Effects of Phacoemulsification and Intraocular Lens Implantation on the Corneal Endothelium in Primary Angle-closure Glaucoma

Yu-Chieh Ko, Catherine Jui-Ling Liu, Joe C. Chou and Wen-Ming Hsu

Background: Phacoemulsification and intraocular lens implantation (P-IOL) is an option for intraocular pressure (IOP) control for primary angle-closure glaucoma (PACG). This study examined the effects of P-IOL on the corneal endothelium in eyes with PACG.

Patients and Methods: Ultrasound biometry and pachymetry, as well as specular microscopy, were performed preoperatively and 3 months after surgery in 24 eyes with PACG that underwent P-IOL. The postoperative changes in central corneal endothelial density and central corneal thickness (CCT) were evaluated. The correlations between postoperative endothelial changes and both preoperative IOP control and biometric features were analyzed.

Results: After surgery, corneal endothelial cell density decreased significantly \((p < 0.001)\), with a mean cell loss of 15.7\%, and mean CCT increased by 7 \(\mu m\) \((p = 0.034)\). A greater postoperative corneal endothelial loss was correlated with a higher preoperative mean IOP and more glaucoma medications (correlation coefficients = 0.487 and 0.427, \(p = 0.016\) and 0.038, respectively). The corneal endothelial changes did not correlate with preoperative biometric features including anterior chamber depth, lens thickness, and axial length.

Conclusion: Significant corneal endothelial cell loss after P-IOL in PACG patients suggests that corneal endothelium status should be carefully evaluated before performing this surgery in these patients, especially those with poor preoperative IOP control.


KEY WORDS: • primary angle-closure glaucoma • corneal endothelium • pachymetry • biometry • phacoemulsification
INTRODUCTION

Predisposing factors for primary angle-closure glaucoma (PACG) relate primarily to a small, crowded anterior segment, including a shallow anterior chamber and a thick, anteriorly positioned lens [1]. Peripheral iridotomy (PI) is the initial surgical treatment of choice for PACG [2]. It relieves the pupillary block mechanism that is responsible for most cases of PACG and precipitates the cascade of anatomic angle closure. However, accumulating evidence indicates that many PACG eyes require further treatment to control intraocular pressure (IOP), even with patent PI [3,4]. Traditionally, the elevated IOP in iridotomized eyes is treated in stages: medical therapy first, followed by glaucoma filtering surgery if the IOP remains uncontrolled. Unlike glaucoma filtering surgery, the purpose of lens extraction with intraocular lens (IOL) implantation in PACG is to restore a normal iridocorneal anatomic relationship. Several studies have shown that cataract surgery with posterior chamber IOL implantation in PACG eyes may result in lower mean IOP with the need for fewer glaucoma medications [5–7]. Compared with extracapsular cataract extraction (ECCE), phacoemulsification has the advantages of a smaller incision, less iris manipulation, better intraoperative maintenance of the anterior chamber, less risk of iris prolapse, and better preservation of the chamber angle. However, the ocular characteristics of PACG, such as a shallow anterior chamber, which makes the corneal endothelium more vulnerable to ultrasound or turbulent flow damage, and fewer corneal endothelial cells, on which surgical trauma may lead to postoperative corneal decompensation, make phacoemulsification and IOL implantation (P-IOL) more challenging [8,9]. In addition, pupillary miosis with posterior synechia in eyes treated with pilocarpine over long periods will complicate the situation even further by obscuring part of the surgical field.

In this study, we investigated the effects of P-IOL on corneal endothelial cell density and central corneal thickness (CCT), as CCT may reflect the function of the endothelium, in eyes with primary angle closure.

PATIENTS AND METHODS

Patients with primary angle closure undergoing P-IOL between July 2003 and February 2004 were enrolled and followed prospectively for at least 3 months. All patients had a normal cornea on biomicroscopy and had previously undergone a PI. Eyes with occludable angles secondary to inflammation, trauma, tumor, neovascularization, iridocorneal endothelial syndrome, or aqueous misdirection were not included. Eyes with a history of incisional ocular surgery, total peripheral anterior synechia extending up to Schwalbe’s line, advanced glaucomatous visual field defects threatening central vision, or retinal vascular disorders were also excluded.

All patients underwent examination preoperatively and 3 months after surgery in both eyes. Ultrasound pachymeter was performed using the TOMMY Bio and Pachy Meter (AL-1000, Tomey Corp, Nagayo, Aichi, Japan) to measure the anterior chamber depth (ACD), lens thickness (LT), and axial length (AL). Central corneal endothelial cell density was measured using a non-contact specular microscope (SD-9000, Konan Inc, Nishinomiya, Hyogo, Japan). An ultrasound pachymeter (DGH-550, DGH Technology Inc, Frazer, PA, USA) was used to measure CCT. Each biometric measurement was repeated three times for each eye and the mean of the three readings was used for analysis.

Except for replacing prostaglandin analogue with oral acetazolamide, 125 mg every 6 hours for 3 weeks starting from the day of surgery, preoperative glaucoma medications were maintained during the perioperative period. Postoperative glaucoma medications were adjusted according to changes in IOP. Clear cornea phacoemulsification was performed by one surgeon (C. Liu) using a 3.2-mm incision, manual continuous curvilinear capsulorhexis, and a divide-and-conquer or stop-and-chop technique in the capsular bag using the Storz Protégé phacoemulsifier (DPX100, Storz Instrument Co, St. Louis, MO, USA) with an adjustable ultrasound power kept below 45%. After the nucleus and cortex had been removed, the incision was enlarged appropriately to accommodate a one-piece PMMA IOL (MZ30BD, Alcon Laboratories Inc, Houston, TX, USA) or a foldable acrylic IOL (MA60BM, Acrysoft, Alcon Laboratories Inc). In cases with a small synechial pupil, the pupil was enlarged by dissecting the posterior synechia using sodium chondroitin-sodium hyaluronate (Viscoat®). The number of glaucoma medications needed to maintain acceptable IOP...
control preoperatively and 3 months after surgery was recorded.

Data were analyzed with SPSS version 10.0 (SPSS Inc, Chicago, IL, USA) for Windows. Corneal condition before and after phacoemulsification was compared using the Wilcoxon signed rank test. The correlations between the patients’ preoperative characteristics and both postoperative endothelial cell loss and changes in CCT were analyzed using the Spearman correlation coefficient. The level of significance was set at $p < 0.05$.

**RESULTS**

Twenty-four patients were included in the study and clinical data are listed in Table 1. The preoperative means ± standard deviations for ACD, LT, and AL were $2.27 ± 0.26$ mm, $5.03 ± 0.41$ mm, and $22.52 ± 1.12$ mm, respectively, in the operated eyes.

Surgery was uneventful and the IOL was positioned in the bag in each eye. Vision improved significantly after surgery ($p < 0.001$). The IOP was better controlled with fewer medications postoperatively and the vertical cup-to-disc ratio remained unchanged (Table 1).

The cornea was clear on biomicroscopy 3 months after surgery in each operated eye. However, corneal endothelial density decreased significantly postoperatively ($p < 0.001$), with a mean cell loss of 15.7%. In addition, the mean postoperative CCT increased by 7 μm ($p = 0.034$) (Table 2). No significant postoperative changes were observed in central corneal endothelial density or CCT in unoperated fellow eyes.

The percentage endothelial cell loss was correlated with preoperative IOP (correlation coefficient, $r = 0.487; p = 0.016$) and the number of glaucoma medications used ($r = 0.427; p = 0.038$), but not with the type of IOL inserted or the biometric features ACD, LT, and AL. Furthermore, the preoperative endothelial cell count did not predict postoperative cell loss.

**DISCUSSION**

Predisposing factors for PACG include a shallow anterior chamber, a small corneal diameter and radius of curvature, a thick lens with steep anterior surface curvature, an anterior lens position, and a short axial length of the globe [1,10]. These anatomic factors influence the anterior chamber configuration and suggest the contribution of a lens component in the disease process of PACG. Several studies have shown that cataract, even clear lens, extraction is effective in treating PACG patients whose disease cannot be controlled medically after PI [5–7]. Furthermore, in cases of acute PACG, primary phacoemulsification is safe and even more effective in reducing IOP than surgical PI [4,11]. However, the effects of phacoemulsification on the already-compromised corneal endothelium in patients with PACG have not been thoroughly evaluated. Compared to age-matched controls, the corneal endothelial count is significantly lower in PACG patients [8,9]. The mean endothelial cell loss can be as high as 35% after an acute glaucoma attack [8]. Although it is not known whether the residual endothelium is at risk for further damage, procedures potentially hazardous to the endothelium should be handled with great care in these patients.

In this study, P-IOL in PACG eyes resulted in a mean endothelial cell loss of 15.7%. This figure is higher than the average 10% reduction in endothelial cell density after phacoemulsification in non-glaucomatous eyes [12,13], but lower than the 18.3% decrease in 18 PACG eyes that underwent P-IOL reported by Kubota et al [6]. In addition,

### Table 1. Pre- and postoperative clinical data

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vision (ETDRS chart)</td>
<td>52.65 ± 11.40</td>
<td>69.00 ± 6.47</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Intraocular pressure (mmHg)</td>
<td>14.75 ± 4.87</td>
<td>11.83 ± 3.57</td>
<td>0.002</td>
</tr>
<tr>
<td>Vertical cup-to-disc ratio</td>
<td>0.62 ± 0.19</td>
<td>0.59 ± 0.22</td>
<td>0.222</td>
</tr>
<tr>
<td>No. of glaucoma medications</td>
<td>1.17 ± 1.2</td>
<td>0.375 ± 0.77</td>
<td>0.002</td>
</tr>
</tbody>
</table>

ETDRS = early treatment of diabetic retinopathy study.
some studies have reported transient corneal de-compensation after uneventful cataract surgery in eyes with PACG [5,14].

In a prospective study of 859 eyes, Hayashi et al identified the firmness of the nucleus as the most significant risk factor for endothelial cell loss and suggested that mechanical contact with nuclear fragments is the principal cause of endothelial injury [15]. Additionally, they reported that a small pupil diameter was also associated with endothelial cell loss. In PACG eyes, the shallow ACD and small anterior chamber volume may increase the chance of contact between lens fragments and the corneal endothelium. The ACDs in our subjects were shallower than that in the general population, between 1.92 and 2.58 mm, which is comparable to the results of previous studies of PACG [16,17]. However, no significant correlation between percentage endothelial cell loss and ACD was identified in our study, which may have been influenced by the narrow range of ACD distribution. To verify a possible relationship between ACD and corneal endothelial cell loss after P-IOL, we would need to recruit more PACG eyes or compare cell loss between primary open angle glaucoma and PACG eyes, controlling for factors that may influence the corneal endothelium other than ACD.

We found a positive correlation between percent postoperative endothelial cell loss and both preoperative IOP and the number of preoperative glaucoma medications. It is probable that the endothelial cells in eyes with higher preoperative IOP are under greater stress than in eyes with lower IOP, making them more susceptible to surgical injury. Gagnon et al found that corneal endothelial cell counts in glaucomatous eyes were inversely proportional to mean IOPs measured during the previous 24 months [9]. Sihota et al compared corneal endothelium status among different subtypes of PACG and found that patients with an acute attack had the lowest endothelial cell counts and highest CCTs, especially those with attacks lasting more than 72 hours [8]. They also reported that patients with symptomatic chronic PACG had lower endothelial cell counts than their asymptomatic counterparts [8].

On the other hand, the disease process of glaucoma may involve both the corneal endothelium and endothelial-like trabecular meshwork (TM) cells. Alvarado et al described lower TM cell counts in glaucomatous eyes, and a predisposition to TM cell loss through a pressure-dependent mechanism cannot be ruled out [18]. Finally, medication toxicity may result in endothelial cell abnormality and make cells more vulnerable. In the Gagnon et al study, patients receiving three or four glaucoma medications had lower cell counts than those receiving one or two [9].

Although the corneas of all subjects remained clear on biomicroscopy, the mean CCT increased by 7 µm postoperatively. Whether the change in CCT implies a mild dysfunction of the corneal endothelium or merely reflects a long-term measurement variation by the equipment requires further research. Studies by Bourne et al and Liesegang et al have reported continued endothelial cell loss up to 10 years after ECCE [19,20].

This was a short-term study and continued follow-up is needed to more comprehensively evaluate the impact of P-IOL on the corneal endothelium. In view of the higher percentage endothelial cell loss in PACG than non-glaucomatous eyes after P-IOL, we emphasize the importance of taking great care to protect the corneal endothelium while performing surgery in eyes with a shallow anterior chamber, especially in patients with high IOP or those being treated with several glaucoma medications.

REFERENCES


