
2 months	15.2 ± 2.0	14.5 ± 3.2

years) were prospectively enrolled (Table 1). Mean preoperative IOP was 42.2 ± 15.9 mmHg and 43.7 ± 15.6 mmHg, and mean postoperative IOP was 15.2 ± 2.0 mmHg and 15.5 ± 3.2 mmHg in the LI and PT groups, respectively (Table 2). There was no significant difference in IOP between the two groups.

There were statistically significant increases in AOD500 and Θ_1 in both groups after each procedure: preoperative AOD500 was 69.46 ± 25.39 μm and 79.66 ± 31.12 μm, and postoperative AOD500 was 187.15 ± 13.30 μm and 230.00 ± 67.82 μm; preoperative Θ_1 was 11.92 ± 3.40° and 9.33 ± 3.88°, and postoperative Θ_1 was 27.31 ± 5.23° and 25.30 ± 2.07° in LI and PT, respectively.

ACD and TPCD were slightly increased, but there was no statistical significance: preoperative ACD was 1917.61 ± 281.73 μm and 2036.66 ± 406.23 μm , and postoperative ACD was 2050.00 ± 251.46 μm and 2186.66 ± 416.15 μm; preoperative TCPD was 800.23 ± 106.52 μm and 912.50 ± 127.03 μm, and postoperative TCPD was 872.54 ± 105.98 μm and 1007.83 ± 140.02 μm in LI and PT, respectively.

CPI was decreased from 26.15 ± 7.89 to 4.39 ± 1.22° in LI, and from 24.17 ± 7.76 to 11.17 ± 6.91° in PT.

ILCD was increased significantly from 605.38 ± 100.38 to 1053.85 ± 106.34 μm in LI and from 588.33 ± 67.06 to 980.00 ± 128.99 μm in PT.

Iris thickness (ID1 and ID3) was not changed after either procedure (Table 3, 4).

There were no significant differences in parameters before and after both procedures except postoperative CPI (P = 0.019).

DISCUSSION

In our previous study of ACG compared with normal patients with open-angle using UBM, most cases of ACG were characterized by forward rotation of ciliary process. Also, we assumed that the fragility of the iris root and the location of the iris insertion are the most important parameters to describe the mechanisms of appositional angle closure.[1] In eyes with acute attack, a forward movement of the lens contributes to the initiation of the attack, causing greater iris convexity. So, the attacks result from small anatomic dimensions and an additional physiological event that causes anterior lens movements.

Salmon et al[5], studying 46 patients, all with chronic ACG, found that the lenses were the same thickness as in normal subjects, that a relatively anterior lens position, rather than a large lens, was

Table 3. Mean preoperative and postoperative ultrasound biomicroscopy (UBM) parameters in the laser iridotomy group

UBM parameter	Preoperative	Postoperative	P value
AOD*500(μm)	69.46 ± 25.39	187.15 ± 13.30	.000
θ_1†(°)	11.92 ± 3.40	27.31 ± 5.23	.000
ACD‡(μm)	1917.61 ± 281.73	2050.00 ± 251.46	.100
TPCD§(μm)	800.23 ± 106.52	872.54 ± 105.98	.081
CPI‖(°)	26.15 ± 7.89	4.39 ± 1.22	.005
ILCD#(μm)	605.38 ± 100.38	1053.85 ± 106.34	.000
ID※1(μm)	545.38 ± 108.68	505.38 ± 104.61	.237
ID※(μm)	620.77 ± 108.28	569.23 ± 89.58	.190

**: Angle-opening distance at a point 500(m from the scleral spur, †: Trabecular-iris angle, ‡: Anterior chamber depth, §: Trabecular ciliary process distance, ‖: Ciliary process-iris angle, #: Length of iris-lens contact distance, ※: Iris thickness*

Table 4. Mean preoperative and postoperative ultrasound biomicroscopy (UBM) parameters in the trabeculectomy group

UBM parameter	Preoperative	Postoperative	P value
AOD*500(μm)	79.66 ± 31.12	230.00 ± 67.82	.004
θ_1†(°)	9.33 ± 3.88	25.30 ± 2.07	.004
ACD‡(μm)	2036.66 ± 406.23	2186.66 ± 416.15	.229
TPCD§(μm)	912.50 ± 127.03	1007.83 ± 140.02	.109
CPI‖(°)	24.17 ± 7.76	11.17 ± 6.91	.020
ILCD#(μm)	588.33 ± 67.06	980.00 ± 128.99	.004
ID※(μm)	581.67 ± 109.26	531.67 ± 85.42	.335
ID※(μm)	648.33 ± 95.17	598.48 ± 96.3	.199

**: Angle-opening distance at a point 500(m from the scleral spur, †: Trabecular-iris angle, ‡: Anterior chamber depth, §: Trabecular ciliary process distance, ‖: Ciliary process-iris angle, #: Length of iris-lens contact distance, ※: Iris thickness*

responsible for the crowded anterior segment in the chronic ACG patients and that a more anteriorly situated ciliary process might be a racial characteristic of the ethnic group studied.

However, pupillary block is the predominant mechanism of PACG. LI or PT with peripheral LI may deepen the anterior chamber by releasing the pupillary block. The effect of LI is to eliminate the posterior-anterior pressure difference across the iris.[6,7] An opening of the iris effectively carries aqueous flow without significant resistance. The typical flat peripheral configuration of the iris without a pressure difference is assumed by gonioscopy, photograph, or ultrasound imaging. The angle was opened after releasing the pupillary block, which was evidenced by an angle open distance at 500 μm (AOD500) and Θ_1 increased.

However, in our study, central ACD was not increased significantly after LI or PT. The central ACD has not been known to change acutely with LI in primary angle closure eyes.[8-13]

Elimination of the trans-iris pressure differential might alter the lens position slightly. However, ultrasound studies demonstrated that the lens did not move posteriorly after LI or PT.[7,13] Furthermore, there were some cases that the IOP still remained high with anteriorly positioned lens after both procedures. So, we can imagine some factors that might induce the lens to move forward still remained or could not be corrected by LI or PT. This means that the potential risk of attack still remains after both procedures. Previous studies that measured central

ACD before and after LI found no significant deepening.[6] While some studies were confounded by the use of miotic eyedrops, the prevailing conclusion was that the lens did not move posteriorly after LI.[14] The tendency for the lens to move anteriorly in acute attacks, and potentially in the chronic form of the disease as well, may be derived from expansion of the choroids, which might be contributing factors in malignant glaucoma.[13] However, the position of the lens is one of the important factors in the ACG mechanism. One part of the evidence of lens factor is that cataract extraction lowers IOP by improving the angle configurations in ACG.[15-19]

In our study, TCPD was slightly increased after LI or PT. CPI was decreased after both procedures. We could speculate that the iris was pushed back and the angle opened after releasing the pupillary block but the anteriorly displaced ciliary process did not move back.

TCPD, as well as the iris thickness (ID1), is measured on the UBM at a point 500 μm from the scleral spur. TCPD constitutes the gap available for the iris between the trabecular meshwork and the ciliary process. An anteriorly placed ciliary process or a thick iris can reduce the peripheral ACD making it occludable. In our previous study, TCPD were seen to present a continuum, with the highest values in the normal eyes, and the lowest values in the narrow form of ACG.[1]

Iris thickness, the other parameter that contributes to AOD, was not significantly different before and after either procedure. In our previous study, iris thickness was not significantly different between the normal and angle-closure groups. Caronia et al[6] showed that flattening of the iris after LI for pupillary block increases iris-lens contact. Also, in our study, ILCD significantly increased after both procedures.

Although we did not check the iris thickness according to iris insertion type of the angle-closure group because of the small number of subjects in the study group, the fragility of the iris root and the location of the iris insertion may be two of the important parameters to describe the mechanisms of appositional angle closure. So, it can be possible that the different changes of AOD may occur according to the type of iris insertion after LI or PT. Also, the efficacy of the IOP reduction by both procedures may depend upon the type of iris insertion and the fragility of iris root, not on the iris thickness.

We compared all the parameters between the LI and PT groups. There were no significant differences in the parameters before and after either procedure except for postoperative CPI (P= 0.019), indicating that the degree of iris moving back was less in the PT group than in the LI group. However, we did not check CPI according to the type of iris insertion or iris thickness that could affect CPI measurement, and further study will be needed to determine the meaning of CPI measurement in both procedures.

In this study, we demonstrated the changes of the UBM parameters after LI and PT, and these changes were similar after both procedures except CPI; the lens position and ciliary body were not significantly moved back, AOD was increased, and CPI was decreased after both procedures. It was evident that both the LI and PT procedures could improve the pressure gradient between the anterior and posterior chambers, but couldn't improve the lens and ciliary body positions. This means that the potential risk of attack still remains unless the lens position is normalized. Further study is needed into the efficacy of IOP control according to the iris insertion type and the role of the lens extraction for ACG.

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