ORIGINAL ARTICLE

ROLE OF 360° SQUARE EDGED PCIOL IN PREVENTING PCO

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ABSTRACT: CONTEXT: PCO is a common long term complication of cataract surgery. Considering the factors responsible for PCO, role of 360° square edged PCIOL in preventing PCO is studied. **AIMS:** To study the incidence of PCO in patients implanted with 360° square edged PMMA PCIOL after cataract surgery. **MATERIALS & METHODS:** Prospective study including 100 eyes of 100 patients diagnosed as having senile cataract. All of them underwent SICS by the same surgeon & were implanted with 360° square edged single piece PMMA PCIOL. **RESULTS:** Out of 100 patients implanted with 360° sharp edged PMMA PCIOL, 9 patients developed PCO during 3 yrs. follow-up period. Whereas, out of 100 patients implanted with round edge PMMA PCIOL during the same period, 22 patients developed PCO within 3 yrs. **CONCLUSION:** Incidence of PCO is less with 360° square edged PCIOL.

INTRODUCTION: Cataract surgery is currently the most common and well-established ophthalmic surgical procedure in the world. This procedure involves the extracapsular extraction of the natural opaque lens fibres and implantation of an intraocular lens (IOL), which restores good vision. However, posterior capsular opacification (PCO) is a common long term complication of cataract surgery.

The first IOL implantation was performed by Sir Harold Ridley in 1949. Since that time, technology has undergone a wide variety of improvements that reduced the incidence of PCO but did not eliminate it. Decreased visual acuity induced by PCO is reported to occur in 20% to 40% of patients 2 to 5yrs after surgery. It is not the capsule that opacifies, rather an opaque membrane develops as the retained lens epithelial cells proliferate and migrate onto the posterior capsule surface.

The interval between surgery and PCO varies widely, ranging from 3 months to 4 yrs after surgery. The causes of PCO are multifactorial. Cells having the potential to produce significant opacification are:

1. The cuboidal anterior epithelial cells.
2. Epithelial cells at the equatorial bow that has significant mitotic activity.[1]

The opacification usually takes one of two morphologic forms. One form consists of capsular pearls, which can consist of cluster of swollen, opacified epithelial pearls or clusters of posteriorly migrated equatorial epithelial (E) cell (Bladder or Wedl cells). It is probable that both LEC types can contribute to the fibrous form of opacification. Anterior epithelial (A) cells are probably important in the pathogenesis of fibrous PCO, since the primary type of response of these is to undergo fibrous metaplasia.[2,3,4]

PCO is certainly more common in young patients with uveitis or traumatic cataracts. This is partially related to disruption of blood-aqueous barrier.

Release of inflammatory Mediators and complement activation may also stimulate the proliferation of cells.[5] Certain cytokines such as interleukin-1 (IL-1), tissue necrosis factor (TNF) & interleukin-6(IL-6) can act as growth factors and may cause migration of inflammatory cells.

Sommerauer et al found PCO to occur 10 times more frequently in pseudo-exfoliation syndrome. This may be attributed not only to inflammation, but also to the fact that a much more cautious and less thorough cortical clean-up was performed in these cases by the surgeons to avoid disturbance to the delicate and fragile capsular and zonular apparatus present in such cases.

GRADING OF POSTERIOR CAPSULAR OPACIFICATION: PCO can be graded at slit-lamp using slit beam and retro-illumination technique.

PCO Grade	Description
0*	None, no evidence of PCO
1*	Trace, few discrete epithelial pearls
2†	Mild, Multiple discete epithelial pearls
3†	Moderate, Multiple coalescent epithelial pearls
4†	Severe, thick sheet of epithelial pearls

* <2 - lines drop in BCVA; clinically non-significant PCO

†>2 - lines drop in BCVA; clinically significant PCO

There are four IOL related and four surgical factors that are particularly important in the prevention of PCO.[6,7,8]

I. SURGICAL FACTORS:

1. Hydrodissection and enhanced cortical clean-up.
2. In the bag (capsular) fixation.
3. Capsulorhexis edge on IOL surface.
4. Sealed capsular irrigation.

II. OL RELATED FACTORS:

1. Biocompatible IOL to reduce stimulation of cellular proliferation.
2. Barrier effect of IOL.
3. Maximal IOL optic -posterior capsule contact angulated haptic, adhesive biomaterial to create a 'shrink wrap'.
4. IOL optic geometry- square truncated edge.

I. SURGICAL FACTORS:

1. Hydrodissection – enhanced cortical clean –up:

Thorough removal of cortex, best accomplished after CCC and with the help of

hydrodissection not only decreases the number of cells that have the potential to proliferate, but also reduces the potential for a lens induced inflammation that may in turn mediate and exacerbate the proliferative process towards PCO.

2. In the bag (capsular) fixation:

Advantage of in the bag fixation of IOL is the accomplishment of good optic centration and sequestration of IOL from adjacent uveal tissues, thus avoiding uveal chaffing & chronic breakdown of blood- aqueous barrier that often occurs after ciliary sulcus fixation of PCIOL.[9]

This also enhances the IOL barrier effect when the IOL stays in the bag & is in full contact with the posterior capsule. Secure capsular bag fixation, especially of one-piece PMMA IOLs is likely to create a radial stretch or tautness of the posterior capsule. This increases the contact between posterior capsule & IOL optic surface more than would occur if the capsule was not placed on a stretch.

The CCC technique clearly represents an evolutionary advance from the can-opener capsulotomy technique for this purpose of in the bag fixation of both the loops of IOL. The size and position of continuous curvilinear capsulorhexis (CCC) has been suggested to influence PCO. It is hypothesized that LECs more easily migrate from the anterior capsule onto the posterior capsule if the capsulorhexis margins are partially or totally outside the IOL optics. In case one or both haptics are not placed in the bag, a potential space is created allowing avenue for cells to grow posteriorly towards the visual axis.

3. CAPSULORHEXIS EDGE ON IOL:

If the IOL optic is 6 mm, the rhexis diameter would ideally be slightly smaller, perhaps 5.0-5.5 mm. This places the anterior capsularrhexis edge on the anterior surface of the optic, providing tight fit and helping to sequester the optic in the capsular bag from surrounding aqueous. This mechanism may support protecting the milieu within the capsule from some potentially deleterious factors within the aqueous, especially some macromolecules & inflammatory mediators.

II. IOL RELATED FACTORS:

1. IOL BIOCOMPATIBILITY:

Lens material biocompatibility is defined as the ability to inhibit stimulation of epithelial cellular proliferation. The less the proliferation, lower the chance for PCO formation. Surface modifications of PMMA IOLs by carbon & titanium, [10] heparin[11] & polytetrafluroethylene (Teflon; Dupont de Nemours, Wilmington, Delaware)[12] and of silicon IOLs by oxygen & carbon dioxide plasma[13] or a sulfonate & carboxylate group containing ploymer[14] have been reported to have higher biocompatibility & effectiveness in prevention of PCO. Recently, IOL surface modification by gas plasma[15] & polyethylene glycol[16] has been shown to influence LEC behavior & to prevent PCO.

2. BARRIER EFFECT OF THE IOL OPTIC:

The IOL optic barrier effect plays an important role as a second line of defence against

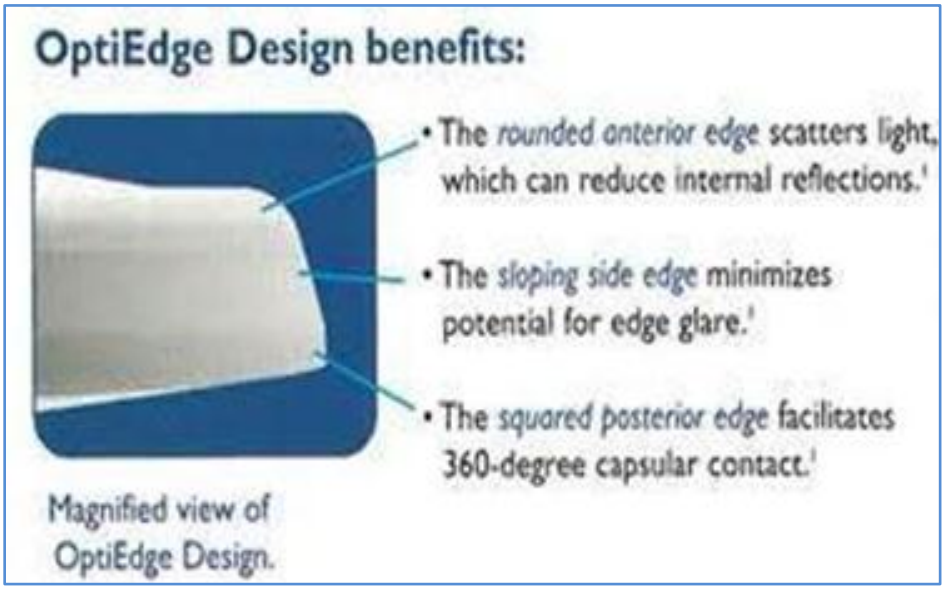
PCO, especially in cases where retained cortex and cells remain following ECCE. If accurately implanted in the capsular bag, it provides an excellent barrier effect, with almost complete filling of the capsular bag & contact of the posterior IOL optic to the posterior capsule ('no space, no cells') (Spalton1999). A lens with one or both haptics 'out of the bag' has much less chance to produce barrier effect.

3. MAXIMUM IOL OPTIC- POSTERIOR CAPSULE CONTACT:

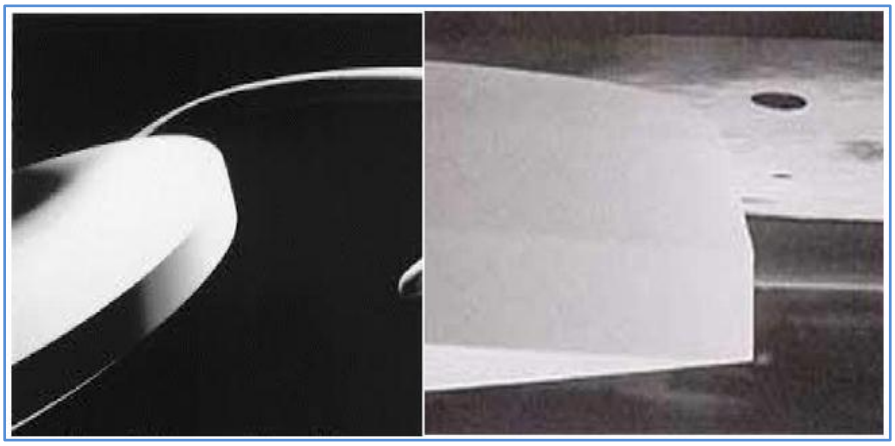
Other contributing factors in reducing PCO are posterior angulation of the IOL haptics & posterior convexity of the optic. This is due to creation of 'Shrink Wrap' a tight fit of the posterior capsule against the back of IOL optic. It is proposed that the residual epithelial cells in the lens capsular bag are inhibited by direct pressure inhibition &/or necrosis of cells caused by the IOL.

4. IOL OPTIC GEOMETRY - SQUARE OR TRUNCATED EDGE:

A high PCO inhibitory effect has been observed with IOLs that provide a mechanical barrier effect on the posterior lens capsule. Nishi et al demonstrated that the sharp edge optic IOL & the formation of a capsular bend are highly effective in reducing PCO. Adhesion of the IOL material with the lens capsule also plays a role in PCO prevention by creating a sharp capsular bend, which inhibits LEC migration onto the posterior capsule. Nishi & other investigators also demonstrated that contact inhibition of migrating LECs is induced at the capsular bend, which leads to PCO prevention.



Prevention of epithelial cell migration at the edge of the IOL



Microscopic view of the square edge posterior chamber IOL

TREATMENT OF POSTERIOR CAPSULE OPACIFICATION: Visually significant PCO is usually managed by creating an opening within the opaque capsule using Nd: YAG laser.

Haemorrhage used to be a significant cause of clinical PCO & opacification of media in general. The causes of haemorrhage include bleeding from wound or direct trauma to iris caused by chaffing from IOL insertion, sometimes causing uveitis- glaucoma- hyphema (UGH) syndrome.[17,18]

Intraocular lenses with at least 1 edge that creates sharp bend in the posterior capsule have become the preferred design regardless of the IOL material because of the edge barrier effect to LECs.

The ideal implant material should have the following characteristics:

1. High optical quality.
2. Light weight.
3. Resistance to biodegradation.
4. Lack of inflammatory reaction.

5. Lack of antigenicity.
6. Lack of carcinogenicity.

The heparin surface modification may render the surface of PMMA implants more hydrophilic & improve the biocompatibility.

One piece PMMA IOLs with PMMA loops are superior to 3 piece polypropylene loop IOL in that it has superior loop memory. PMMA loops symmetrically stretch the posterior capsule & make possible a close uniform contact of the posterior surface of IOL & posterior capsule. This close contact is supposed to provide a barrier effect to proliferation & migration of cells leading to posterior capsule opacification- ' No space –No cells' effect.

Biconvex or posteriorly convex IOLs & posterior angulation of IOL optic with respect to the haptics upto 10° enhance this effect.

Angulation of the loop optic in anterior & posterior plane to about 10° is optimum to maximize contact with posterior capsule. Angular haptics have become popular based on the belief that anteriorly angled haptics will keep the optic more posterior, thus adding to the effect of preventing PCO formation by retarding the ability of equatorial cells to migrate onto the posterior capsule & might reduce the chances of both iris capture behind the lens implant & chaffing of the iris pigment epithelium. The angle was originally suggested as 10° but recently some have advocated 6° angle.

AIMS & OBJECTIVES:

AIM: The present study is aimed at finding the incidence of PCO after cataract extraction & PCIOL implantation in patients attending the outpatient department of ophthalmology in Rajshree Chatrapati Shahu Maharaj Medical College, Kolhapur.

OBJECTIVE: To study the incidence of posterior capsule opacification in patients implanted with 360° square edge PMMA posterior chamber IOL after cataract surgery.

MATERIALS & METHODS: This prospective study includes 100 eyes of 100 patients diagnosed as uncomplicated senile cataract. All of them underwent small incision cataract surgery by the same surgeon & were implanted with one- piece PMMA IOLs. Each IOL is 12.5 mm long with an optic diameter of 6 mm. The optic has plano convex surface with a sharp, rectangular edge.
Eligibility Criteria for Patients selection:

INCLUSION CRITERIA:

1. Patients of age between 40 & 80 yrs.
2. Patients with senile cataract- irrespective of grade & type of cataract.

EXCLUSION CRITERIA:

1. Patients <40yrs & > 80yrs of age.
2. Patients with cardiac and serious illness.
3. Glaucoma patients.

4. Patients with pseudoexfoliation.
5. Traumatic cataract.
6. Uveitis and Complicated cataract.
7. Diabetic Retinopathy.

A 360° square edged single piece PMMA PCIOL with accurate dioptric power is selected for implantation.

On the 1st post-operative day, the cases were examined under slit lamp for any post-operative complications. The next visits were conducted at day 7, 1month, 3months, 6months, 8months & 12months. The best- corrected visual acuity was tested using Snellen's chart, both aided & unaided. PCO was graded.

OBSERVATIONS & RESULTS: Surgery was done by single surgeon & was uneventful in all patients with no intraoperative complications.

All patients were followed up completely for a period of 1yr. Of the 100 patients, 4 patients developed clinically significant PCO in the central visual axis obscuring the fundus details. In 3 cases, it is of elschnig's pearl type & in 1 patient it is thick fibrous membrane type of PCO.

Nd: YAG laser capsulotomy was performed 1yr after surgery. The BCVA of these patients improved from 6/9 to 6/6 after capsulotomy procedure.

The incidence of PCO is very much reduced in our patients with square edge PMMA IOL implantation when compared with the development of PCO in patients with round edge PMMA IOL during the same period of study at our institution. Out of the 100 cases implanted with round edge PCIOLs, 15 cases developed PCO after the same period of follow–up as in our study, showing incidence of 15% when compared with 4% PCO incidence in patients with square edge IOL.

Post-op visual outcome of 6/6 was achieved in 88 patients and 6/9 in 12 patients. 4 patients with PCO also finally improved to 6/6 after Nd: YAG laser capsulotomy procedure. Final visual outcome of 6/6 is achieved in 92 patients & 6/9 in 8 patients.

Distribution of cases according to type of cataract:

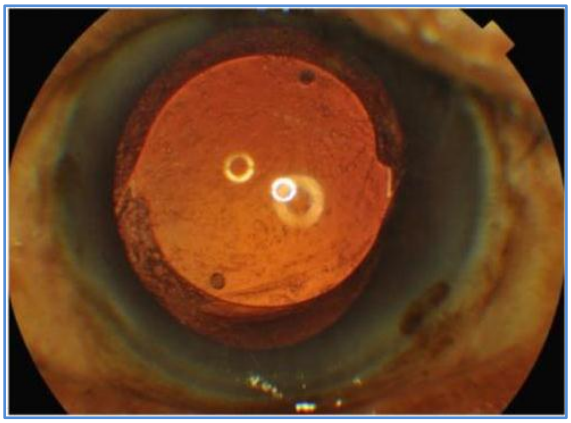
TYPE OF CATARACT	NO.OF CASES
MSC	26
IMSC, NS GR. V	2
IMSC, NS GR. IV	12
IMSC, NS GR. III	14
IMSC, NS GR. II	22
IMSC, NS GR I	16
IMSC	8
TOTAL	**100**

POST	NO.OF CASES
OP.COMPLICATIONS	
Corneal edema	12
Iritis	2
Nil	**86**

Incidence of posterior capsule opacification:

TYPE OF POSTERIOR CAPSULE OPACIFICATION	NO.OF CASES
Fibrous membrane type of PCO	3
Elschnig's pearl type of PCO	6
NO PCO	91

FIBROUS MEMBRANE TYPE OF PCO



ELSCHNIG'S PEARL TYPE OF PCO

POST OP VISUAL OUTCOME:

PRE-OP VA	POST-OP VA	NO.OF CASES
6/60	6/6	12
CF 2 mts	6/6	47
HM+	6/6	19
PL+	6/6	10
CF 3 mts	6/9	12

FINAL VISUAL OUTCOME:

FINAL VISUAL OUTCOME	NO.OF CASES
BCVA OF 6/6	97
BCVA OF 6/9	3

COMPARISON WITH ROUND EDGE PMMA IOL:

TYPE OF IOL USED IN THE STUDY	NO. OF CASES INCLUDED IN THE STUDY	NO.OF PATIENTS DEVELOPED PCO
SQUARE –EDGE	100	9
ROUND- EDGE	100	22

DISCUSSION: In a meta- analysis of published articles on PCO, Schaumberg & co-authors[19] estimate a post-operative PCO incidence of 11.8% at 1yr, 20.7% at 3 yrs & 28.5% at 5 yrs.

Studies that were done comparing IOL materials found the lowest PCO rates with acrylic IOLs with a sharp optic edge[20]. Experimental studies by Nishi & Nishi, & co-authors attribute the PCO inhibiting effect of IOLs to the barrier effect of truncated edge rather than to the characteristic of the lens material. Our clinical study attempted to determine whether a square-edged PMMA IOL reduces the incidence of PCO.

The PCO inhibiting effect of the square –edge IOLs can be explained by the following mechanism. The LECs migrate scarcely onto the posterior capsule in eyes that received the IOLs with sharp rectangular edges. This is because the migrating LECs were inhibited or retarded at the distinct sharp bend & complex folds in the posterior capsule, which were created by the sharp rectangular optic edges.

Studies representing the histopathological analysis of a series of human eyes obtained postmortem were done that confirms the capsular bend phenomenon of the square edge IOL8.
The formation of Soemmering's ring cataract showed that migrating LECs were inhibited at the optic edge. Because LECs migrate onto the lens capsule, serving as a scaffold, the sharp,

discontinuous bend in the capsule may induce contact inhibition of the migrating LECs, which cease proliferating & migrating at the site.

1. Studies by Findl O, Buehl W et al,[21] found significantly less PCO at 1, 3 & 5yrs after surgery in all eyes receiving 3-piece PMMA IOLs with square edge optic.[22]

COMPARISON OF PRESENT STUDY WITH PREVIOUS STUDY:

Parameters	Findl 0, Buehl W et al	Present study
Incidence	PCO score of 2.49*	9%
Type of IOL	3-piece PMMA IOL	1-piece PMMA IOL

AQUA PCO score (0-10), p<0.001% at 5 years.

2. Murali K. Aasuri, Urmi Shah et al[23] studied the role of truncated edged silicone foldable intraocular lenses in preventing posterior capsule opacification (PCO) in 39 patients. All IOLs were placed in the bag. None of the patients in their series had clinically significant PCO at the end of one year, which ultimately concluded the barrier effect of the square edged IOL.

COMPARISON OF PRESENT STUDY WITH PREVIOUS STUDY:

Parameters	Murali K.Aasuri et al	Present Study
TYPE OF IOL	SQUARE EDGED	SQUARE EDGED
	SILICONE IOL	PMMA IOL
INDENCE OF	NIL*	9%†
PCO		

* 1 patient in 39 patients had grade 1 PCO (clinically non-significant) at 1year.
† 4 patients in 100 patients had grade III PCO (clinically significant) at 3 years.

In our study, 4 patients developed a clinically significant grade 3 PCO, out of them 1 had fibrous membrane type of PCO & 3 patients developed elschnig's pearl type of PCO, obscuring central visual axis. Fibrous membrane type of PCO developed earlier than elschnig's pearl type of PCO.

All 100 patients had a significant Soemmering's ring formation beyond the IOL optic edge. However, the absence of epithelial pearls behind the IOL optic in 96 patients, despite their collection in the periphery, points towards the barrier function of the square edge.

Nishi & co-authors[24] report that a vast Soemmering's ring can eliminate the capsular bend created by the square edge IOLs, allowing the LECs migration onto the posterior capsule. This could well be one of the mechanisms for the development of PCO in one patient.

Hydrodissection has been reported to play an important role in limiting PCO.[25] A

moderately sized capsulorhexis that envelops the IOL optic has been reported as beneficial in reducing PCO, particularly with square edge IOLs.[25] Sandwitching the IOL in the capsular bag (shrink-wrap effect) has also been suggested as an important factor in preventing PCO, particularly with bioactive hydrophobic acrylic IOLs. We obtained a complete capsulorhexis margin overlap of the IOL optic in 99 patients. Incomplete capsulorhexis overlap, associated with decentration of IOL was observed in one patient, who developed fibrous membrane type of PCO.

A comparative analysis of PCO incidence was done in patients with implantation of round edge posterior chamber single piece PMMA IOL after cataract extraction in our institution during the same period. This shows that out of 100 cases, 15 patients developed PCO. By this we can say that, incidence of PCO has decreased with 360° square edged posterior chamber PMMA IOL.

Visual outcome & astigmatism were satisfactory in our study. No patient experienced glare, which has been reported with square edged IOLs[26]. This can partly be explained by the differences in the lifestyles (particularly night driving) between patients in the west & our patients. One implication is the motivation level of patients, hence we have done this study with a PMMA IOL though other IOL materials are proved to be more biocompatible.

This series contributes information to our rapidly increasing understanding of PCO & thereby, ultimately, to its reduction to acceptable levels.

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