Anterior Chamber Morphology Changes Before and After Laser Peripheral Iridotomy in Eyes with Primary Angle Closure Using Ultrasound Biomicroscopy

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Abstract

Purpose: To study the changes in anterior chamber parameters before and after laser peripheral iridotomy (LPI) in primary angle closure (PAC) using ultrasound biomicroscopy (UBM).

Design: Prospective interventional case series.

Methods: Forty eyes of 40 patients with PAC underwent detailed ophthalmic evaluation including applanation tonometry, gonioscopy, optic disc evaluation with +78D lens and achromatic automated perimetry. UBM was performed to evaluate angle parameters before and after LPI to study the trabecular-iris angle (TIA), the angle-opening distance at 500 mm (AOD) and the central anterior chamber depth (ACD), iris convexity and thickness.

Results: Before and after LPI the mean superior TIA changed from 19.5±5.840 to 28.82±6.710 (p<0.0001) and inferior TIA changed from 21.18±6.030 to 28.68 ± 7.100 (p<0.0001) and central ACD changed from1.24±0.25 mm to 1.44 ±0.21mm (p=-0.0001).

Conclusion: LPI in eyes with PAC results in significant changes in angle, iris and anterior segment morphology and unlike gonioscopy these can be objectively documented with UBM.

Introduction

The estimated burden of glaucoma is escalating every decade. It is estimated that by this year 2010, 60.5 million people world-wide would have glaucoma and that by 2020, there would be 79.6million sufferers.1 Angle closure regarded as much less common than primary open-angle glaucoma, comprises approximately 10% of glaucoma in the West. In population studies a generation ago, narrow angles were found in approximately 2% of whites, whereas the frequency of acute angle-closure glaucoma in whites was somewhat less than 0.1%. Recent epidemiologic studies have borne out that angle closure is almost as common as or more common than open-angle glaucoma in South and East Asia. Most patients have asymptomatic chronic angle closure, and bilateral blindness in China from angle-closure glaucoma exceeds that from open-angle glaucoma.3,4

The situation in India is somewhat similar. Approximately, 12 million people in the nation are affected and 12.8% of blindness is due to glaucoma. In Asian eyes, the majority of the closures arise from a combination of a pupil block and nonpupil blocking mechanisms. Primary angle closure suspect (occludable angle), primary angle closure (PAC) and PACG are now distinct entities reflecting the severity of the disease.

More than 80% of the chronic angle closures have no significant symptoms. Few landmark studies conducted in India, The Aravind comprehensive eye survey reported a prevalence of 0.5% for PACG (95% CI 0.3 - 0.7). The Chennai Rural and Urban Glaucoma Study concluded overall prevalence of primary angle closures to be 0.8% Prevalences of PACS was 6-7%. Prevalences of PACG and PACS were similar in the rural and urban populations; PAC was more common in the urban population. In both groups, the disease was asymptomatic.5,6 Angle closure is an anatomic disorder, with an open angle as the easily visible end point of therapy. Laser peripheral iridotomy (LPI) achieves this end point and is a proven prophylactic treatment for the prevention of symptomatic angle closure. 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. 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. 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. Ultrasound biomicroscopy (UBM) is a reproducible approach to measuring anterior chamber angle anatomy and allows quantitative analyses of angle relationships.7 Ultrasound biomicroscopy examination is able to demonstrate angle changes after LPI in contralateral eyes of persons suffering symptomatic angle closure, and is able to measure relatively small changes in response to other stimuli.8,9 If one could study the anterior segment morphology before and after the laser peripheral iridotomy procedure, it would possibly throw light onto the different mechanisms that lead to this sight threatening condition.

Aim of the Study

To study the changes in anterior chamber parameters before and after laser peripheral iridotomy (LPI) in primary angle closure (PAC) using ultrasound biomicroscopy (UBM).

Materials

A total of 40 eyes of forty patients with Primary Angle Closure were prospectively enrolled. Detailed ophthalmic examination including slit lamp examination, Goldmann Applanation tonometry and gonioscopy was done. Slit lamp gonioscopy was carried out using a Goldmann-type 2-mirror.
lens 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 Sussman’s 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. In this classification system, peripheral anterior synechiae is a defining feature of PAC. Hence, all subjects recruited in this study had gonioscopically verified synechial or appositional angle closure. Participants in whom 270° or more of the posterior (usually pigmented) trabecular meshwork was not visible during static gonioscopy were eligible for this study. All patients with established PAC (with evidence of previous acute episode or established peripheral anterior synechiae) were included. Those with PACG (with established glaucomatous optic neuropathy) were excluded. The definition was based on the International Society of Geographical and Epidemiological Ophthalmology classification system.13This report describes cases of primary angle closure, signifying contact between the iris and trabecular meshwork occurring without significant influence of any other pathologic or iatrogenic process. Patients with sudden change in size or position of the lens were excluded, as were patients whose disease was precipitated by aqueous misdirection. 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.

Laser peripheral iridotomy was performed using yttrium–aluminum–garnet laser technique in 1 randomly selected eye by the same ophthalmologist. 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. The baseline IOP, number of laser applications, and energy settings were recorded. All individuals undergoing LPI were discharged an hour after the treatment. Patients were given oral carbonic anhydrase inhibitor and/or 0.5% timolol after ruling out contraindications to antiglaucoma drugs. If no further rise was seen in the second hour, the patients were discharged. All patients were given 1% dexamethasone drops to apply 6 times daily for 1 week and tapered and stopped thereafter. Pilocarpine was not used after the treatment. The intraocular pressures were monitored at timely intervals. At least 6 weeks after LPI, the patients were asked to return for a postoperative examination. These examinations included: visual acuity, IOP, gonioscopy, optical pachymetry, and ultrasound biomicroscopy (UBM). Both slit lamp and UBM evaluations were used to confirm patency of the iridotomy.

**Ultrasound Biomicroscopy Examination**

Ultrasound biomicroscopy examination was performed before and at least 6 weeks after LPI by the same ophthalmologist. All UBM examination was conducted in the same room light conditions. Radial images of the 2 quadrants—superior (12-o’clock) and inferior (6-o’clock) angle as shown in Figure 1 and a horizontal image centred on the anterior chamber for depth measurements (Figure 2) were acquired while subjects fixated on ceiling using the fellow eye. 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. The UBM images were transferred to a personal computer for analysis. The definitions of the angle opening distance at 500 microns from the scleral spur (AOD500) were identical to Pavlin’s. The trabecular –ciliary process distance was measured on a line extending from the corneal endothelium at 500 µ m from the sclera spur perpendicularly through the iris, to the ciliary process. The measurements made using the callipers provided by the machine before and after iridotomy included: iris curvature displacement or iris convexity, 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. This was done using callipers provided on the machine. Figure 3 shows the perpendicular line drawn from the posterior surface of the iris which measures the iris convexity before and after iridotomy. The iris thickness was measured at three points specified at the superior 12-o’clock position (Figure 4): at the root of the iris (ID1) along the line of trabecular ciliary process distance, ID 2 is the iris thickness at 2 mm from the iris root; ID 3 is the maximum iris thickness near

![Figure 3: Iris convexity Before and after LPI](image-url)

**Table 1 Average intraocular pressure measurements before and after laser iridotomy and central corneal thickness and cup disc ratios of the optic nerve head.**

<table>
<thead>
<tr>
<th></th>
<th>Before LPI</th>
<th>After LPI</th>
<th>P-value</th>
</tr>
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<tbody>
<tr>
<td>IOP (mm of Hg)</td>
<td>22.68±12.85</td>
<td>16.95± 6.55</td>
<td>0.014</td>
</tr>
<tr>
<td>CCT</td>
<td>-</td>
<td>521.71±87.04</td>
<td>-</td>
</tr>
<tr>
<td>CDR</td>
<td>-</td>
<td>0.52± 0.19</td>
<td>-</td>
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**Statistical Analysis:** Measurements were tabulated and SPSS version 11 was used for statistical calculations. The Student T-test was used to make two tailed paired sample comparisons. A p-value of <0.05 was considered statistically significant.

**Results:** A total of 48 persons with occludable angles in both eyes were considered to be eligible for the study and were offered laser iridotomy. Forty patients (23 right eyes, 17 left eyes) were recruited for the study, the rest were excluded due to inadequate follow up. The average age of participants was 57.2 (Range 40-76) years. There were 22 males and 18 female participants. By definition, there were 32 primary angle closure suspects without synaechia and 8 primary angle closure patients. The iridotomy was patent in all but 3 eyes after a single treatment session. The size of the iridotomy was approximately 0.2 to 0.3 mm in all patients. In the 3 patients in whom the iridotomy was not fully patent at the initial follow-up examination, a repeat laser successfully created an iridotomy, and data were collected 2 weeks after the repeat procedure. The mean IOP of the enrolled participants before LPI treatment was slightly lower than for the larger population studied, but this difference was not statistically significant. After LPI, the IOP decreased by an average of 5.725 mmHg (P<0.014, paired t test) in treated eyes at 6 weeks (Table 1).
The anterior segment morphology changes following iridotomy were studied using ultrasound biomicroscopy and findings are tabulated in Table 2.

### Table 2 Anterior segment morphology changes before and after laser peripheral iridotomy.

<table>
<thead>
<tr>
<th></th>
<th>Before LPI</th>
<th>After LPI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Angle</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior</td>
<td>19.5 ± 5.84</td>
<td>28.82 ± 6.71</td>
<td>P&lt;0.0001</td>
</tr>
<tr>
<td>Inferior</td>
<td>21.18 ± 6.03</td>
<td>28.68 ± 7.01</td>
<td>P&lt;0.0001</td>
</tr>
<tr>
<td><strong>ACD</strong></td>
<td>1.24 ± 0.25</td>
<td>1.44 ± 0.21</td>
<td>P&lt;0.0001</td>
</tr>
<tr>
<td><strong>Iris Convexity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior</td>
<td>0.33 ± 0.144</td>
<td>0.05 ± 0.07</td>
<td>P&lt;0.0001</td>
</tr>
<tr>
<td>Inferior</td>
<td>0.31 ± 0.125</td>
<td>0.05 ± 0.07</td>
<td>P&lt;0.0001</td>
</tr>
<tr>
<td><strong>Iris Thickness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ID1</td>
<td>0.3 ± 0.09</td>
<td>0.32 ± 0.1</td>
<td>P=0.37</td>
</tr>
<tr>
<td>ID2</td>
<td>0.3 ± 0.1</td>
<td>0.43 ± 0.11</td>
<td>P=0.07</td>
</tr>
<tr>
<td>ID3</td>
<td>0.6 ± 0.15</td>
<td>0.6 ± 0.13</td>
<td>P=0.29</td>
</tr>
</tbody>
</table>

Thus, the angle opening distance after iridotomy at the superior and inferior area were 21.18 ± 6.03 and 28.68 ± 7.01 respectively and more than that measured before iridotomy (p<0.0001). The central anterior chamber depth changed to 1.44 ± 0.21 significant increase following procedure. More importantly, the change in the curvature of the iris could be documented and both superior and inferior bowing of iris was lost in most cases except one in which it remained the same. This patient had significant synaechia on gonioscopy. The iris thickness measurements at the two sites did not differ following procedure (Table 2).

### Discussion

Laser peripheral iridotomy is the standard first-line intervention for acute and chronic angle closure. It is proven to reduce intraocular pressure in the affected eyes (Table 1). It prevents recurrence of acute episodes and eliminates the risk of acute attacks in fellow eyes. By allowing aqueous to flow directly through the iridotomy site, LPI equilibrates the pressure between the anterior and posterior chambers. Eliminating this pressure gradient flattens the iris, allowing the peripheral iris to fall backward, resulting in a wider angle configuration. 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. UBM helps to quantitatively document these findings. The superior and inferior quadrant angle were measured as these have shown to be more affected in light and dark conditions with UBM studies and also for comparison to gonioscopic findings. Both areas showed a statistical increase in the angle in the current study. Liwan et al. studied similar patients with PACS and PAC and found similar result on a Chinese population. The angle measurements of Liwan et al differ possibly due to difference in the machine and measuring callipers. Dada et al. studied angle parameters and found it to widen significantly, though angle measurements were less than the current study. Kaushik et al compared UBM and gonioscopic findings and angle measurements were comparable to the current study population. Liwan et al in his study did not find the central ACD to change. However, Dada and Gazzard et al found the ACD to increase similar to current study. Flattening of the iris contour after LPI was found to be nearly universal in this study population, presumably due to relief of stretch forces placed on the iris by relative pupillary block causing an increased pressure in the posterior chamber. However, iris thickness failed to show a difference after iridotomy unlike that in Gazzard’s study.

### Conclusion

Substantial changes in anterior segment morphology occurs in response to LPI in eyes with primary angle closure and
Unlike gonioscopy, these can be objectively documented with UBM. Prospective studies will help to determine which characteristics on UBM are predictive of clinical outcomes, and this may help to define the standards that should be used.

References