

The Effect of the Haptic Portion of Intraocular Lens on the Development of Posterior Capsular Opacification in Rabbit

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Abstract

Using a white rabbit model, the effect of the haptic portion of the intraocular lens (IOL) and intracapsular ring on the development of posterior capsular opacification (PCO) after extracapsular cataract extraction (ECCE) with phacemulsification was studied. Implantation of both the intracapsular ring and IOL developed less PCO than implantation of the IOL alone. ECCE followed by implantation of the intracapsular ring alone also developed less PCO than ECCE alone. Through this experimental work in a rabbit model, it could be conceived that the haptic portion of IOL and the intracapsular ring can prevent the development of PCO.

Key Words: Extracapsular cataract extraction, posterior capsular opacification, haptic portion of intraocular lens, intracapsular ring

INTRODUCTION

Cataract has been one of the main cause of blindness and it can be treated by operation. Among the several types of surgical procedures, extracapsular cataract extraction with implantation of the intraocular lens (ECCE with IOL) has been known as an excellent method to prevent certain complications including vitreous loss, retinal detachment and cystoid macular edema by preserving the posterior capsule.¹⁻¹² However, the main cause of visual impairment after ECCE with IOL is posterior capsular opacification (PCO) which occurs in 10 to 50% of adult cataracts¹³ and most pediatric cataracts.^{14,15} PCO can be treated with Nd : YAG Laser posterior capsulotomy,¹⁶⁻¹⁸ but the advantages of the intact posterior capsule could be lost. Therefore, from the point of PCO, prevention is more important than surgery or treatment.

The main cause of PCO is posterior migration and

proliferation of the lens epithelial cells.¹⁹⁻²⁴ If one can remove all the lens epithelial cells during operation, it might be possible to prevent PCO. Practically, it's very difficult to remove all the lens epithelial cells by mechanical method.²⁵⁻²⁷ There have been several reports on preventing PCO using antimetabolites, but it has not been used clinically because of the complications.²⁸⁻³²

Several studies have been done to prevent PCO using modifications of the shape and materials of the intraocular lens.^{21,33-35} The intraocular lens made of PMMA (Polymethyl-methacrylate) with biconvex-shaped optic, 5-10 degree posteriorly angulated haptics, and total 12.0 mm length, is most desirable for the prevention of PCO. The optic portion of the intraocular lens is closely attached to the posterior capsule to help maintain tension of the posterior capsule. The "no cell no space" theory is known as the main mechanism of prevention for posterior capsular opacification of the intraocular lens by eliminating the potential space for cellular proliferation between the optic part of the intraocular lens and posterior capsule. But the haptic portion of the intraocular lens is also very important. If it maintains the tension of the posterior capsule and is located at the equator of the lens capsule where the lens epithelial cells begin to migrate posteriorly, the haptic of the IOL works as a mechanical barrier to the posterior migration, and thus reduces posterior cap-

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sular opacification. If the haptic portion of the IOL could block the migration of the lens epithelium, the capsular opacification might depend on the size of the contact area between the haptic and lens capsule. We compared the amount of capsular opacification by changing the length as well as the direction of the haptic portion of the IOL. However, there were several problems in modifying the length of the haptic portion of the IOL, so we used an intracapsular ring as an alternative. The intracapsular ring consists of only the haptic portion of the IOL which contacts the equator of the capsule for the full 360 degrees, and thus we could evaluate the pure function of the haptic portion in the prevention of posterior capsular opacification. The intracapsular ring may also reduce capsular opacification by stretching the capsule and maintaining the tension of the capsule. The purpose of this study was to compare the capsular opacification according to the different lengths of the haptic by using the IOL and intracapsular ring.

MATERIALS AND METHODS

Materials

Experimental animal: 25 white male rabbits (New Zealand) were used.

Drug: After the anterior chamber paracentesis, Sodium Hyaluronate (Healon, Pharmacia, Upsala, Sweden) was used as viscoelastics.

Intraocular lens: A biconvex, 12.5 mm length, 6.5 mm optic diameter, 10 degree posterior angulated, 20 diopter, all PMMA IOL (UNI intraocular lens, Universal Optics, Seoul, Korea) was used.

Intracapsular ring: 12 mm in diameter, open loop, one piece PMMA ring without optic portion was used.

Methods

Experimental group: One control and 4 experimental groups were used. Each group consisted of 10 eyes.

Control: Only ECCE (extracapsular cataract extraction) was performed.

Group 1: Horizontal implantation of the IOL after ECCE.

Group 2: Vertical implantation of the IOL after

Table 1. The Grade of Posterior Capsular Opacification

Grade	Posterior capsular opacification
0	Transparent
1	Minimal opacification, retina is clearly visible
2	Moderate opacification, retina is hazy
3	Severe opacification, retina is almost invisible
4	Very severe opacification, retina is not visible

ECCE.

Group 3: Implantation of the intracapsular ring after ECCE.

Group 4: Implantation of the intracapsular ring and horizontal implantation of the IOL after ECCE

Operation: Under general anesthesia by 50 mg/kg ketamine, extracapsular cataract extraction was performed with phacoemulsification and continuous curvilinear capsulorhexis, while sodium hyaluronate was inserted into the anterior chamber to protect the corneal endothelium. Then the IOL or intracapsular ring was implanted as scheduled. After operation, antibiotic and corticosteroid solution were used.

Evaluation of posterior capsular opacification

1. Direct ophthalmoscopic examination; After operation, the severity of PCO was evaluated 1# day, 1# week, 1# month and 3 months after operation according to the grading system (Table 1).

2. Evaluation of visual light obstruction by using optical power meter; At 3 months after operation, all eyes were enucleated and fixed in 10% formalin for 24 hours. The eyes were bisected in the equator coronally and the cornea, iris and vitreous were carefully removed. A 250 W tungsten halogen lamp was used as a light source and the infrared filter (model L5-371R, Sony, Tokyo, Japan) was used to filter out infrared light. The light was passed through an iris with an 8 mm diameter and then passed through the center of the posterior capsule of the eye specimen.

The optical power meter could detect the power of visual light from 400 to 700 nm wave length because the optical power meter detected the light from 400 to 1100 nm wave length and the infrared light was filtered out. The attenuation filter (model 883-SL, Newport corporation, Fountain Valley, CA, USA) was used to increase the sensitivity of the test. Finally, the obstruction ratio of visual light was calculated by comparing the power of visual light

before and after passing the posterior capsule.

Evaluation of the ocular structure after operation by slit lamp biomicroscopic examination: The slit lamp biomicroscopic examination was performed after 1 day, 1 week, 1 month and 3 months respectively. The conjunctiva, cornea, anterior chamber, iris and intraocular lens were evaluated and the states were described according to the ocular scoring system.

Histopathologic examinations: At 3# months after operation, the cornea, lens zonule, iris, ciliary body, choroid, and retina were fixed with 10% formalin. Those specimens were stained with hematoxylin and eosin, and observed by light microscopy.

Statistics: Kruskal-Wallis test and Mann-Whitney U test were used and the results were estimated statistically significant when the p value was less than 0.05.

RESULTS

Evaluation of posterior capsular opacification by direct ophthalmoscopic examination

One week after operation, control group developed more capsular opacification than experiment groups 1, #2, and 4. This differences were statistically significant ($p < 0.05$). One month after operation, control group had more dense capsular opacification than all experiment groups. Three months after operation, experiment group 4 (intraocular lens and intracapsular ring) developed less capsular opacification than

control and experiment groups 2 and 3 (Fig. 1).

Evaluation of posterior capsular opacification and obstruction of visual light by optical power meter

The power of visual light before passing the posterior capsule was 20.9 mW. The power of visual light after passing the posterior capsule was 3.9 mW in control group, 13.0 mW in group 1, 12.0 mW in group 2, 8.8 mW in group 3 and 17.3 mW in group 4. There were statistically significant differences among control and all the experiment groups, except between groups 1 and 2. Group 4 (intraocular lens and intracapsular ring) developed the least posterior capsular opacification, and group 3 (intracapsular ring only) had less capsular opacification than control group (Table 2).

Examination of the specimen under the operating microscope

The enucleated eye was bisected coronally after formalin fixation and the cornea, iris and vitreous was removed. Then the degree of PCO was observed under the operating microscope. In the control group, not only severe posterior capsular opacification but also cortex proliferation and Sommering's ring were found. The same findings were observed in groups 1, 2 and 3, but the amount was less than in control group. In group 4 (intraocular lens and intracapsular ring), the least amount of posterior capsular opacification was demonstrated and it developed along the area in the absence the haptic or ring (Fig. 2).

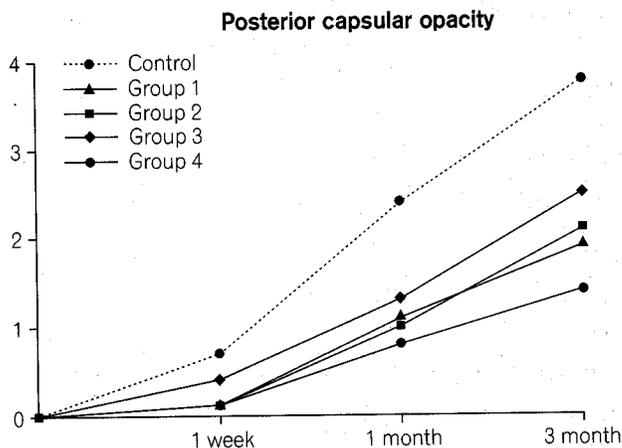


Fig. 1. The grade of PCO by direct ophthalmoscopic examination showed the least PCO in group #4.

Table 2. The Obstruction of Visual Light Measured by Optical Power Meter (3# Months after Operation)

Group	Mean (%)	Standard deviation
Control (ECCE only)	79.6	3.3
Group 1 (IOL horizontal)	37.4	13.6
Group 2 (IOL vertical)	41.5	7.5
Group 3 (Ring)	57.2	6.9
Group 4 (Ring & IOL)	16.4	5.4

There were statistically significant differences among all groups ($p < 0.05$) except between groups 1 and 2 ($p > 0.05$).

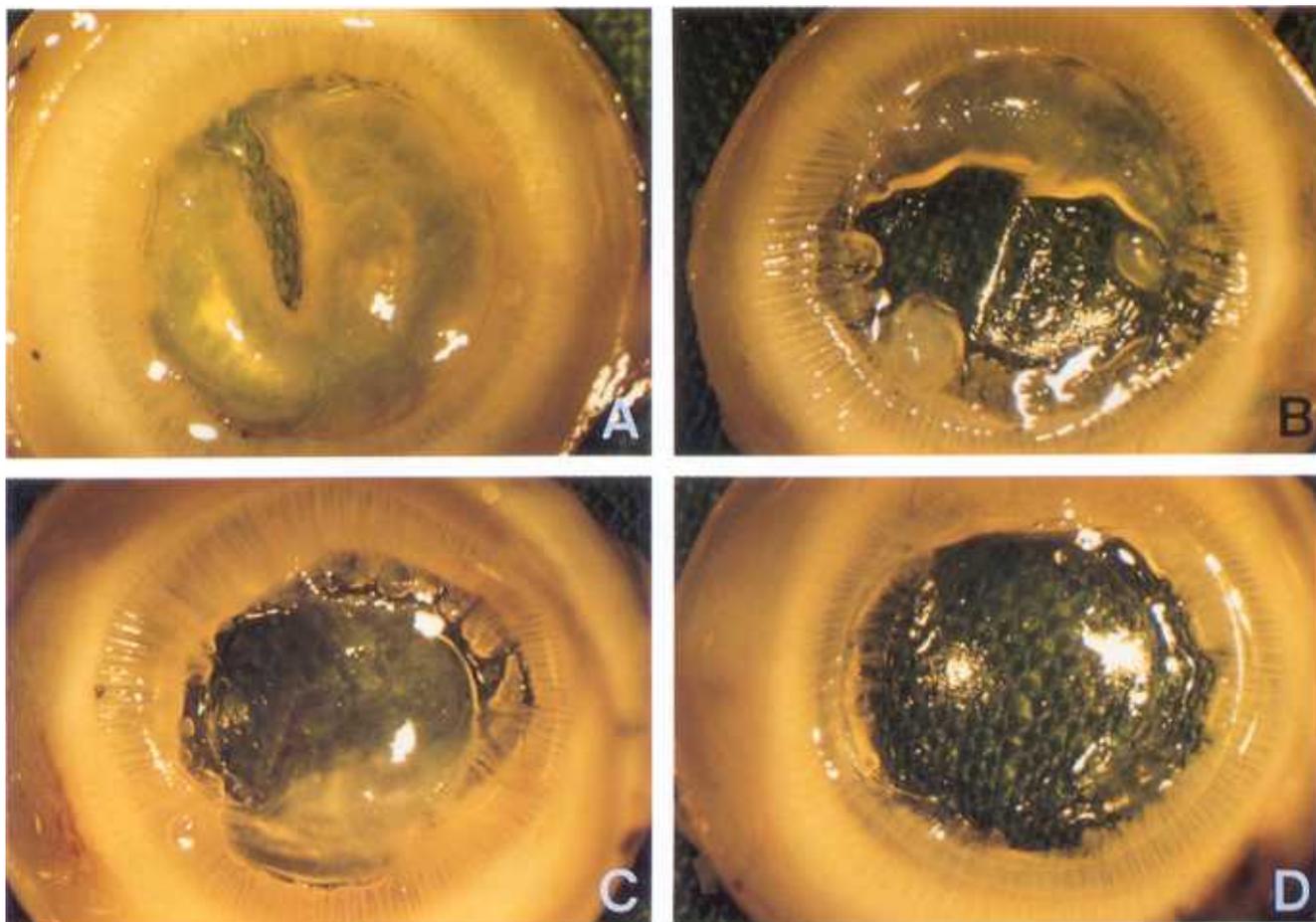


Fig. 2. Operating microscopic finding 3 months after operation. (A) Newly developed lens cortex almost formed a new lens in the control group. (B) Group 3 with intracapsular ring shows a smaller amount of lens material than control group. (C) Group 1 with intraocular lens shows new lens material along the area without the haptic of intraocular lens. (D) The least amount of capsular opacification developed in group 4 with intraocular lens and intracapsular ring.

Ocular examination after operation

All the conjunctival findings after operation including injection, subconjunctival hemorrhage and edema were subsided within 1 week in all the operated eyes. The corneal and anterior chamber inflammation were also subsided within 2 weeks in every case.

Histological examination

The abnormal histological findings were not found in the cornea, iris, ciliary body, retina and choroid under light microscopic examination.

DISCUSSION

The equatorial lens epithelial cells are known to induce PCO.³⁶ A part of the anterior capsule is removed during cataract surgery, therefore the amount of remaining lens epithelial cells depends on how much of the anterior capsule is removed and this can influence posterior capsular opacification.⁸ We made a linear incision of the anterior capsule during surgery instead of removing the anterior capsule and therefore the effect of the anterior capsule was minimized. As well, PCO was induced rapidly because we left all possible lens epithelial cells.

The main sources of PCO are known to be the remaining lens epithelial cells and the cortex remnant after cataract surgery.²¹ Other factors known to induce PCO are inflammatory cells, pigment, protein,

and the complement system which are all induced by inflammation after surgery.^{12,21,27} Therefore, inflammation after surgery could influence PCO, but there were no significant differences in inflammation after surgery among the operated eyes and we could exclude the effect of inflammation.

The degree of PCO can be evaluated by direct ophthalmoscopy, slit lamp biomicroscopy and histological evaluations. However, these methods are based on subjective findings and they do not represent the actual obstruction of visual light objectively. Therefore, we used an optical power meter to evaluate visual obstruction objectively. The results could also represent clinical visual obstruction because the light was passed through the central posterior capsule at 8mm diameter. As we expected, the results showed that the combined use of the intraocular lens and intracapsular ring was the best method of preventing PCO. The intracapsular ring alone can also prevent PCO compared to extracapsular cataract extraction only, and that means the haptic portion could prevent PCO.

The mechanism of prevention of PCO by haptic could be explained by maintaining the tension of the posterior capsule and mechanical barrier to the lens epithelium. The intracapsular ring could locate at the equator portion of the capsular bag, and could therefore contact the lens epithelial cells and prevent posterior migration of the lens epithelium. It also stretches the posterior capsule 360 degrees and maintains the tension of the capsule which could also prevent migration of the lens epithelium.

According to our results, the haptic portion of the intraocular lens can play an important role in the prevention of PCO. Therefore, the haptic portion of the intraocular lens could be considered as an important part of the intraocular lens in the development of a new intraocular lens. The intracapsular ring could be used in cataract surgery for the purpose of prevention of PCO and increasing the stability of the capsular bag. However, more objective study may be required to evaluate the clinical effect of the intracapsular ring, and it is also necessary to use methods that can be tested more objectively.

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