Surgical membranectomy with modified incision and capsulotomy microscissors for persistent pupillary membrane

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Background: To evaluate the visual outcome and complications of surgical membranectomy with modified incision and capsulotomy microscissors in patients with persistent pupillary membrane (PPM).

Methods: We enrolled eight eyes with PPM in six patients and performed surgical membranectomy with modified incision located near the limbus and corresponding to the middle of the densest membrane strands. Strands near the collarette of the iris were then cut using capsulotomy microscissors and thick strands were removed with capcularhexis forceps. Complications during or after surgery were evaluated, and uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA) were compared pre- and post-surgery.

Results: The mean age of the patients at surgery was 9.5±3.4 years (range, 5.3 to 13.8 years). Bilateral PPMs were found in two patients, small anterior capsular cataracts not locating on the visual axis in three eyes, and deprivalional amblyopia in four eyes. There were no traumatic cataracts, endophthalmitis, corneal opacitics, or other complications in patients during or after modified surgical membranectomy. After a mean follow-up period of 5.8±0.4 (range, 5.0 to 6.0) months, UCVA was significantly improved from 0.23±0.14 to 0.36±0.20 (P=0.026), and BCVA was also significantly improved from 0.32±0.22 pre-operatively to 0.56±0.25 post-operatively (P=0.006).

Conclusions: Surgical membranectomy with modified incision and capsulotomy microscissors may be a safe approach to clear the visual axis of patients with PPM. However further treatments were needed in amblyopic eyes after surgery.

Keywords: Membranectomy; persistent pupillary membrane; modified incision; capsulotomy microscissors

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Introduction

A persistent pupillary membrane (PPM) is a remnant of the tunica vasculosa lentis, which is the blood supply for the lens epithelium during fetal life (1,2). PPM appears as fine iris strands along the pupil and can be seen in 95% of neonates and 20% of adult population (3). While PPMs not affecting vision are common and require no treatment (4,5), dense membrane can hinder vision development as less than 1.5 mm pupillary apertures may obscure light to the retina and occlude visual axis (6,7). To reduce the risk of deprivalional amblyopia for these patients, early surgical intervention should be considered (8).

Surgical membranectomy has been employed in patients with thick or dense PPM in previous studies. However, traumatic iatrogenic cataract could be induced if the
lens is accidentally damaged (9,10). To reduce the risk of complications, membranectomy with modified incision and capsulotomy microscissors was performed and the surgical outcome was evaluated. We present the following article in accordance with the STROBE reporting checklist (available at http://dx.doi.org/10.21037/apm-21-995).

**Methods**

The study was approved by the Medical Ethics Committee of Shenzhen Eye Hospital (Number: 20201230-04) and adhered to the provisions of the Declaration of Helsinki (as revised in 2013) for research involving human subjects. All patients involved gave written informed consent by their parents or guardians after discussion of the potential benefits and risks of surgical membranectomy.

This study enrolled eight eyes (six patients) with thick or dense PPM from who presented between February 2015 and June 2018 to the Shenzhen Eye Hospital. PPM was diagnosed as a thick membrane covering the pupil and attached to the iris collarette. Indications for surgical membranectomy included decreased visual acuity, poor red reflex from retinoscopy, or impaired fundus visualization. Sequential surgery was performed in bilateral PPM cases with the thicker membrane removed first.

The main outcome measures included slit-lamp-assisted biomicroscopy (Haag-Streit, Koeniz, Switzerland), intraocular pressure (IOP), uncorrected visual acuity (UCVA), and best corrected visual acuity (BCVA) using a logMAR chart. All subjects underwent a broad ophthalmologic examination at baseline and the follow-up visit.

The same surgeon performed the surgical procedure for all eyes in this study following the Gregg T. Lueder’s technique with modification (11). The operations were performed under general anesthesia, and Tropicamide eye drops were placed prior to surgery for pupil dilation. The anterior chamber was entered using a 3.0mm keratome via a modified corneal tunnel incision located near the limbus and corresponding to the middle of the densest membrane strands (Figure 1).

A high-viscosity viscoelastic material (Pe-Ha-Luron F, ALBOMED, Schwarzenbruck, Germany) was then injected into the anterior chamber which then went behind the central iris adhesion to lift the PPM (Figure 2A). Care was taken to avoid touching the lens anterior capsule, and
additional viscoelastic was injected beneath the strands after the central iris adhesions were lysed. Strands near the collarette of the iris were then cut using capsulotomy microscissors (Hoffer-Stern Scissors, Stephens Instruments, Lexington, KY, USA) (Figure 2B) and thick strands were removed with capmulorhexis forceps. Residual small floating strands and viscoelastic were removed completely by an automated irrigation and aspiration apparatus (Alcon Laboratories Inc., Fort Worth, TX, USA) (Figure 2C). The corneal incision was hydrated with sterile balanced salt solution (Figure 2D), then required a single 10-0 nylon suture (Alcon Laboratories Inc., Fort Worth, TX, USA) which was removed one month postoperatively.

Postoperative medications included topical 0.5% levofloxacin eyedrops four times daily, 1% prednisolone acetate ophthalmic suspension four times daily, and tobramycin/dexamethasone ointment once a day tapered over 3–4 weeks. Postoperative examinations were performed 1 day, 1 week, 1 month, and 6 months after surgery. Postoperative complications, including cataract, bleeding, and inflammation, were observed for, and visual acuity, IOP, pupil size, pupil shape, and reactivity were also assessed.

Statistical Analysis
Statistical analysis was performed using SPSS (Statistical Package for the Social Sciences, IBM, Armonk, New York, Ver. 25) and the means ± standard deviations of all the main parameters were analyzed. T test was used to compare the differences between pre- and post-operative groups and P
values <0.05 were considered statistically significant.

Results

As shown in Table 1, a total of eight eyes of six patients (five males) were included in this study. The mean age at surgery was 9.5±3.4 years (range, 5.3 to 13.8 years).

Bilateral PPMs were found in two patients, small anterior capsular cataracts not locating on the visual axis in three eyes, and deprivational amblyopia in four eyes. There were no traumatic cataracts, endophthalmitis, corneal opacities, or other complications in patients during or after modified membranectomy. The depth of the anterior chamber and IOP were within normal limits. Figure 3A,B show post-operative anterior segment imaging of eyes 3 and 7 one day after surgery. The membrane had been completely removed and the pupil is 3 mm × 3 mm round. In eye 3, small clumps of anterior lens capsule pigmentation are seen (Figure 3A).

After a mean follow-up period of 5.8±0.4 (range, 5.0 to 6.0) months, post-operative UCVA improved in six eyes, BCVA improved in seven (Figure 3C,D), and the mean visual acuity of patients was significantly improved. UCVA was 0.23±0.14 (range, 0.04 to 0.4) at baseline and was 0.36±0.20 (range, 0.05 to 0.6) at the final visit (P=0.026, paired t-test). Before surgery, BCVA was 0.32±0.22 (range, 0.04 to 0.6) and at the final visit this was 0.56±0.25 (range, 0.05 to 0.8) (P=0.006).

Discussion

The management of PPM depends on the membrane extent and papillary opening size. Small PPM can be observed only or treated by topical mydriatic agents (4,12). While membranectomy by Nd:YAG laser or Argon laser has been successfully employed in older patients with thick PPM (13-15), it is technically difficult in children and carries a risk of hyphema (16), cataract formation, and pigment dispersion (14,15). High-viscosity viscoelastic protected membranectomy represents an effective approach in dense and thick PPM (11,17-21). Different incisions and surgical instruments have been applied in previous studies (Table 2), with the risk of developing traumatic iatrogenic cataract the most important surgery complication (9,10).

To minimize this risk, we modified the position of corneal tunnel incision near the limbus corresponding to the middle of the densest membrane strands. The modified incision has several advantages. First, it shortens the distance for the viscoelastic needle, lifting dense membrane away from the crystalline lens. Second, the risk of surgical instruments going through the central pupil zone is reduced, and third, the incision is much closer to the iris collarette, providing an optimum angle for the iris strands cut.

In this study, capsulotomy microscissors were applied in the surgery. The blunt tips and curved thinning blade of this instrument protects the lens against damage, while the 11 mm cutting length of the blades avoids repeated moving and cutting at the limited space of the anterior chamber. Further, the automated irrigation and aspiration apparatus, which was applied to remove the residual strands and viscoelastic, provided a more stable anterior chamber and less damage to the angle structure (22). After membranectomy, only one single suture was needed in our technique as the incision was only 3.0 mm, through which surgically induced astigmatism was reduced.

Table 1  Clinical characteristics of patients with PPM

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Eye No.</th>
<th>PPM eye</th>
<th>Other diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>7</td>
<td>1</td>
<td>OD</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>5</td>
<td>3</td>
<td>OD</td>
<td>Anterior capsular cataract</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>14</td>
<td>5</td>
<td>OD</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>13</td>
<td>6</td>
<td>OD</td>
<td>Anterior capsular cataract</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>10</td>
<td>7</td>
<td>OD</td>
<td>Amblyopia</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>8</td>
<td>8</td>
<td>OS</td>
<td>Amblyopia</td>
</tr>
</tbody>
</table>

PPM, persistent pupillary membrane; M, male; F, female; OD, right eye; OS, left eye; OU, both eyes.
There were no intra- or post-operative complications of the modified membranectomy procedure during the follow-up period in this study, although in eye 3, small clumps of anterior lens capsule pigmentation presented during and after surgery, which may be due to posterior synechia of PPM and was not considered to be a complication.

In our study, the BCVA at baseline of patients with PPM was only 0.32±0.08, possibly due to the low retinal illumination caused by a small pupil (23), and while post-operative BCVA improved in seven eyes, it remained lower than normal for the age of patients. Further treatments, such as eye patching and refractive correction were still needed in amblyopic eyes, which were present in four of the eight eyes prior to surgery. Patients with amblyopic eyes in this study came from rural areas and did not undertake routine eye examinations. Children with PPM should be evaluated for the risk of amblyopia at an early stage, especially in monocular cases, to ensure the appropriate...
Table 2 Previously reported surgical membranectomy in patients with PPM

<table>
<thead>
<tr>
<th>Authors</th>
<th>Eye No.</th>
<th>Sex</th>
<th>Age</th>
<th>Incision size and position</th>
<th>Surgery Instruments</th>
<th>Follow-up</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lim &amp; Yu 1996</td>
<td>5</td>
<td>1M/3F</td>
<td>1–9 years</td>
<td>1.5mm</td>
<td>Vitreous</td>
<td>3–50 months</td>
<td>No</td>
</tr>
<tr>
<td>Burton &amp; Adams 1998</td>
<td>2</td>
<td>1M</td>
<td>4 weeks</td>
<td>Small (superior), side incision</td>
<td>Vitreous</td>
<td>5 months</td>
<td>Small amount of bleeding</td>
</tr>
<tr>
<td>Tsai et al. 2004</td>
<td>2</td>
<td>1F</td>
<td>21 years</td>
<td>1.5–2 mm (3, 6, 9, 12 o’clock)</td>
<td>Vannas</td>
<td>3 months</td>
<td>No</td>
</tr>
<tr>
<td>Oner et al. 2007</td>
<td>2</td>
<td>1F</td>
<td>14 years</td>
<td>4.0 mm (superior)</td>
<td>Vannas</td>
<td>2 months</td>
<td>No</td>
</tr>
<tr>
<td>Ramappa et al. 2012</td>
<td>2</td>
<td>1M</td>
<td>12 years</td>
<td>2 incisions</td>
<td>Not mentioned</td>
<td>16 months</td>
<td>No</td>
</tr>
<tr>
<td>Altun et al. 2014</td>
<td>2</td>
<td>1M</td>
<td>15 years</td>
<td>1.5 mm (3, 9 o’clock)</td>
<td>Vitrectomy probe, microscissors</td>
<td>Not mentioned</td>
<td>2 lens capsules damaged</td>
</tr>
<tr>
<td>Kraus &amp; Lueder 2014</td>
<td>10</td>
<td>4M/2F</td>
<td>2.5 months–2.5 years</td>
<td>1 incision</td>
<td>Intraocular scissors</td>
<td>5.3 years</td>
<td>No</td>
</tr>
<tr>
<td>Iida et al. 2015</td>
<td>2</td>
<td>1M</td>
<td>7 years</td>
<td>2.4 mm (superior)</td>
<td>Curved iris</td>
<td>5 months</td>
<td>No</td>
</tr>
<tr>
<td>Banigallapati et al. 2018</td>
<td>2</td>
<td>1F</td>
<td>36 years</td>
<td>2.8 mm (superior)</td>
<td>Curved iris</td>
<td>6 weeks</td>
<td>No</td>
</tr>
<tr>
<td>Lee et al. 2018</td>
<td>32</td>
<td>16M/10F</td>
<td>43.7±36.0 months</td>
<td>1.5mm</td>
<td>Vitreous</td>
<td>6.5±3.3 years</td>
<td>2 lens opacity</td>
</tr>
</tbody>
</table>

PPM, persistent pupillary membrane; M, male; F, female.
intervention to maintain visual acuity is provided.

The limitations to this study are its the short follow-up period and small sample size, which is due to the rarity of thick or dense PPM.

**Conclusions**

Surgical membranectomy with modified incision and capsulotomy microscissors may be one of the safest and most effective approaches to clear the visual axis with a low risk of complication. However, further treatment is needed in amblyopic eyes after surgery.

**Acknowledgments**

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**Footnote**

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was approved by the Medical Ethics Committee of Shenzhen Eye Hospital (Number: 20201230-04) and adhered to the provisions of the Declaration of Helsinki (as revised in 2013) for research involving human subjects. All patients involved gave written informed consent by their parents or guardians after discussion of the potential benefits and risks of surgical membranectomy.

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