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CLINICAL INVESTIGATION

Posterior capsular opacification in highly myopic eyes with an endocapsular equator ring

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Abstract
Purpose Closed 9.5-mm-diameter endocapsular equator rings (E-rings) prevent posterior capsular opacification (PCO). However, in our research, some highly myopic patients unexpectedly developed late, extensive PCO that required capsulotomy. We also report for the first time how the capsule reacted to neodymium-doped yttrium aluminium garnet (Nd:YAG) laser shots.
Methods Sixty-two eyes (39 patients; average age, 48 ± 13.2 years) were implanted with a closed, square-edged silicone E-ring (outer diameter, 9.5 mm) and an intraocular lens between April 16, 2008, and November 30, 2011.
Results During the postoperative, minimal 2-year follow-up, PCO requiring Nd:YAG laser capsulotomy developed in six (9.7 %) of 62 eyes, of which five had −8.75 to −12.5 diopters (D) of myopia preoperatively. The axial lengths of those eyes ranged from 25.86 to 29.97 mm. However, none of the 13 eyes with higher myopia had severe PCO that required capsulotomy. All capsulotomies were performed uneventfully.
Conclusion The standard 9.5-mm-diameter closed E-ring does not prevent extensive PCO in eyes with preoperative myopia ranging between −8.75 and −12.5 D and an axial length between 25.86 and 29.97 mm. Posterior capsulotomies were performed safely. Further study is needed to determine why PCO did not occur in more high myopic eyes (larger axial length eyes).

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Keywords Endocapsular equator ring · Posterior capsular opacification · Nd:YAG laser · Capsulotomy

Introduction

The current study provides new information about the clinical use of endocapsular equator rings (E-rings). In 1991, we introduced the E-ring, which was designed to maintain the circular shape of the capsular equator and prevent posterior capsular opacification (PCO) after cataract surgery [1]. The device is a closed flexible silicone ring with a square edge that prevents posterior movement of the metamorphosed lens epithelial cells at the equator. Following studies of E-ring implantation in rabbit [2], monkey eyes [3], and a human eye [4], we reported the clinical results from 51 eyes in 2011 [5]. Despite the closed construction of the ring, only one size with an outer diameter of 9.5 mm was used for all cases. After 2–7 years of follow-up, no eyes with an E-ring required postoperative capsulotomy.

However, in the current series, to our surprise, we found that considerable PCO that required posterior capsulotomy developed in a substantial number of eyes with an E-ring. Because implantation of an E-ring is a relatively new clinical procedure and the device mostly preserves the capsular shape and probably tension, the effect of laser application on the posterior capsule was unknown. Keles et al. [6] report that posterior capsulotomy was performed uneventfully in eyes with a capsular tension ring; however, no reports have been published about use of a larger E-ring. The current study was undertaken primarily to determine the incidence of PCO and report that the application of laser posterior capsulotomy did not cause any adverse effects in eyes with an E-ring.

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Table 1 Preoperative and postoperative data from six eyes with extensive posterior capsular opacification after implantation of an E-ring

Eye	Age at first visit (years)	Preoperative data		Cataract surgery			Postoperative data			Follow-up period after posterior capsulotomy (months)
		Refraction SE (D)	Axial length (mm)	Date	Surgical time (min)	Loop fixation in ring groove	Duration from initial surgery to posterior capsulotomy (months)	BCVA immediately before posterior capsulotomy	BCVA after posterior capsulotomy	
1	59	−2.75	25.86	9/9/2009	10	Good	25	1.2	1.2	17.5
2	50	−8.75	29.97	2/10/2010	11	Good	37	1.2	1.2	11.0
3	43	−9.75	26.35	3/17/2010	9	Good	26	0.3	1.2	4.8
4	43	−10.25	26.41	5/7/2010	11	Good	26	0.08	1.2	2.7
5	55	−12.5	27.30	7/16/2010	8	Good	12	0.4	1.2	18.5
6	55	−9.75	26.30	7/21/2010	7	Good	24	1.0	1.2	6.5
Mean ± SD	51 ± 6.8	−9 ± 3.3	27 ± 1.5		9 ± 1.6		25 ± 7.8	0.7 ± 0.50	1.2 ± 0	10 ± 6.7

Patients and methods

The selection criteria included patients who needed cataract surgery at Hara Eye Hospital and agreed to E-ring implantation. Exclusion criteria included patients who had a severe systemic disorder or who could not undergo cataract surgery with topical anesthesia. Sixty-two eyes of 39 patients (average age, 48 ± 13.2 years; range 25–69 years) underwent cataract surgery with implantation of an E-ring and intraocular lens (IOL) between April 16, 2008, and November 30, 2011. The patients were selected based on the standards approved by the ethics committee of Hara Eye Hospital. Informed consent was obtained from all subjects in accordance with the Declaration of Helsinki for research involving human subjects.

Thirty-eight (61.3 %) of the 62 eyes had preoperative high myopia of −8.0 diopters (D) or more. Preoperative intraocular lens (IOL) power calculations are more difficult to calculate in highly myopic eyes and a higher rate of postoperative IOL exchange is expected. In eyes with an E-ring, because there is no adhesion between the capsule and IOL, postoperative IOL exchange seems easier, which is the reason for the high incidence of high myopia preoperatively in the current patients.

Various values were measured in the same manner as reported previously [5]. The ocular axial length was measured using a non-contact optical device (IOL Master version 5, Carl Zeiss Meditec Co. Ltd., Tokyo, Japan).

One surgeon (Takeshi Hara) performed all cataract extractions and IOL implantations through 3.2-mm

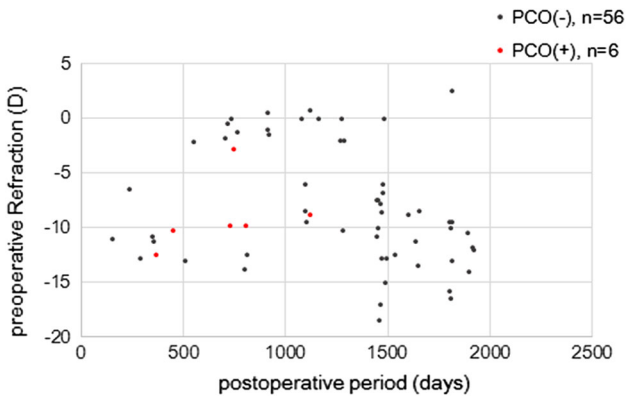

Fig. 1 Scatterplot of preoperative refractive powers. Each *dot* represents one eye. If more than one eye has the same refraction, the dots are shifted slightly horizontally. The *red dots* indicate eyes that required postoperative capsulotomy; the *black dots* indicate eyes that did not require postoperative capsulotomy. Most eyes that underwent capsulotomy had from −8.75 to −12.5 diopters (D) of myopia preoperatively. However, no capsulotomies are required among eyes with myopia exceeding −12.5 D, despite longer follow-up periods. *PCO* posterior capsular opacification, *D* diopters

corneoscleral incisions as reported previously [5]. The average time of the initial surgery was 9 ± 1.6 min. (range 7–11 min.) and all IOL loops were engaged in the inner groove of the E-ring. Neodymium-doped yttrium aluminium garnet (Nd:YAG) laser capsulotomy was performed when the patients had considerable visual disturbances. The capsulotomy was performed in the same manner used for control eyes [5]. Patients were followed for at least 2 years (average, 44 ± 12.1 months; range 23–64 months), with the exception of one eye followed for 23 months.

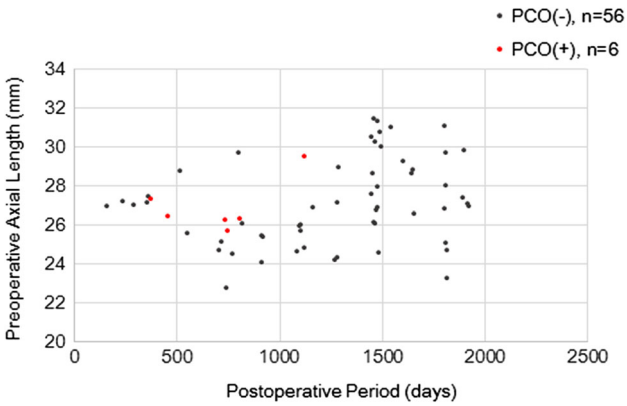

Fig. 2 Scatterplot of preoperative axial length. Each *dot* represents one eye. The *red dots* indicate eyes that required postoperative capsulotomy. The *black dots* indicate eyes that required no postoperative capsulotomy. Most eyes that underwent capsulotomy had from 26 to 30 mm of axial length. No capsulotomies are required among eyes with axial length longer than 30.0 mm despite longer follow-up periods. *PCO* posterior capsular opacification

Results

Six (9.7 %) of the 62 eyes required a postoperative posterior capsulotomy. The table shows the data from the six eyes including the degree of preoperative myopia and axial length. Five of the six eyes had preoperative high myopia between −8.75 and −12.5 D (−8.75, −9.75, −9.75, −10.25, and −12.5 D). However, none of the 13 eyes with higher myopia had severe PCO that required capsulotomy even during a longer follow-up period (Fig. 1). Six capsulotomy eyes had a long axial length (25.86–29.97 mm) (Table 1). None of the ten eyes with a longer axial length required capsulotomy despite longer follow-up periods (Fig. 2). The reaction of the opacified posterior capsule to Nd:YAG laser capsulotomy was the same as that in posterior capsules without an E-ring. No radial tears developed from the point of laser application to the periphery (Fig. 3), which was in contrast to our long-term expectation.

Discussion

E-rings prevent posterior movement of the postoperative metamorphosed lens epithelial cells (LECs) at the equator [2, 3], thus preventing PCO that requires capsulotomy [4, 5]. Because the previous results were excellent and stable, the current result of PCO requiring posterior capsulotomy in 9.7 % of eyes was surprising. It was not due to the surgical procedure. In these six eyes, the average surgical time was 9 min., within the normal range. The most probable cause of the PCO was the preoperative high myopia exceeding

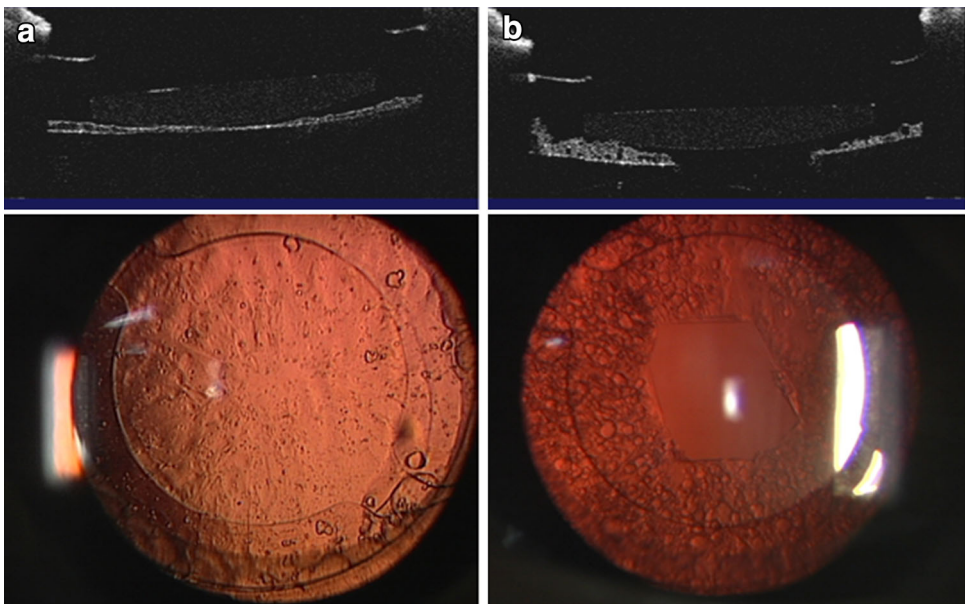

Fig. 3 Pre-capsulotomy and post-capsulotomy findings in case 5. **a** Pre-capsulotomy. **b** Post-capsulotomy. The *top images on the left* and *right* are optical coherence tomography images. The *bottom images on the left* and *right* are transillumination findings. No contact is seen between the intraocular lens and posterior capsule before and after capsulotomy. No extended tears resulting from the point of laser application to the periphery are observed

−8.75 D. Because cataracts induce myopic changes, it seems more reasonable to study the axial length.

Vass et al. [7], Tehrani et al. [8], and Zhao et al. [9] report that in highly myopic eyes, the capsular bag enlarges along with elongation of the axial length. As shown in Table 1, the axial length of the capsulotomy eye was considerably long and ranged from 25.86 to 29.97 mm. If the capsular bag is larger than the size of the E-ring, the ring cannot block the backward movement of the proliferative tissue at the equator. Therefore, it seems reasonable that using an E-ring larger than 9.5 mm in those eyes will improve the results.

However, Figs. 1 and 2 present an interesting observation. No eyes with preoperative myopia over −12.5 D, or axial length longer than 30 mm required capsulotomy, even during a longer follow-up period. Currently, attention has been paid to the effect of aqueous flow in contact with residual LECs [10–12]. The current report indicates that research is needed to determine how to prevent PCO. We have no definite hypotheses at present, but plan to address it in a future study. The current study only shows that extensive PCO appears in some eyes with high myopia or a long axis despite the presence of an E-ring. However, this knowledge is useful to share with patients preoperatively.

Including the posterior capsular reaction to the YAG laser shots, the current results are useful for further study of PCO.

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Conflicts of interest T. Hara, None; T. Hara, None; T. Hashimoto, None; Y. Motoyama, None; M. Narita, None.

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