Ultrasound Biomicroscopic Evaluation of Changes in Anterior Segment Morphology After Nd:YAG Laser Iridotomy in Primary Angle Closure Glaucoma

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ABSTRACT

Purpose: To prospectively quantify changes in anterior segment morphology after laser iridotomy using ultrasound biomicroscopy (UBM) in angle closure glaucoma.

Study Design: Prospective interventional study

Methods: Patients presenting as Primary Angle Closure, Primary Angle Closure Glaucoma & Primary Angle Closure Suspect (PAC, PACG & PACS) were examined with UBM having probe frequency of 35 MHz to measure anterior segment parameters including ACD, TIA, AOD500, TCPD, ID1 & ID3. Sequential measurements of the same were taken 2 weeks post Nd:YAG laser iridotomy and changes noted.

Results: 42 eyes of 22 patients were examined. There was a statistically significant increase in ACD, TIA, AOD500, TCPD in all the subgroups. Iris thickness was seen to decrease post LPI, though not found to be clinically significant.

Conclusion: Anterior segment dimensions can be significantly influenced by laser peripheral iridotomy in primary angle closure, offering significant protection against acute angle closure and UBM unlike gonioscopy, is a viable tool for documentation and quantification of angle morphology.

Aim

- To assess the anterior segment morphology of the PACS, PAC and PACG using UBM
- To further quantify the changes in anterior segment morphology of these patients post Nd:YAG laser iridotomy using UBM.

Materials & Methods

The study design was a prospective interventional study. Patients presenting with PAC (occludable drainage angle and features of trabecular obstruction, such as peripheral anterior synechiae (PAS), iris whorling, glaukomflecken, excessive pigment deposition on the trabeculum, and/or raised IOP) or PACG (PAC together with signs of glaucomatous optic neuropathy) or PACS (suspects with normal IOP) at our tertiary referral centre were included in the study. Exclusion criteria included:

1. Presence of other PAS-associated disorders like iris neovascularization
3. Presence of secondary angle closure glaucoma due to lens abnormalities, retinal surgeries or other cause
4. Use of any pupillary diameter altering drugs

The diagnosis was based on clinical history & examination, slit-lamp biomicroscopy, visual field testing and indirect gonioscopic examination.

Gonioscopy was done with a Goldmann 2 mirror lens. The gonioscopic criteria taken for an occludable angle were:

1. The trabecular meshwork invisible in 270° or more of the entire angle in the primary position of gaze
2. The angular width was less than 20 degrees by the Shaffer grading.

After initial assessment of angle closure patient, the anterior chamber parameters were measured using the Sonomed VuMax-1 UBM, which is a high frequency ultrasonic B-Scan with a water-bath probe, with transducer of center frequency 35 MHz, made of gold-coated polyvinylidene fluoride (PVDF). The theoretical axial resolution of the 35 MHz transducer is 0.0219 mm and lateral resolution is 0.42 mm in tissue. The scan depth is 15 mm.

After surface anesthesia with 4% xylocaine, a plastic eyecup containing physiologic saline was applied to the eyeball between the eyelids. The scanning was performed by placing the probe at the limbus and ciliary body region, always perpendicular to the surface of the eyeball, and profile images of the limbal area in the superior, inferior, nasal and temporal meridians of the angle were obtained per eye with the patient in a supine position. An image centered on the pupil was also captured. The UBM examination was done in the undilated state under dim light illumination, the
conditions being uniform for the whole examination. The various parameters listed below were measured by a single observer to rule out interobserver variability. The various parameters measured include:

**Anterior chamber depth (ACD)** indicates the distance between the endothelium and the anterior surface of the lens along the visual axis.

**Angle opening distance (AOD500)** corresponds to the distance between the trabecular meshwork and the iris at 500 μm anterior to the scleral spur.

**Trabecular iris angle (TIA)** is defined as an angle formed with the apex at the iris recess and the arms passing through the point on the meshwork 500 μm from the scleral spur and the point on the iris perpendicularly opposite.

**Trabecular ciliary process distance (TCPD)** indicates the distance between the trabecular meshwork and the ciliary process at 500 μm anterior to the scleral spur.

**Iris thickness (ID1)** - thickness measured at same line as TCPD; ID3: max iris thickness near pupillary margin.

The LPI was performed using a Nd:YAG laser, set at variable energy levels between 2 and 6 mJ (5–10 shots). All patients received the same preinterventional regimen that consisted of pilocarpine QID before the intervention and continued use of antiglaucoma medications if on any. Using an Abraham lens, one opening was performed selecting, if possible, a crypt in the peripheral superotemporal or superonasal iris. After the intervention, patients were given systemic azetazolamide 250mg BD for 2 days, along with topical Dexamethasone QID which is later tapered.

The same patient was then reassessed 2 weeks following Nd:YAG laser iridotomy with indirect gonioscopy and UBM for changes in anterior segment parameters, along visual acuity and IOP reassessment. The measurements were tabulated and compared using students paired T test.

**Results**

As per inclusion criteria, 42 eyes of 22 subjects diagnosed as either PACS, PAC or PACG were evaluated. Of which 16(38%) were PACS, 18(43%) were PAC and 8(19%) were diagnosed as PACG. The age of presentation varied from 46 to 70 years with a mean age of 56.05 ±6.98 years. The maximum frequency was seen in the age group of 46-50 years.

The mean anterior chamber depth(ACD) pre-laser iridotomy was 1.855±0.242mm and post laser iridotomy was 1.950±0.252mm.(p=0.000) The mean change in ACD in each group is as follows:

<table>
<thead>
<tr>
<th></th>
<th>ACDprePI</th>
<th>ACDpostPI</th>
<th>P value</th>
</tr>
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<tbody>
<tr>
<td>PACS</td>
<td>1.912±0.257</td>
<td>2.000±0.260</td>
<td>0.000</td>
</tr>
<tr>
<td>PAC</td>
<td>1.727±0.189</td>
<td>1.812±0.191</td>
<td>0.000</td>
</tr>
<tr>
<td>PACG</td>
<td>2.031±0.178</td>
<td>2.153±0.187</td>
<td>0.018</td>
</tr>
</tbody>
</table>

The TIA, mean value pre-laser iridotomy was 8.006±1.838º & post iridotomy was 15.964±2.941º(p=0.00). The mean change in each group is as follows:

<table>
<thead>
<tr>
<th></th>
<th>TIAprePI</th>
<th>TIApostPI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACS</td>
<td>8.781±1.663</td>
<td>16.093±1.359</td>
<td>0.00</td>
</tr>
<tr>
<td>PAC</td>
<td>7.388±16.055</td>
<td>16.055±4.165</td>
<td>0.00</td>
</tr>
<tr>
<td>PACG</td>
<td>7.843±0.855</td>
<td>15.500±2.065</td>
<td>0.00</td>
</tr>
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</table>

Angle opening distance at 500μ(AOD500) increased from a mean value of 0.075±0.016mm to 0.144±0.020mm

The net mean value of AOD500 for each sub group is as follows:

<table>
<thead>
<tr>
<th></th>
<th>AOD500prePI</th>
<th>AOD500post-PI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACS</td>
<td>0.081±0.013</td>
<td>0.150±0.014</td>
<td>0.00</td>
</tr>
<tr>
<td>PAC</td>
<td>0.071±0.019</td>
<td>0.138±0.024</td>
<td>0.00</td>
</tr>
<tr>
<td>PACG</td>
<td>0.070±0.007</td>
<td>0.145±0.018</td>
<td>0.00</td>
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</tbody>
</table>

The Trabecular ciliary process distance(TCPD), showed a statistically significant mean increase from a figure of 0.681±0.060mm to 0.737±0.058mm.

There was a mean increase in TCPD by 0.054mm in PACS, 0.058mm in PAC & 0.056mm in PACG groups.

<table>
<thead>
<tr>
<th></th>
<th>TCPDpre</th>
<th>TCPDpost</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACS</td>
<td>0.693±0.055</td>
<td>0.747±0.054</td>
<td>0.00</td>
</tr>
<tr>
<td>PAC</td>
<td>0.667±0.568</td>
<td>0.725±0.577</td>
<td>0.00</td>
</tr>
<tr>
<td>PACG</td>
<td>0.689±0.763</td>
<td>0.745±0.071</td>
<td>0.00</td>
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</tbody>
</table>

The iris thickness(ID1) is measured along the same line as TCPD; ID3: max iris thickness near pupillary margin. The mean pre-laser iridotomy ID1value was 0.401±0.034mm & mean value post laser iridotomy was 0.394±0.033mm.(p<0.05)

The average values computed for each group include:

<table>
<thead>
<tr>
<th></th>
<th>ID1pre PI</th>
<th>ID1post PI</th>
<th>P value</th>
</tr>
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<tbody>
<tr>
<td>PACS</td>
<td>0.396±0.028</td>
<td>0.393±0.029</td>
<td>0.28</td>
</tr>
<tr>
<td>PAC</td>
<td>0.395±0.025</td>
<td>0.385±0.024</td>
<td>0.00</td>
</tr>
<tr>
<td>PACG</td>
<td>0.424±0.053</td>
<td>0.414±0.049</td>
<td>0.01</td>
</tr>
</tbody>
</table>
The values reached statistical significance only in PAC & PACG group.

The mean ID3 the maximum iris thickness measured near the pupillary margin pre-laser iridotomy was 0.564±0.052mm & post iridotomy was 0.559±0.051mm

The values reached statistical significance only in PAC & PACG group.

<table>
<thead>
<tr>
<th></th>
<th>ID3pre PI</th>
<th>ID3post PI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACS</td>
<td>0.556±0.035</td>
<td>0.554±0.035</td>
<td>0.155</td>
</tr>
<tr>
<td>PAC</td>
<td>0.559±0.058</td>
<td>0.552±0.059</td>
<td>0.000</td>
</tr>
<tr>
<td>PACG</td>
<td>0.591±0.060</td>
<td>0.585±0.057</td>
<td>0.012</td>
</tr>
</tbody>
</table>

The values reached statistical significance only in PAC & PACG group.

Discussion

Laser peripheral iridotomy and if indicated laser iridoplasty is the mainstay of treatment of angle closure by influencing the aqueous humour dynamics and reducing the pressure gradient between the anterior and posterior part of the AC, with the iris falling back, causing apparent widening of the angle with lowering of the intraocular pressure. Visualization of the anterior chamber is therefore important in narrow and occludable angles, which is routinely done by gonioscopy. UBM provides a more objective assessment of iridocorneal angle. It enables clinicians to quantitatively assess the iris curvature and degree of angle opening, since it images a cross-section of angle structures similar to that of a low power microscope section. One can determine the state of closure of the entire angle, even when it cannot be visualized by gonioscopy.1,2

In this study 42 eyes of 22 subjects were examined pre and post laser iridotomy. Out of the 42 eyes 16(38%) were PACS, 18(43%) were PAC and 8(19%) were PACG. Of the 18 PAC eyes, 16 patients presented with features of acute attack like nausea, vomiting, periorcular pain, coloured haloes with blurred vision, raised intraocular pressure with evidence of corneal edema, mid-dilated pupil and shallow anterior chamber. The other two eyes had peripheral anterior synchiae but with no evidence of glaucomatous damage to optic nerve. The other eye of these subjects were included as PACS, if satisfying the diagnostic criteria. Two eyes were excluded due to the presence of neovascular glaucoma in one eye & due to loss of follow up in the other eye. Out of the 8 PACG eyes, 3 eyes presented with acute attack. The mean age of presentation was 56.05±6.98years, the range varied from 46-70years.

The mean anterior chamber depth (ACD) pre-laser iridotomy was 1.855±0.242mm and post laser iridotomy was 1.950±0.252mm with an average increase of depth by 0.095mm. The ACD increased by 0.088mm in PACS, 0.085mm in PAC & 0.12mm in PACG.

Gazzard et al6 in his prospective study on Asian population in PACS eyes did not find significant increase in ACD after laser iridotomy (2.41±0.28mm vs. 2.42±0.30mm). Similar finding was obtained by Caronia et al9 in his study.

In study on Indian population by T Dada et al9, described a statistically significant increase in ACD in PAC (2.19mm to 2.30mm), as against PACG where the increase was not statistically significant (1.79mm to 1.82mm). Savita et al10 also in her study on PACS & PAC obtained a significant increase in ACD from 1.24±0.25mm to 1.44±0.21mm. The significant increase in ACD in PACG eyes in our study population can be explained on the basis of significant PAS being present in only 2 eyes & 4 eyes suspected to be having combined mechanism glaucoma.

The mean Trabecular iris angle (TIA) which is the angle formed with the apex at the iris recess, pre-laser iridotomy was 8.006±1.838º & post iridotomy was 15.964±2.941º with a mean increase of 7.958±3.774º. There was an average increase of angle by 7.312º in PACS, 8.667º in PAC and 7.657º in PACG. In all the groups the superior angle was found to be the narrowest and inferior the widest angle which opened correspondingly after laser iridotomy.

Giorgi et al6,7 in his study found a mean anterior chamber angle of 11.72º in acute PACG & 19.87º in chronic PACG in comparison to normal patients with 31.29º. Caronia et al8 study on Caucasian population demonstrated similar figures to the present study with angle opening from 8.3±1.3º to 18.6±2.8º. Kyung-Chul et al9 displayed an increase in mean TIA from 11.92±3.40º to 27.31±5.23º post LPI. After LPI, the mean superior TIA increased significantly from 6.46±6.8º to 12.1±8.1º, and mean inferior TIA increased from 7.5±6.7º to 12.9±8.5º in study on Indian population by T Dada et al9 which were comparable to the present study.

The Angle Opening Distance at 500μm (AOD500), is a measure of the angle opening at the level of the anterior Schwalbe’s line in the present study, increased from a mean value of 0.075±0.016mm to 0.144±0.020mm which was statistically significant. Significant change in AOD500 was obtained in each sub group as well, with it increasing by a value of 0.069mm in PACS, 0.067mm in PAC and 0.075mm in PACG. The individual increase in each examined quadrant was also statistically significant in each group.
The values for mean AOD500 obtained for acute PACG was 0.13±0.09 mm & chronic PACG was 0.21±0.10 mm in the study done by Giorgio et al6,7 which were slightly higher than those obtained in the present study. In the prospective study by Mansouri et al8, the mean superior AOD increased from 0.060±0.07 to 0.107±0.07 mm (P=0.09), and the mean inferior AOD increased from 0.100±0.10 mm to 0.152±0.08 mm after LPI in light conditions(P=0.148). Maraffa et al9 described an increase of AOD500 from 0.109±0.07 mm to 0.183±0.09 mm.

Kyung-Chul et al8 described an increase in AOD500 to 187.15±13.30 mm from mean of 69.46±25.39 mm pre-LPI. Dada et al9 in their mixed group of patients, described an increase from 0.107±0.06 mm to 0.208±0.18 mm in PAC and 0.065±0.09 mm to 0.13 mm in PACG. Kaushik et al9 in a study including 55 angle closure patients, found a mean increase of AOD500 in the LPI quadrant from 0.092±0.08 mm to 0.170±0.08 mm i.e. an increase of 71.2%.

The Trabecular Ciliary Process Distance (TCPD) is a parameter of primary importance since it indicates the gap available for the iris between the trabecular meshwork and the ciliary process. In the study population, TCPD showed a statistically significant increase from a figure of 0.681±0.060 mm to 0.737±0.058 mm which can be speculated as due to the anteriorly displaced ciliary process moving backwards to relieve the occludable angle. The TCPD in each group showed statistically significant improvement post iridotomy. There was a mean increase in TCPD by 0.054 mm in PACS, 0.058 mm in PAC & 0.056 mm in PACG groups.

The Liwan eye study10 found a mean increase in TCPD by 0.024 mm post LPI. Dada et al9 though found no significant change in the trabecular ciliary process distance (0.751±0.22 to 0.785±0.23 mm, P=0.12) in the total study population , in PAC the TCPD increased from 0.748±0.19 mm to 0.837±0.19 mm which was statistically significant.

The mean iris thickness (ID1), measured along the same line as TCPD pre-laser iridotomy, was 0.401±0.034 mm & mean value post laser iridotomy was 0.394±0.033 mm (p<0.05) The change was found to be statistically significant. The mean iris thickness (ID3), which is the maximum thickness at pupillary margin, pre-LPI was 0.564±0.052 mm & post iridotomy was 0.559±0.051 mm (p=0.00) i.e there was a decrease by 0.005 mm which was found to be statistically significant.

Kyung et al3 described a decrease in iris thickness both ID1 & ID3 from a 545.38±108.68 mm to 505.38±104.61 mm and 620.77±108.28 mm to 569.23±89.58 mm respectively (p=0.2). Dada et al9 described a decrease in the ID1 from 0.473±0.08 mm to 0.486±0.11 mm in PAC (p=0.42) & from 0.492±0.12 mm to 0.484±0.096 mm (p=0.195) in PACG.

Most of the studies do not quote a significant difference in iris thickness post LPI. Though small but statistically significant flattening and thinning of the iris was observed in the study population post LPI, it doesn’t seem to have a clinical significance, because individual values for each quadrant in different subgroups did not all reach statistical significance.

The present study highlights that LPI is effective in opening up the angle recess and deepening the anterior chamber in primary angle closure glaucoma when there is only an appositional closure of the angle and also when synechial closure is not extensive.

**Conclusion**

This study shows that anterior segment dimensions can be significantly influenced by laser peripheral iridotomy in primary angle closure, offering significant protection against acute angle closure and UBM unlike gonioscopy, is a viable tool for documentation and quantification of angle morphology.

**Reference**

6. Giorgio Marchini, Andrea Pagliaruso, Andrea


