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The effect of capsulorhexis size on development of posterior capsule opacification: Small (4.5 to 5.0 mm) versus large (6.0 to 7.0 mm)

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PURPOSE. *The most common surgically related cause of reduced vision after extracapsular cataract extraction is posterior capsule opacification (PCO), which occurs in up to 50% of eyes following cataract extraction. This study examined whether small capsulorhexes of 4.5 to 5.0 mm, which lie completely on the 5.5 mm intraocular lens (IOL), and large capsulorhexes of 6.0 to 7.0 mm, which lie completely off the lens optic, are effective in preventing PCO development.*

METHODS. *In this prospective study, 496 eyes of 367 patients underwent standardized phacoemulsification with capsulorhexis and capsular bag foldable acrylic IOL implantation. The patients were randomly assigned to receive either a small capsulorhexis of 4.5 to 5 mm to lie completely on the IOL optic or a large capsulorhexis of 6 to 7 mm to lie completely off the lens optic. Retroillumination photographs were taken at 6 months and then yearly.*

RESULTS. *Throughout the follow-up, there was less PCO in the small capsulorhexis group than in the large capsulorhexis group.*

CONCLUSIONS. *Small capsulorhexes were associated with less wrinkling of the posterior capsule and less PCO than were large capsulorhexes. PCO after IOL implantation has a multifactored pathogenesis. Small (4.5 to 5.0 mm) capsulorhexis and capsular bag implantation of 5.5 mm acrylic IOL are likely to reduce the PCO incidence when compared with the 6.0 to 7.0 mm capsulorhexis. The significance of the IOL optic diameter in association with the capsulorhexis size should also be documented by further studies. (Eur J Ophthalmol 2003; 13: 541-5)*

KEY WORDS. *Capsulorhexis, Posterior capsule opacification, Phacoemulsification*

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INTRODUCTION

Posterior capsule opacification (PCO) or aftercataract is a major complication of cataract surgery. Postoperative lens epithelial cell proliferation and migration within the capsular bag after extracapsular cataract extraction causes PCO (1-3). Fibrotic membrane formation with or without Elschnig pearls on the posterior capsule brings about the opacification and patients experience a decrease in visual acuity (1). The incidence of PCO is estimated to be up to 50% within 5 years after surgery (1). The standard treatment for PCO is neodymium:YAG (Nd:YAG) laser capsulotomy (1), which has been associated with retinal detachment, increase of intraocular pressure, cystoid macular edema, and damage to the intraocular lens (IOL). Current clinical research on the prevention of PCO focuses on surgical techniques, changes in

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IOL material and designs, and pharmacologic methods; authors have examined extensive intraoperative polishing of the anterior and posterior capsules (4), the use of lenses with posterior convexity to ensure closer IOL-capsule contact (5-7), and application of several antimitotic drugs or anti–lens epithelial cells (LEC) immunologic agents (8,9).

Continuous curvilinear capsulorhexis (CCC) allows true capsular bag fixation of the IOL with better centration and has become a routine procedure in cataract surgery (10). The severity of the blood–aqueous barrier breakdown and the foreign body cellular reaction on the IOL surface are reduced by the intact capsulorhexis, which prevents contact between the IOL and uveal tissue (11).

The ideal diameter of the capsulorhexis is particularly important. There are some advantages and disadvantages of both the small and large diameter capsulorhexes (12,13). The effect of the size of the capsulorhexis on PCO is unclear. PCO results from the proliferation of LEC remaining in the equator of the capsular bag and under the anterior lens capsule (1). After surgery, a wound healing response with cellular proliferation and laying down of extracellular matrix is induced and these residual cells proliferate and migrate over the capsule to produce Elschnig pearls or transform into myofibroblasts and cause capsular fibrosis (14). It has been shown that the anterior epithelial cells in both rabbits and humans initially undergo proliferation and by 4 days after surgery transform into myofibroblasts starting at the cut edge of anterior capsule and by 1 week a ring of fibrosis forms around the rhexis where it touches the posterior capsule in the aphakic eye (15,16). Lens epithelial cells at the equator of the capsular bag are believed to be the most important in the pathogenesis of PCO and it has been postulated that a large capsulorhexis with a diameter greater than the IOL optic will allow fusion of the anterior capsular flap to the posterior capsule, creating a mechanical barrier to LEC migration from the equator, leading to a reduced incidence of PCO (17,18). If the capsulorhexis opening is smaller then the lens optic, the anterior capsule leaf is separated from the posterior capsule by the IOL, leading to an increase in LEC ingrowths and PCO development (19). The opposing view is that anterior capsular LEC are responsible for the development of PCO (14). In this case, a large capsulorhexis appears to facilitate migration of LEC from the anterior capsule onto the posterior capsule, increasing PCO production (20). Other views are that a larger capsulotomy will reduce PCO by removing more LEC and increasing the distance for the cells to migrate to the visual axis. Another hypothesis is that LEC proliferate after capsulotomy because they have been released from contact inhibition and that a smaller anterior capsulotomy will release fewer cells from this inhibition and therefore decrease LEC proliferation (21).

This prospective study demonstrates that capsular capsulorhexis size and its relation to the IOL has a significant influence on the rate of PCO.

MATERIALS AND METHODS

Between 1999 and 2002, 5.0 mm (Group I) or 6.0- to 7.0-mm (Group II) capsulorhexis and 5.5 mm foldable acrylic IOL implantations were performed in uncomplicated cataract extraction of 496 eyes of 367 adult patients without any medical or ocular history. Group I consists of 256 eyes of 198 patients; 240 eyes of 169 patients were included in Group II. Patient ages ranged from 57 to 87 years (mean 66). No difference existed in age and sex distribution between the two groups.

All patients were operated for cataract by one surgeon (A.H.B.) and the same surgical technique was used to remove the crystalline lens. Phacoemulsification was performed through a 5.0 mm anterior capsulorhexis using a standard two-handed divide and conquer technique. The patients were randomly chosen preoperatively to receive either a small capsulorhexis of 5.0 mm in diameter or a large capsulorhexis of 6.0 to 7.0 mm in diameter. The small capsulorhexis free edge had to be located on the IOL optic for 360 degrees whereas the edge of the large capsulorhexis had to be located peripherally to the IOL optic or, if it was eccentric, had to have less than 180 degrees on the lens optic. Both anterior and posterior capsule polishing was performed in order to reduce LEC. All patients had a 5.5 mm optic diameter three-piece foldable acrylic IOL (MA30BM Alcon) implanted in the capsular bag after it was refilled with Healon. Healon was aspirated from the capsular bag and the anterior chamber. Postoperative treatment consisted of instillation of three different eye dropsindomethacin, ciprofloxacin, and prednisolone- four times daily for 1 month.

At 6 months, 1 year, 2 years, and 3 years after surgery, pupils were dilated with a mixture of tropicamide and phenylephrine and the eyes were evaluated at the slit lamp. Standardized photographs of the pseudophakic anterior segment were obtained with a Nikon FS-2 digital slit lamp using retroillumination and lateral illumination. The PCO site is evaluated in relation to the capsulorhexis edge location relative to the IOL optic and graded qualitatively as Grade I (peripheral), Grade II (paracentral), or Grade III (central).

The photographs taken at different time intervals were evaluated by two observers for the presence of posterior capsule fibrosis or Elschnig pearl formation.

Chi-square test was used to analyze the presence of PCO. Kolmogorov Smirnov test was used to make a comparison according to grading for each period.

RESULTS

A total of 367 patients were enrolled randomly to each capsulorhexis size group: 256 eyes of 198 patients had small capsulorhexis and 240 eyes of 169 patients had large capsulorhexis. Four patients from Group 1 were excluded because the capsulotomies were not completely on the IOL optic and six patients were excluded from Group 2 because the capsulorhexes were in contact with the IOL for more than 180 degrees. The overall complete follow-up rates were 97.9% for 6 month follow-up, 92.4% for 1 year follow-up, 88.3% for 2 year follow-up, and 81.3% for 3 year follow-up in Group 1 and 96.4% for 6-month follow-up, 92.3% for 1 year follow-up, 86.9% for 2 year follow-up, and 84.0% for 3 year follow-up in Group 2.

The average age was 66 years, with a range of 57 to 87 years. No difference existed in age and sex distribution between the two groups.

Comparisons of the two groups for the presence of PCO are shown in Table I. In each examination period, there is a statistically significant difference between the two groups.

In the small capsulorhexis group, 4.76% of patients had grade 1, 1.98% of patients had grade 2, and no patients had grade 3 PCO at 6 months; 11.10% had grade 1, 6.80% had grade 2, and 1.23% had grade 3 with large capsulorhexis (Tab. I). Patients with small capsulorhexis were significantly less likely to have PCO than were those with large capsulorhexis ($p<0.0001$).

A total of 4.52% of patients had grade 1, 1.87% had grade 2, and 1.68% had grade 3 PCO in the small capsulorhexis group at 1 year, compared with 13.00%, 7.07%, and 5.75% of the large capsulorhexis group ($p<0.00001$).

Patients with small capsulorhexis were significantly less likely to have PCO than were those with large capsulorhexis at 2 and 3 years ($p<0.00001$ and $p<0.0001$). Table II shows a comparison of the groups according to grading for each period. In each examination period, there was a statistically significant difference according to PCO grade ($p<0.05$).

DISCUSSION

PCO, one of the most common complications of phacoemulsification with IOL implantation, occurs in up to 50% of eyes by 5 years postoperatively. The standard treatment for PCO is Nd:YAG laser capsulotomy, which is expensive and has been associated with retinal detachment, intraocular pressure increase, cys-

TABLE I - COMPARISON OF THE GROUPS ACCORDING TO THE PRESENCE OF POSTERIOR CAPSULE OPACIFICATION (PCO)

	PCO^+		PCO^-		
Period	**Group 1**	**Group 2**	**Group 1**	**Group 2**	**χ^2; p**
6	17	42	229	184	χ^2 = 23.25; <0.0001
1	25	77	208	139	χ^2 = 39.64; <0.00001
2	31	74	192	129	χ^2 = 29.10; <0.00001
3	36	89	169	107	χ^2 = 36.22; <0.0001

TABLE II - COMPARISON OF THE GROUPS ACCORDING TO GRADING FOR EACH PERIOD

Period	Group	Absent	PCO Grade 1	PCO Grade 2	PCO Grade 3	Kolmogorov Smirnov Test, p
6 months	1	229	12	5	0	<0.05
	2	184	26	16	3	
1 year	1	208	14	7	4	<0.05
	2	139	42	23	12	
2 years	1	192	16	10	5	<0.05
	2	129	45	20	9	
3 years	1	169	17	13	6	<0.05
	2	107	49	33	7	

PCO = Posterior capsule opacification

toid macular edema, and IOL damage.

Several techniques have been advocated to reduce the incidence of PCO, including intraoperative polishing of the anterior and posterior capsules, the use of lenses with posterior convexity to ensure closer IOL capsule contact, and application of several antimitotic drugs or anti-LEC immunologic agents.

The correlation of capsulorhexis contact with the IOL optic with the presence of PCO in our study clearly indicates that if the capsulorhexis edge is completely on the IOL optic, the likelihood of PCO development at all examination periods is less than if the capsulorhexis is partly or completely off the optic. Ravalico et al reported that capsulorhexis with slightly smaller diameter than the IOL optic decreased PCO incidence when compared to large capsulorhexis (20). The complete in-the-bag fixation provides an accurate lens centration and enhances the IOL-optic barrier effect. In cases where one or both haptics are out of the bag, a potential space exists that allows for ingrowth of cells and PCO formation. Instead, a tight fit of the capsule around the optic may be provided by creating an ideal CCC with edge on the IOL surface. In one study, the tight adhesion of capsulorhexis edge around the lens optic was concluded to help sequester the interior compartment of the capsule, containing the IOL optic from the surrounding aqueous humor and any potentially deleterious factor (22). IOL implantation in the capsular bag was also suggested to cause less inflammation and PCO formation when compared with sulcus fixation (23). The authors concluded that using a large CCC does not affect the total amount of after-cataract but may enhance the inflammatory response.

Polyacrylic lenses are associated with a low incidence of PCO (24,25). Recently, two comparative studies concluded that Acrysof lens implantations resulted in lower rates of PCO formation (26,27). Pohjalainen et al also suggested that concurrent ocular disease did not seem to increase the risk of PCO formation in acrylic IOL implanted eyes when compared with silicone IOL implanted eyes (27). This may be evidence of the material effect of Acrysof on PCO formation. Our observations also support these studies. We emphasize, however, that there appears to be a stronger interaction between the capsule and acrylic IOL that prevents PCO development in cases where the rhexis overlaps the optic. The capsulorhexis should be continuous and of a diameter that will just overlap the lens edges completely. Small capsulorhexis covers the edges of the lens and increases contact between the IOL and the posterior capsule and reduces the incidence of PCO. We suggest that 360-degree full interaction of anterior capsular flap to the polyacrylic lens has an important role in reducing PCO development. A possible mechanism may result from both bioadhesiveness of acrylic lenses and full capsule-IOL interaction yielding LEC inhibition.

The ideal diameter of the capsulorhexis has yet to be elucidated. In a recent study, in patients with a rhexis larger than the IOL, Acrysof IOL were found to cause potentially less PCO formation than a polymethyl methacrylate IOL with a similar rhexis size (28). Our study indicates that the frequency of PCO is much lower in cases with small capsulorhexes where the anterior capsule was 360 degrees on the optic than with large capsulorhexes.

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REFERENCES

1. Apple DJ, Solomon KD, Tetz MR, et al. Posterior capsule opacification. Surv Ophthalmol 1992; 37: 73-116.
2. Ohadi C, Moreira H, Mc Donnell PJ. Posterior capsule opacification. Curr Opin Ophthalmol 1991; 2: 46-52.
3. Kappelhof JP, Vrensen GFJM. The pathology of after-cataract; a minireview. Acta Ophthalmol 1992; 205 (Suppl): S13-24.
4. Nishi O, Nishi K, Sakka Y, et al. Intercapsular cataract surgery with lens epithelial cell removal. Part IV: capsular fibrosis induced by poly(methylmethacrylate). J Cataract Refract Surg 1997; 17: 471-7.
5. Sterling S, Wood TO. Effect of intraocular lens convexity on posterior capsule opacification. J Cataract Refract Surg 1986; 12: 655-7.
6. Sellman TR, Lindstrom RL. Effect of a plano-convex posterior chamber lens on capsular opacification from Elschnig pearl formation. J Cataract Refract Surg 1988; 14: 68-73.
7. Born CP, Ryan DK. Effect of intraocular lens optic design on posterior capsular opacification. J Cataract Refract Surg 1990; 16: 188-91.
8. Legler UFC, Apple DJ, Assia EI, et al. Inhibition of posterior capsule opacification: the effect of colchicine in a sustained drug delivery system. J Cataract Refract Surg 1993; 19: 462-9.
9. Power WJ, Neylan D, Collum LMT. Daunomycin as an inhibitor of human lens epithelial cell proliferation in culture. J Cataract Refract Surg 1994; 20: 287-90.
10. Martin RG, Sanders DR, Souchek J, et al. Effect of posterior chamber intraocular lens design and surgical placement upon postoperative outcome. J Cataract Refract Surg 1992; 18: 333-41.
11. Miyake K, Asakura M, Kobayashi H. Effect of intra ocular lens fixation on the blood aqueous barrier. Am J Ophthalmol 1984; 98: 451-5.
12. Davidson JA. Capsule contraction syndrome. J Cataract Refract Surg 1993; 19: 582-9.
13. Young DA, Orlin SE. Capsulorhexis contraction in phacoemulsification surgery. Ophthalmic Surg 1994; 25: 477-8.
14. Cobo LM, Ohsawa E, Chandler D, Arquello R, George G. Pathogenesis of capsular opacification after extracapsular cataract extraction: an animal model. Ophthalmology 1984; 91: 857-63.
15. Mc Donnell PJ, Zarbin MA, Green WR. Posterior capsule opacification in pseudophakic eyes. Ophthalmology 1983; 90: 1548-33.
16. Mc Donnell PJ, Rowen SL, Glaser BM, et al. Posterior capsule opacification. An *in vitro* model. Arch Ophthalmol 1985; 103: 1378-81.
17. Tetz M, O'Morchoe D, Gwin T, et al. Posterior capsule opacification and intraocular lens decentration: experimental findings on prototype circular intraocular lens design, part 1. J Cataract Refract Surg 1988; 14: 614-23.
18. Kappelhof JP, Vrensen GFJM, de Jong PTVM, et al. An ultrastructural study of Elschnig's pearls in the pseudophakic eye. Am J Ophthalmol 1986; 101: 58-69.
19. Hiles DA, Johnson BL. The role of crystalline lens epithelium in postpseudophakos membrane formation. Am Intra-Ocular Implant Soc J 1980; 6: 141-7.
20. Ravalico G, Tognetto D, Palomba M-A, et al. Capsulorhexis size and posterior capsule opacification. J Cataract Refract Surg 1996; 22: 98-103.
21. Jacob TLC, Humphrey RC, Davies EG, Thompson GM. Cytological factors relating to posterior capsule opacification following cataract surgery. Br J Ophthalmol 1987; 71: 659-63.
22. Moghaddam ZJS, Huygens MMAV, Callebaut F. Neodymium:YAG Capsulotomy rates after phacoemulsification with hydrophobic and hydrophilic acrylic intraocular lenses. Bull Soc Belge Ophtalmol 2002; 283: 13-7.
23. Laurel CG, Zetterstrom C, Lundgren B. Phacoemulsification and lens implantation in rabbit eyes: capsular bag vs ciliary sulcus implantation and 4.0 versus 7.0 mm capsulorhexis. J Cataract Refract Surg 1998; 24: 143-4.
24. Oshika T, Suzuki Y, Kizaki H, et al. Two-year study of a soft intraocular lens. J Cataract Refract Surg 1996; 22: 104-9.
25. Ursell PG, Spalton DJ, Pande MV, et al. The relationship between intraocular lens biomaterials and posterior capsule opacification: a 2-year prospective randomized trial comparing PMMA, silicone and polyacrylic lenses. J Cataract Refract Surg 1998; 24: 350-60.
26. Beltrame G, Salvetat ML, Chizzolini M, et al. PCO and Nd:YAG capsulotomy rates after implantation of silicone, hydrogel and soft acrylic intraocular lenses: a two-year follow-up study. Eur J Ophthalmol 2002; 12: 388-94.
27. Pohjalainen T, Vesti E, Uusitab RJ, Laatikainen L. PCO in pseudophakic eyes with a silicone or acrylic intraocular lenses. Eur J Ophthalmol 2002; 12: 212-8.
28. Meacock WR, Spalton DJ, Hollick EJ, Barman S, Boyce JF. The effect of PMMA and Acrysof IOLs on the posterior capsule in patients with a large capsulorhexis. Jpn J Ophthalmol 2001; 45: 348-54.