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Efficacy of Chandelier Illumination for Combined Cataract Operation and Penetrating Keratoplasty

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Purpose: The aim of this study was to describe a method for non–open-sky continuous curvilinear capsulorhexis (CCC) with chandelier retroillumination for penetrating keratoplasty triple procedure and report its effectiveness in decreasing intraoperative complications and enabling successful primary intraocular lens (IOL) insertion in patients with moderate or dense central corneal opacities.

Methods: Seventeen eyes of 17 patients were enrolled in this study, divided into a chandelier group, including 7 eyes of 7 patients, and a nonchandelier group, including 10 eyes of 10 patients. In each group, time to achieve CCC (in seconds), open-sky time (in seconds), and operation time (in minutes) were measured, and the rates of successful CCC completion, rupture of the posterior capsule or zonule of Zinn, and successful IOL insertion were recorded.

Results: CCC time was not significantly different in both groups. In the chandelier group, however, open-sky time and operation time were significantly shorter than in the nonchandelier group (1429 ± 67 vs. 2016 ± 354 seconds, and 90.4 ± 3.5 vs. 108.9 ± 10.3 minutes, respectively). In the chandelier group, the rate of successful CCC completion was significantly higher than in the nonchandelier group (86% vs. 30%). The rates of posterior capsule or zonule of Zinn rupture and successful IOL insertion were not significantly different (14% vs. 40%, 14% vs. 10%, and 86% vs. 70%, respectively).

Conclusions: Non–open-sky CCC with chandelier illumination has many advantages for penetrating keratoplasty triple procedure compared with open-sky CCC without chandelier illumination.

Key Words: PKP triple procedure, chandelier illumination, continuous curvilinear capsulorhexis

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Combined phacoemulsification and aspiration (PEA) or extracapsular cataract extraction (ECCE) and penetrating keratoplasty (PKP), the so-called PKP triple procedure, was routinely performed by the middle of 1970s.[1,2] However, this procedure was performed in the "open-sky" state, and the high pressure of the vitreous body hindered the achievement of complete continuous curvilinear capsulorhexis (CCC) and/or intraocular lens (IOL) implantation during initial surgery. Later, Shimomura et al[3] found that core vitrectomy before trephination was an effective way of achieving complete CCC and primary IOL implantation in open-sky surgery, because of the resulting lowered vitreous pressure.

Capsular staining has been used in mature cataracts in some studies,[4] or in cataracts with corneal opacities.[5] However, PEA for cataracts with moderate or dense corneal opacities at the center of the cornea can be very difficult, because capsular staining does not enable visualization of the anatomical structure of the anterior capsule. Oshima et al[6] investigated intraocular chandelier illumination as a method of mitigating this difficulty, and found that it was a very effective tool for patients with corneal opacities in CCC and the following intraocular surgical procedures, for example, PEA. Other studies have found that retroillumination is effective for PEA in eyes with a weak fundus reflex caused by dense vitreous hemorrhage.[7] However, central corneal opacities can prevent adequate postoperative improvement of visual acuity, and in such cases, the PKP triple procedure can provide better final visual acuity than PEA alone.

In this study, we describe a non–open-sky CCC technique, using chandelier retroillumination, for the triple procedure in patients with moderate or dense central corneal opacities. We found that this technique effectively decreased intraoperative complications and successfully enabled initial IOL insertion.

MATERIALS AND METHODS

Study Design and Patients

This is a retrospective study that included 17 eyes of 17 patients. The study adhered to the tenets of the Declaration of Helsinki, and the protocols were approved by the Clinical Research Ethics Committee of the Tohoku University Graduate School of Medicine. All patients underwent triple PKP procedure with a follow-up period of at least 3 months at Tohoku University Hospital between January 2008 and October 2012. Patients were divided into

2 groups based on intraoperative use of intraocular chandelier illumination.

The chandelier group included 7 eyes of 7 patients (average age, 77.1 ± 8.3 years, male:female, 3:4), including 3 cases of interstitial keratitis, 3 cases of herpetic keratitis, and 1 case of advanced bullous keratopathy (bullous keratopathy with moderate stromal haze) (see Table, Supplemental Digital Content 1, http://links.lww.com/ICO/A254). The nonchandelier group included 10 eyes of 10 patients (average age, 73.5 ± 10.8, male:female, 6:4), including 4 cases of interstitial keratitis, 3 cases of herpetic keratitis, 2 cases of bullous keratopathy with interstitial opacities, and 1 case of trauma (see Table, Supplemental Digital Content 2, http://links.lww.com/ICO/A255). All patients underwent slit-lamp microscopy. Corneal opacities were graded according to the Fantes classification[8] and cataracts were graded according to the Emery–Little classification. All patients had cataracts of grade 3 or 4 and corneal opacities of grade 3 (moderate) or 4 (severe). Patients with central visual field defects (measured with Goldmann perimetry) were excluded.

In each group, time to achieve CCC (in seconds), open-sky time (in seconds), and the operation time (in minutes) were measured. Rates of successful CCC completion, rupture of the posterior capsule or zonule of Zinn, and successful IOL insertion were also recorded. Open-sky time was defined as the time from trephination of the recipient cornea to completion of 8 interrupted sutures. Complete CCC was defined as CCC without an acute angle heading outward or resection with scissors. Logarithm of the minimum angle of resolution best-corrected visual acuity (BCVA) was also recorded 3 months after the operation.

Surgical Technique

All surgeries were performed under general anesthesia by the same surgeon (S.Y.). First, a scleral ring was sutured to the globe with 7-0 silk. In the chandelier group, a 25-gauge chandelier (Synergetics, Inc) was inserted obliquely into the vitreous cavity through the bulbar conjunctiva at the lower temporal pars plana. After staining the anterior capsule with 0.1% trypan blue and filling the anterior chamber (AC) with Healon V (Abbott Medical Optics), CCC was performed with side port capsular forceps under retroillumination in a closed state. The chandelier illumination fiber was removed and the vitreous port was left intact. Core vitrectomy was then performed through the same port with a 25-gauge vitreous cutter (Alcon) to reduce vitreous pressure. The recipient cornea was excised with 6.5- to 7.5-mm-diameter Hessburg–Barron trephine (Katena) and the donor cornea was punched out using 7.0- to 8.0-mm-diameter (0.5 mm larger than the recipient cornea) Barron donor punch (Katena). After PEA or ECCE, the residual cortex was removed with a Simco cortex extractor (Katena). Unless the zonule of Zinn was ruptured during PEA or ECCE, Healon (Abbott Medical Optics) was injected to make room for IOL implantation; an IOL (LS-106S; Santen) was inserted in or out of the bag and the donor button was sutured with 10-0 nylon. In the nonchandelier group, open-sky CCC was performed after core vitrectomy with a 25-gauge vitreous cutter after excision of the recipient cornea. The procedure after CCC was the same as in the chandelier group (Fig. 1).

Statistical Analysis

The time to achieve CCC, open-sky time, and operation time were compared with the Mann–Whitney U test. $P < 0.01$ was considered statistically significant. A Fisher exact test was used to analyze the rates of successful CCC completion, rupture of the posterior capsule or zonule of Zinn, and successful IOL insertion. $P < 0.05$ was considered statistically significant. BCVA was compared between groups with a Mann–Whitney U test.

RESULTS

Time to achieve CCC was not significantly different in the two groups. In the chandelier group, however, open-sky time and operation time were significantly shorter than in the nonchandelier group (1429 ± 67 vs. 2016 ± 354 seconds, and 90.4 ± 3.5 vs. 108.9 ± 10.3 minutes, respectively). In the chandelier group, successful CCC completion rate was significantly higher than in the nonchandelier group (86% vs. 30%).

Rates of posterior capsular rupture or Zinn zonular rupture and successful IOL insertion rate were not significantly different in the 2 groups (14% vs. 40%, 14% vs. 10%, and 86% vs. 70%, respectively). In the chandelier group, IOL insertion was unsuccessful in only 1 case, in which CCC was incomplete, but posterior capsular rupture did not occur. After ECCE, however, there was severe Zinn zonular rupture. In the nonchandelier group, IOL insertion was not achieved in 3 cases. In both cases, CCC was incomplete and posterior capsular rupture arose from an anterior capsular crack during PEA or ECCE. This complicated capsular rupture led to abandonment of primary IOL insertion. Graft rejection, retinal detachment, vitreous hemorrhage, and expulsive hemorrhage did not occur in either group. Three months after the operation, BCVA did not differ significantly between the groups (0.8 ± 0.4 vs. 0.9 ± 0.7; Table 1).

DISCUSSION

Open-sky time and operation time were significantly shorter in the chandelier group than in the nonchandelier group. Moreover, in the chandelier group, only 1 case required resection of vitreous herniation, in which incomplete CCC was followed by severe Zinn zonular rupture. In all other cases, successful CCC completion diminished the incidence of capsular rupture during PEA and ECCE. The resulting retrenchment of surgical procedures resulted in lower open-sky and operation times. IOL insertion was unsuccessful in only 1 case, in which the zonule of Zinn ruptured during ECCE in an area far from the crack in the anterior capsule. In the nonchandelier group, rate of successful CCC completion was significantly lower than in the chandelier group, and IOL insertion was unsuccessful in 2 cases. In these cases, CCC was not completed and the posterior capsule ruptured due to a rift in the anterior capsule. These results

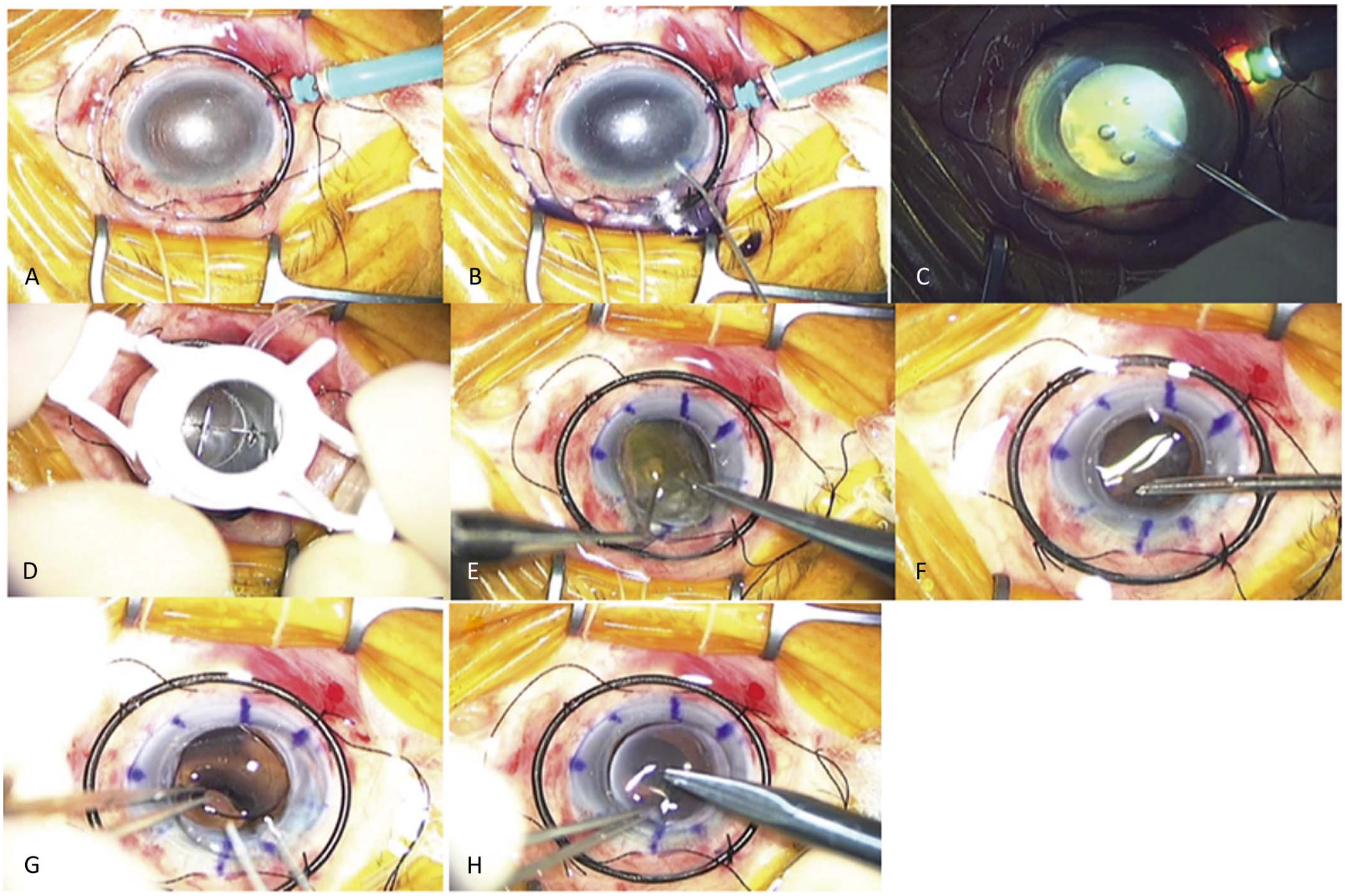

FIGURE 1. Surgical procedure. A, Insertion of 25-gauge chandelier. B, Capsular staining with trypan blue. C, CCC under retroillumination. D, Trephinization after core vitrectomy. E, ECCE. F, Removal of residual cortex. G, Insertion of IOL. H, Suture of corneal button.

suggest that chandelier illumination can improve CCC completion rates in a closed state, can effectively shorten open-sky time, and can increase successful IOL insertion rates. In both groups, surgeries included core vitrectomy under general anesthesia to reduce vitreous pressure, but successful CCC completion rate was lower in the nonchandelier group. Previously, Higaki et al[9] reported that core vitrectomy before CCC in the open-sky state was effective. However, when vitreous pressure is decreased by core vitrectomy, open-sky state requires surgical mastery of the procedure to achieve a high rate of successful CCC completion. However, CCC using chandelier illumination, in the closed state, is a simple procedure even for inexperienced surgeons. Our method may be especially suitable for surgeons unfamiliar with the PKP triple procedure, because CCC in the closed state is less stressful on the practitioner.

In general, cataract progresses in patients older than 50 years who undergo PKP.[10] In cases with Emery grade 3 or 4 cataracts before PKP, it is often difficult to plan cataract surgery because of the presence of intumescent cataracts and/or low endothelial cell density in the corneal graft. Chandelier illumination enables a procedure combining PEA and IOL implantation for patients with Fantes grade 3 or 4 central corneal opacities, but cataract surgery alone does not lead to adequately improved postoperative BCVA in these patients. They are therefore good candidates for a PKP triple procedure, due to its quick postoperative visual rehabilitation and low rate of surgical complications.

TABLE 1. Clinical Results

	Chandelier Group	Nonchandelier Group	*P*
CCC time, s	135 ± 76	90 ± 30	0.320
Open-sky time, s*	1429 ± 67	2016 ± 354	0.002
Operation time, min*	90.4 ± 3.5	108.9 ± 10.3	0.001
CCC completion, %	86	30	0.049†
Posterior capsule rupture, %	14	40	0.338
Zinn zonular rupture, %	14	10	1.000
Successful IOL insertion, %	86	70	0.602
Postoperative BCVA, logMAR	0.8 ± 0.4	0.9 ± 0.7	0.881

*Mann–Whitney *U* test.
†Fisher exact test.
logMAR, logarithm of the minimum angle of resolution.

Agarwal et al[11] reported that iridectomy with a vitrectomy cutter at the beginning of cataract surgery created a clear optical zone in patients with central or paracentral corneal opacities and suggested that this technique may be an alternative to a PKP triple procedure. However, corneal opacities were still present after this procedure, visual acuity was less than after a PKP triple procedure, and cosmetic rehabilitation was difficult because of the dislocated pupil and remaining corneal opacity. Nardi et al[12] showed that temporary corneal grafting using corneas that were unsuitable for PKP enabled CCC, PEA, and IOL implantation in a closed state, but this technique would be prohibitively expensive in most countries due to the need for an additional corneal button.

Endoilluminators have been used in vitrectomy as light sources outside the cornea for CCC in eyes with intumescent/white cataracts and clear corneas,[13,14] or for CCC and PEA in cataracts with corneal opacities.[15,16] This technique is very simple, but may require a well-trained assistant to keep the light probe in position for the surgeon, especially if the surgeon must perform the operation bimanually. In our technique, it is not necessary for an assistant to hold the illuminator.

Light intensity of chandelier illumination during CCC may be weaker than during vitrectomy because of halation at the corneal opacity and near the insertion point of the 25-gauge chandelier, which can interfere with visualization of the anterior capsule. Although we used chandelier illumination with a light intensity between 2 and 3 on the intensity scale, halation did not completely disappear. In cases with Fantes grade 3 or 4 diffuse corneal opacities, the entire cornea would be halated by chandelier illumination, because the corneal opacity is very near the insertion point of the 25-gauge chandelier. Therefore, we consider that non–open-sky CCC with chandelier illumination is unsuitable in such cases.

Core vitrectomy is an effective procedure for reducing vitreous pressure. In patients with a shallow (Shaffer grade 1 or 2) AC, core vitrectomy also deepens the AC and simplifies CCC. In patients with normal depth (Shaffer grade 3 or 4) ACs however, the AC would become too deep for CCC if core vitrectomy were performed before CCC. Therefore, we recommend deciding the surgical order of CCC and vitrectomy before the operation, based on the depth of AC.

In conclusion, non–open-sky CCC with chandelier illumination has many advantages for PKP triple procedures compared with open-sky CCC without chandelier illumination.

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