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The Effect of Capsular Tension Ring on Posterior Capsular Opacity in Cataract Surgery

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This study was performed to evaluate the efficacy and safety of the capsular tension ring on posterior capsular opacity in comparison with cases undergoing intraocular lens (IOL) implantation alone. We analyzed 127 eyes which had undergone cataract surgery, including capsular tension ring insertion, along with 127 eyes which had undergone IOL implantation alone by the same surgeon from September 1998 to March 2003. In the insertion group, 41 eyes (group A) had been followed up for more than one year after silicone IOL implantation, as had 40 eyes (group B) in the control group. We compared the incidence, type, and degree of capsular opacity between A and B groups and also endothelial cell loss after surgery between the two groups. For insertion group A, the frequency of posterior capsular opacity was lower(7.3%), the duration to development was longer, and the energy required for Nd-Yag capsulotomy of PCO was less than for control group B (25%) (p=0.037). The endothelial cell count loss rate was not significantly different between the two groups (p=0.522). The capsular tension ring is associated with a significantly reduced incidence of posterior capsular opacity and is a safe procedure.

Key words: Capsular tension ring, Cataract surgery, Posterior capsular opacity

The capsular tension ring, first used by Hara et al. in 1991 to maintain the shape of the capsular bag after the insertion of intraocular lens (IOL), has been used for the role of structural support when lens subluxation or lens zonulysis occurs, and it has been reported to play a role in the fixation of stable IOL position by preventing anterior capsular contracture.[1,2,3] In addition, it has been expected to have a preventive effect on posterior capsular opacity that is currently accepted as an unavoidable side effect after cataract surgery. We have reported already that the after-cataract development rate 1 year after the use of the ring was significantly lower than without the insertion.[4] The incidence of posterior capsular opacification increases with lengthening postsurgical period. Given that continuous follow-up observation for patients with good vision is difficult due to the characteristic of cataract patients, and to produce more realistic effects, follow-up observation of a maximum 1 year after insertion is considered insufficient in some aspects. Therefore, to examine the ring's stability and effect on the prevention of the posterior capsule opacification, we compared the results obtained from a larger population for a long observation period with a control group without the insertion of the ring.

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MATERIALS AND METHODS

The study population was 127 eyes (insertion group) that had undergone capsular tension ring (Lucid Korea, Korea) insertion during cataract surgery performed by one surgeon (CKJ) from September 1998 to March 2003, and 127 control eyes without ring insertion. Retrospective analysis was performed based on their medical records. The control group

comprised age and gender-matched individuals who underwent cataract surgery by the same surgeon (Joo, C) during a similar period to minimize the error of the incidence of posterior capsule opacification due to differenced of gender, age and surgical techniques.

The PMMA capsular tension ring (Lucid Korea, Korea) inserted in the patients has a small hole that facilitates manual maneuvers during surgery and is attached to both ends of the loop. The loop diameter is 11 mm when the eyelets of both ends of the loop contact with each other, and 13 mm when it is extended. The cross section is a circle of diameter 0.17 mm. The external surface of the loop that contacts the equator lens capsule has a smooth surface, is elastic, and it can be inserted through a small incision (3.0-3.2 mm). Both ends of the loop can be placed within the lens capsule by a method similar to the insertion of the support structure of IOL.

Surgery was performed after topical anesthesia with 4 % lidocaine. A 3.2-mm length clear corneal incision was made in the temporal side, and a 1-mm side port was made to the 6 or 12 o'clock direction. Under the anterior injection of viscoelastic material, circular capsulorhexis 5-6 mm in diameter was performed using capsulorhexis forceps (Rheine, USA). During surgery, as many remnant lens epithelial cells as possible were removed by an automatic perfusion aspiration instrument under perfusion with balanced salt solution. After the phacoemulsification of the cataract, the inside of the lens capsule was filled with viscoelastic material, IOL was inserted in the capsule after the insertion of the capsular tension ring in the insertion group but without the insertion in the control group, viscoelastic material was removed, and surgery was completed without suturing.

To examine the effect of the capsular tension ring on the prevention of posterior capsule opacification, the control group to be compared was selected again, and the follow-up observation period after surgery was assessed. As the development frequency of posterior capsule opacification is associated with the IOL material, and thus after the reassessment of the lens material, the subject entry criteria were narrowed to include, firstly, cases visiting outpatient clinics for follow-up observation of duration longer than one year, and secondly, cases with inserted silicone IOL, as this material has a frequency of posterior capsule opacification that is generally known to be high. These criteria reduced the groups to 41 eyes in the insertion group (insertion group A) and 40 eyes in the control group (control group B) that had silicone IOL implanted and were followed up for more than one year. In our study, the definition of the development of post capsule opacification was cases that underwent laser posterior capsule incision due to the deterioration of vision. In the two groups, the frequency of the YAG laser procedure, interval from original surgery to the development, type of posterior capsule opacification, and total energy at the time of YAG laser procedure were compared. To assess the stability of the capsular tension ring, all cases who had reduced vision one week after surgery were excluded since their follow-up observation was not sufficient. Also excluded were the cases predicted to have poor vision after surgery based on presurgical medical record. The maximum vision after surgery, frequency of lower vision than before surgery, and significant reduction of corneal endothelial cells were compared between the two groups.

RESULTS

The male/female ratio was 54:73 in the insertion group and 61: 66 in the control group. At the time of surgery, the average age was 63.33±13.4 years (30-89 years) and 67.55 ±12.5 (39-89 years), respectively, and the difference was not statistically significant. The mean follow-up period of insertion group A was 3±2.64 years (1-5 years), of control group B was 2.1±1.4 years (1-5 years), and the difference

Table 1. Comparsion of follow-up duration between groups A and B

	Group A (tension ring-over 1year-silicone IOL*)	Group B (control-over 1year-silicone IOL*)	P value†
Number of eyes	41	40	
Follow- up duration (years)	3.00±2.64	2.10±1.40	0.432

*IOL: intraocular lens, † t test for equality of means

Table 2. Characteristics of posterior capsular opacity between groups A and B

	Group A (tension ring-over 1year-silicone IOL*)	Group B (control-over 1year-silicone IOL*)
Interval to development of PCO† (months)	34.33±7.63	27.30±13.26
Total energy of Nd-Yag laser capsulotomy (mJ)	272.63±199.81	338.70±179.25

*IOL: intraocular lens, † PCO: posterior capsular opacity.

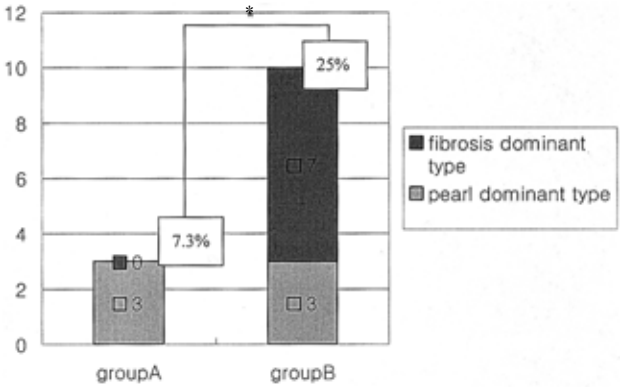

Fig. 1. Comparison of the incidence and type of posterior capsular opacity between groups A and B.
*statistically significant difference (p=0.037 on Fisher's exact test)

was not statistically significant (p=0.432) (Table 1). Three cases (7.3%) developed posterior capsule opacification in insertion group A and 10 (25%) in control group B. The development frequency in the insertion group was significantly lower (p=0.037) (Fig. 1). The interval to the development was 34.33±7.63 months (24-41 months) in insertion group A and 27.30±13.26 months (2-52 months) in control group B (Table 2). The posterior capsule opacification type was classified as either pearl dominant or fibrosis dominant. All 3 eyes in insertion group A were pearl dominant type and among the 10 eyes in control group B, 3 were fibrosis dominant type and 7 were pearl dominant type (Fig. 1). The total energy of laser in insertion group A was 272.63±199.81 mJ (110.9-496 mJ), which was lower than the 338.70±179.25 mJ (155.6-655.6 mJ) of control group B (Table 2).

To assess the safety of the capsular tension ring, the total 127-member insertion and control groups were compared. After the exclusion of cases with vision records shorter than one week and with poor prognosis due to other definite causes, the insertion group comprised 107 eyes and the control group 105 eyes. Cases with postsurgical vision worse than before surgery were not detected in either group.

Corneal endothelial cell test was conducted both before and after surgery to examine whether the capsule tension ring damages corneal endothelial cells. This comparison was performed only on the cases in which specular microscopy was performed before surgery and 2 months after surgery, which reduced both insertion and control groups to 57 eyes. In the comparison of the endothelial cell density, the presurgical density was 2,623.76±332.39/mm^2 (1,801-3,378/mm^2) in the insertion group and 2,657.53±401.42/mm^2 (1,455-3,546/mm^2) in the control group, with the difference not being significant (p=0.624, unpaired t-test) (Fig. 2). The reduction rate in the insertion group was 18.40±22.89% (12.56% increase - 74.56% reduction), and in the control group was 19.70±19.75% (10.57% increase - 64.14% reduction), with the difference not being statistically significant (p=0.522, unpaired t-test) (Table 3).

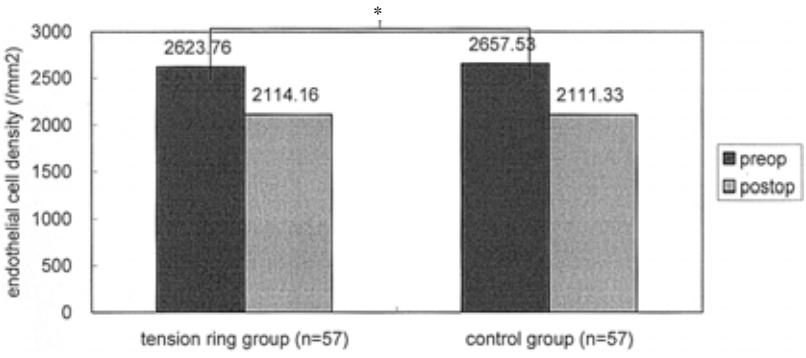

Fig. 2. Comparison of the mean preoperative and postoperative endothelial cell density between the tension ring group and the control group.
*no statistically significant difference (p=0.624, unpaired t test)

Table 3. Comparison of corneal endothelial cell loss on specular microscopy after surgery between the tension ring group and the control group

	Tension ring group	Control group	P value*
Number of eyes	57	57	
Cell loss rate (%)	18.40±22.89	19.70±19.75	0.522

*t test for equality of means

DISCUSSION

Various reports have described the function of the capsular tension ring that was first used to maintain lens capsule morphology after IOL insertion in the prevention of after-cataract. In addition, we have reported the effect of the PMMA capsule tension ring that was developed in Korea.[4] However, since that report was the result of only a one-year follow-up since 1998, the present study was initiated to assess the long-term effect. The incidence of posterior capsule opacification was 30-50 % in the 1980s and 1990s when the importance of the removal of the remnant cortex and lens epithelial cells was not recognized. However, according to Schaumberg DA et al. (1998), the incidence was 11.8% at 1 year after surgery, 20.7% at 3 years and 28.4% at 5 years.[5,6] Posterior capsular opacification is classified by morphology into two types: fibrosis and pearl. In the former, A cells remaining in the anterior capsule proliferate through fibrous metaplasia, express α-smooth muscle actin, have elasticity, and form cell membrane by secreting extracellular matrix components and basal lamina analog, thereby inducing the fold and posterior capsule opacification that result in vision reduction. E cells in the equator of the lens capsule are germinal cells that normally and throughout their life time migrate from the lens equator to the medial side, and form the nucleus, epinucleus and cortex. They are important cells causing posterior capsule opacification after cataract surgery and are a major cause of the pearl type posterior capsular opacification. However, since both A cells and E cells can cause the two types of posterior capsule opacification, and thus cause posterior capsule opacification developed after cataract surgery, these two types may be mixed.[7] Based on the assumption that posterior capsule opacification is the phenomenon of the migration of remnants cells to the posterior capsule, and since a capsule tension ring contacts the entire 360 degrees of the lens equator, it has been known to physically block the migration of lens epithelial cells and the posterior invasion of deformed fibroblasts, and thus to effectively suppress posterior capsule opacification.[8,9] In terms of the prevention of posterior capsule opacification, the factors pertinent to surgery are the removal of the cortex that can be strengthened by hydrodissection, the in-the-bag fixation of IOL and the incision smaller than the optics that barely covers the IOL surface, whereas the factors pertinent to IOL are the biocompatibility that can suppress the proliferation of lens epithelial cells, the maximal IOL optic-posterior capsule contact, and the barrier function of the optic itself and the square truncated edge.[10-13] This last factor is based on the capsular bend theory that explains the preventive effect of the capsule tension ring on posterior capsule opacification.[14,15] The mainstream IOL material that has been inserted since the late 1990s, following the introduction of surgery with a 3-mm small incision window, is polyacrylic and silicone. According to Hollick et al,[16] the incidence of posterior capsule opacification in silicone lens was 40%, which was significantly higher than the 10% for polyacrylic material. Therefore, in the cases with silicone inserted IOL, there is a more urgent need for a means to prevent posterior capsular opacification.

According to our study, the lens material of the majority of cases was silicone: 57.4% of the insertion group and 63.5% of the control group. Among the patients without reduced vision who did not feel the necessity for long-term visit, the follow-up observation record in some cases was as short as 1 month after surgery. Therefore, less than half of the total insertion group of 127 eyes could be assessed 1 year after the surgery for the development of posterior capsule opacification.

In addition, since the comparison had to be made under the assumption that the IOL material was identical in both groups, only patients with silicone lens were included. Hence, the study population was unfortunately reduced to only 41 insertion and 40 control eyes. In conclusion,

posterior capsule opacification was developed in only 3 insertion eye cases (7.3%), and in only 10 control group cases (25%), which confirmed the statistically significant, preventive effect of the capsule tension ring on the reduction of the incidence of posterior capsule opacification. However, it must be considered that the patients who dropped out during the follow-up observation were excluded, and that the follow-up period ranged from 1 year to 5 years, and that, therefore, the true incidence is considered to have been much lower than the recorded 7.3% and 25%. Hence, it is considered that the incidence higher than other studies may not be taken seriously, and that the truly significant finding was the difference of the incidence between the two groups. In addition, the limitation of our study was that posterior capsular opacification after surgery was developed only in 3 eyes. Consequently, the comparison of the interval from prior to surgery to the development of posterior capsule opacification after surgery, the posterior capsule opacification type, and the total energy value during laser operation could not be assessed to the level of statistical significance. Paradoxically, this may be interpreted to indicate that the incidence was too low to analyze statistically; nevertheless, for accurate comparison a larger number of study subject eyes must be collected in any future research.

Analyzing the comparison of numbers only, the ring insertion not only reduced the incidence but also delayed the development time. In regard to the posterior capsule opacification type, all 3 eyes in the insertion group were the pearl type, which may be interpreted, given that the site of the insertion is the equator, to indicate that the intervention of the migration of A cells in the anterior capsule after fibroblast metaplasia may be more effective than the migration of E cells in the equator. However, considering that the pearl type occurs more frequently than the fibrosis type, this issue needs to be confirmed in future study. During laser operation, it is desirable to minimize the total energy value to prevent complications such as retina detachment, etc., and we anticipated that the posterior capsule would be ruptured only with low laser radiation since the pearl type utilizes less energy than the fibrosis type generally and as the capsule tension ring plays a role to pull the posterior capsule tightly from the 360 degree direction. The total energy of YAG laser of the insertion group was 272.63±199.81 mJ (110.9-496 mJ) and of the control group was 338.70±179.25 mJ (155.6-655.6mJ). However, because of the sample size statistical analysis was not feasible.

In our cases, the insertion of the capsule tension ring did not prolong surgery time and no complications occurred due to the insertion. However, the surgical safety was examined in terms of the insertion of a foreign material, and no reduced vision was detected after surgery in comparison with that before surgery in either group. In the comparison that assessed the damage of the corneal epithelial cells caused by the capsule tension ring applying the result of corneal endothelial cell test before and after surgery, a statistically significant difference in reduction rate was not detected. The capsule tension ring may therefore be considered safe.

In conclusion, the capsule tension ring is effective and safe for the reduction of the incidence of posterior capsule opacification. A long-term follow-up study in is required in the future.

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