International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

Original Researcher Article *DOI: 10.61336/im/26-2-12*

Comparative Study of Posterior Capsular Opacification after Small Incision Cataract Surgery with PCIOL Implantation Using Round and Square Edged PMMA Intraocular Lenses in Senile Cataract Patients.

Dr. Pooja Chaudhary[1], Dr. Harpal Singh[2*], Dr. Kanchan Singh[3], Dr. Ashutosh Singhal[4], Dr. Shrusti Chelawat[5], Dr. Jalaj Verma[6].

[1]Third Year Postgraduate, Department of Ophthalmology, People's College of Medical Sciences and Research Centre, Bhopal, Madhya Pradesh, India.

[2]Professor & HOD, Department of Ophthalmology, People's College of Medical Sciences and Research Centre, Bhopal, Madhya Pradesh, India.

[3]Associate Professor, Department of Ophthalmology, People's College of Medical Sciences and Research Centre, Bhopal, Madhya Pradesh, India.

[4]Third Year Postgraduate, Department of Ophthalmology, People's College of Medical Sciences and Research Centre, Bhopal, Madhya Pradesh, India.

[5]Third Year Postgraduate, Department of Ophthalmology, People's College of Medical Sciences and Research Centre, Bhopal, Madhya Pradesh, India.

[6]Second Year Postgraduate, Department of Ophthalmology, People's College of Medical Sciences and Research Centre, Bhopal, Madhya Pradesh, India.

Correspondence:
Dr. Harpal Singh.
Professor & HOD, Department of Ophthalmology, People's College of Medical Sciences and Research Centre, Bhopal, Madhya Pradesh, India.

Received: 20-03-2026
Revised: 14-04-2026
Accepted: 11-05-2026
Published: 19-05-2026

Abstract

Background: Posterior capsular opacification is the most common long-term complication following cataract surgery and may adversely affect postoperative visual acuity. The design of IOLs (Intraocular Lenses), particularly the optic edge profile, plays an important role in preventing the migration of residual lens epithelial cells and reducing PCO formation. This study aimed to compare the incidence and severity of PCO following implantation of round-edged and square-edged PMMA intraocular lenses after uneventful SICS (Small Incision Cataract Surgery). ***Methods:*** A prospective observational study was conducted in the Department of Ophthalmology, Peoples College of Medical Science and Research Center, Bhopal, over a period of 1.5 years. A total of 100 patients aged above 40 years with uncomplicated senile cataracts were randomly divided into two groups: Group A received round-edged PMMA IOLs and Group B received square-edged PMMA IOLs following SICS. Patients were evaluated postoperatively on day 1, at 6 weeks, 3 months, and 6 months. Posterior capsular opacification was assessed clinically using slit lamp examination and graded using Kruger and Sellman-Lindstrom grading systems. BCVA (Best Corrected Visual Acuity) was also recorded. ***Results:*** At 6 months, PCO developed in 29.78% of patients in the round-edged IOL group compared to 16.67% in the square-edged IOL group. Grade 3 PCO was more common in the round-edged group (12.76%) than in the square-edged group (2.08%). Elschnig's pearl type PCO was the predominant morphological variant in both groups. Better visual outcomes were observed in the square-edged group, where 83.33% of patients achieved BCVA of 6/6 compared to 70.21% in the round-edged group. ***Conclusion:*** Square-edged PMMA intraocular lenses demonstrated lower incidence and severity of posterior capsular opacification with better postoperative visual outcomes compared to round-edged PMMA IOLs. Owing to their cost-effectiveness and improved efficacy, square-edged PMMA IOLs are preferable for cataract surgery, particularly in resource-limited settings.

Keywords: Posterior Capsular Opacification, PMMA Intraocular Lens, Square-Edged IOL, Round-Edged IOL, Small Incision Cataract Surgery, Senile Cataract, Visual Acuity.

INTRODUCTION

Cataract, defined as opacification of the crystalline lens, remains one of the leading causes of reversible blindness worldwide, affecting nearly 16 million individuals globally. Advances in cataract surgery, including SICS (Small Incision Cataract Surgery), improved viscoelastic substances, and modern IOL (Intraocular Lens) designs, have significantly enhanced postoperative visual rehabilitation and patient outcomes.[1] Small incision cataract surgery and phacoemulsification are the preferred techniques for cataract extraction. During surgery, the anterior capsule is opened through capsulorhexis while preserving the posterior capsule and peripheral anterior capsule, together forming the capsular

bag.[2] Residual LECs (Lens Epithelial Cells) remain within the capsular bag after surgery, and a posterior chamber intraocular lens is implanted to restore vision.[3] The IOL consists of an optic and haptic component that stabilizes the lens within the capsular bag.[4]

Despite remarkable progress in cataract surgery, PCO (Posterior Capsular Opacification) continues to be the most common long-term postoperative complication. PCO develops due to proliferation, migration, and transformation of residual lens epithelial cells on the posterior capsule after cataract extraction.[5,6] These cellular changes lead to visual deterioration, glare, and reduced contrast sensitivity, thereby compromising surgical outcomes.[7] PCO may occur either as fibrous opacification due to epithelial–mesenchymal transformation or as pearl-type opacification resulting from abnormal proliferation of equatorial epithelial cells.[7]

The incidence of PCO remains clinically significant despite improvements in surgical techniques and IOL materials. A systematic review reported an incidence of 11.8% at 1 year, 20.7% at 3 years, and 28.4% at 5 years following cataract surgery.[6] Prevention of PCO therefore remains an important objective in modern cataract surgery. Various preventive strategies have been proposed, including meticulous cortical cleanup, hydrodissection, capsular polishing, and modification of IOL materials and edge designs.[8] Among these, the optic edge configuration of the IOL plays a crucial role in preventing migration of residual LECs. The square-edged IOL design creates a mechanical barrier at the capsular bend, thereby reducing posterior migration of epithelial cells and lowering the incidence of PCO compared to round-edged IOLs.[8]

AIMS AND OBJECTIVES

The aim of the present study was to compare the outcomes of posterior capsular opacification following uneventful cataract surgery using round-edged and square-edged PMMA (Polymethyl Methacrylate) IOL (Intraocular Lens) implantation in patients with senile cataracts. The study specifically aimed to evaluate the incidence and outcomes of PCO in patients implanted with round-edged PMMA IOLs, assess the outcomes of PCO in patients receiving square-edged PMMA IOLs, and compare the rates of posterior capsular opacification between the two IOL designs following cataract surgery.

MATERIALS AND METHODS

Study Design

This prospective observational study was conducted in the Department of Ophthalmology at Peoples College of Medical Science and Research Center over a period of 1.5 years. The study included 100 patients aged above 40 years with uncomplicated senile cataracts who attended the ophthalmology department and fulfilled the predefined inclusion criteria. The study aimed to evaluate posterior capsular opacification following cataract surgery with implantation of round-edged and square-edged polymethyl methacrylate intraocular lenses. Data were collected from eligible patients undergoing uneventful cataract surgery at the study center.

Inclusion and Exclusion Criteria

Patients aged more than 40 years, belonging to either gender, diagnosed with uncomplicated senile cataract, and willing to participate in the study as well as comply with follow-up visits were included in the study. Patients aged less than 40 years, those presenting with complicated senile cataract, preexisting corneal opacities or posterior segment pathologies, and patients unwilling to participate in the study or adhere to follow-up were excluded from the study.

Data Collection Procedure

Patients aged more than 40 years with uncomplicated senile cataracts attending the ophthalmology outpatient department were included in the study after obtaining written informed consent. Demographic details and clinical history were recorded using a structured proforma. Patients were randomly allocated into two groups using a computer-generated random table: Group A underwent SICS (Small Incision Cataract Surgery) with round-edged PMMA intraocular lens implantation, while Group B received square-edged PMMA intraocular lenses. Preoperative evaluation included visual acuity assessment using Snellen's chart, autorefractometry, slit lamp examination, intraocular pressure measurement, fundus examination, cataract grading, B-scan in opaque media, and IOL power calculation using keratometry and A-scan. Postoperative follow-up was conducted on day 1, at 6 weeks, and at 6 months, during which best corrected visual acuity and slit lamp examination were performed. PCO (Posterior Capsular Opacification) was graded at each follow-up visit using diffuse illumination, narrow slit beam examination, and retroillumination techniques after pupillary dilatation.

Statistical Analysis

Data collected during the study were compiled and entered into Microsoft Excel and subsequently exported to IBM Statistical Package for the Social Sciences (SPSS) Statistics version 29.0 (IBM Inc.) for statistical analysis. Appropriate statistical tests were applied to analyze the study variables, and the results were expressed in suitable tables and charts. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1. Group Wise Distribution of Study Participants

Group	Frequency (n)	Percentage (%)
Round Edge PMMA IOL	50	50.0
Square Edge PMMA IOL	50	50.0
Total	**100**	**100.0**

Table 1 illustrates the distribution of study participants between the two study groups. Equal allocation of subjects was done, with 50 patients in each group, ensuring balanced comparison between round edge and square edge PMMA intraocular lenses.

Table 2. Age Group Wise Distribution among Study Groups

Age Group (in years)	Round Edge n (%)	Square Edge n (%)
41–50	5 (10%)	5 (10%)
51–60	15 (30%)	15 (30%)
61–70	20 (40%)	20 (40%)
71–80	10 (20%)	10 (20%)
81–90	0 (0%)	0 (0%)

Table 2 observes that the majority of patients in both groups belonged to the 61–70 years age group (40%), followed by the 51–60 years age group (30%). The age distribution between groups was comparable and statistically insignificant.

Table 3. Gender Wise Distribution among Groups

Gender	Round Edge n (%)	Square Edge n (%)
Female	31 (62%)	28 (56%)
Male	19 (38%)	22 (44%)
Chi-square = 0.372; p = 0.541		

Table 3 shows gender distribution among the study groups. Female predominance was observed in both groups. However, the difference in gender distribution between the two groups was statistically not significant.

Table 4. Grading of Posterior Capsular Opacification (PCO) at 6 Months

PCO Grade	Round Edge n (%)	Square Edge n (%)
No PCO	34 (72.34%)	42 (87.50%)
Grade 1	5 (10.63%)	5 (10.42%)
Grade 2	8 (17.02%)	1 (2.08%)
Grade 3	6 (12.76%)	1 (2.08%)
Grade 4	0 (0%)	0 (0%)
Chi-square = 6.93; p = 0.074		

Table 4 illustrates the grading of PCO after six months of follow-up. Higher grades of PCO were more frequently observed in the round edge group compared to the square edge group, suggesting better posterior capsule clarity with square edge PMMA IOLs.

Table 5. Morphological Type of PCO in Both Groups at 6 Months

Type of PCO	Round Edge n (%)	Square Edge n (%)
Elschnig's Pearl	8 (57.1%)	5 (62.5%)
Fibrous Membrane	6 (42.9%)	3 (37.5%)
Mixed Type	0 (0%)	0 (0%)
Total	**14 (100%)**	**8 (100%)**
Chi-square = 0.06; p = 0.808		

Table 5 observes the morphological pattern of PCO in both groups. Elschnig's pearl type was the most common form of PCO in both round edge and square edge groups. No mixed type of PCO was observed in either group.

Table 6. Visual Outcome (BCVA) at 6 Weeks among Both Groups

Visual Outcome	Round Edge n (%)	Square Edge n (%)
6/6	36 (72%)	42 (84%)
6/6P	6 (12%)	4 (8%)
6/9	4 (8%)	3 (6%)
6/12	2 (4%)	1 (2%)
6/18	2 (4%)	0 (0%)
6/24	0 (0%)	0 (0%)
6/36	0 (0%)	0 (0%)
Chi-square = 3.34; p = 0.503		

Table 6 shows postoperative visual outcomes at 6 weeks. The majority of patients in both groups achieved 6/6 visual acuity, with slightly better outcomes in the square-edge group compared to the round-edge group.

Table 7. Visual Outcome (BCVA) at 6 Months among Both Groups

Visual Outcome	Round Edge n (%)	Square Edge n (%)
6/6	33 (70.21%)	40 (83.33%)
6/6P	0 (0%)	1 (2.08%)
6/9	0 (0%)	1 (2.08%)
6/12	4 (8.51%)	1 (2.08%)
6/18	2 (4.25%)	2 (4.16%)
6/24	2 (4.25%)	2 (4.16%)
6/36	6 (12.76%)	1 (2.08%)
Chi-square = 8.03; p = 0.236		

Table 7 demonstrates the visual outcomes of patients at six months follow-up. Better visual acuity was observed in the square edge group, where 83.33% achieved 6/6 vision compared to 70.21% in the round edge group.

Table 8. BCVA at 6 Months using LogMAR Chart

LogMAR BCVA	Round Edge n (%)	Square Edge n (%)
0.0	33 (70.21%)	40 (83.33%)
0.2	0 (0%)	2 (4.16%)
0.3	4 (8.51%)	1 (2.08%)
0.5	2 (4.25%)	2 (4.16%)
0.6	2 (4.25%)	2 (4.16%)
0.8	6 (12.76%)	1 (2.08%)
Chi-square = 8.03; p = 0.154		

Table 8 illustrates BCVA assessment using the LogMAR chart at six months. Visual deterioration was comparatively lower in the square edge group, indicating superior long-term visual outcomes with square edge PMMA intraocular lenses.

DISCUSSION

Cataract remains the leading cause of reversible blindness worldwide, and posterior capsular opacification continues to be the most common long-term complication following cataract surgery despite advances in surgical techniques and intraocular lens (IOL) design.[1,2] Among the various preventive strategies, optic edge design of the IOL has been shown to play a major role in reducing migration of residual lens epithelial cells onto the posterior capsule.[8,9] The present study compared the incidence and severity of PCO between round-edged and square-edged PMMA IOLs following uneventful small incision cataract surgery (SICS).

In the present study, 100 patients were equally distributed into round-edged and square-edged PMMA IOL groups, ensuring uniformity and comparability. Most patients belonged to the 51–70 years age group, which corresponds with the epidemiology of senile cataracts. A similar age distribution was reported by Joshi RS et al[10] and Nagrale P et al.[1] Gender distribution showed female predominance in both groups, similar to the findings of Pinnamaneni S et al,[11] although the difference between groups was not statistically significant. Comparable distribution of systemic comorbidities such as diabetes mellitus and hypertension between the two groups minimized confounding bias. SJ G et al[12] also reported no significant association between diabetes and PCO incidence.

The majority of patients in both groups presented with mature and advanced cataracts, reflecting delayed presentation commonly observed in developing countries. Similar observations were made by Tarafder AS et al.[13] Comparable baseline cataract grading between groups ensured that postoperative differences were more likely related to IOL design rather than preoperative disease severity.

The present study demonstrated a higher incidence of PCO in the round-edged PMMA IOL group (29.78%) compared with the square-edged PMMA IOL group (16.67%) at six months follow-up. These findings are consistent with studies by Goudinho SJ et al.,[12] who reported significantly lower PCO rates with square-edged PMMA IOLs. Shweta B et al.,[14] also observed higher PCO incidence in round-edged IOLs (29.6%) compared to square-edged IOLs (9.6%). Similarly, Nagrale P et al.,[1] reported a lower incidence of PCO with 360° square-edged IOLs compared to round-edged lenses during long-term follow-up. The reduced incidence in square-edged IOLs can be attributed to the "barrier effect" created by the sharp optic edge, which inhibits migration of lens epithelial cells across the posterior capsule.[9,15]

However, some studies have reported contrasting findings. Azzam HA et al.,[16] found no statistically significant difference between square-edged and round-edged hydrophilic foldable IOLs over short follow-up duration, suggesting that IOL material and follow-up duration may influence outcomes. Brar GS et al.,[17] also reported comparable PCO rates between square-edged PMMA and acrylic lenses in pediatric cataract surgery.

In addition to lower incidence, the severity of PCO was also reduced in the square-edged group in the present study. Grade 3 PCO was observed in 12.76% of patients in the round-edged group compared to only 2.08% in the square-edged group. Haripriya A et al.,[18] similarly demonstrated significantly lower long-term PCO scores and Nd:YAG capsulotomy rates with square-edged PMMA IOLs. Maedel S et al.,[19] in a systematic review, also concluded that sharp-edged IOLs consistently produce lower PCO scores and reduce the need for Nd:YAG capsulotomy.

Morphologically, Elschnig's pearl type PCO was more common than fibrous PCO in both groups in the present study. Similar findings were reported by Suresh N et al.[20] In contrast, Mudhol RR et al.,[9] observed fibrous PCO as the predominant type, indicating that PCO morphology may vary depending on surgical technique, follow-up duration, and patient characteristics.

Visual outcomes in the present study were satisfactory in both groups; however, better best-corrected visual acuity was observed in the square-edged IOL group. At six months, 83.33% of patients in the square-edged group achieved BCVA of 6/6 compared to 70.21% in the round-edged group. Similar findings were reported by Mudhol RR et al,[9] who demonstrated superior visual outcomes with square-edged IOLs. The lower visual deterioration in the square-edged group can be attributed to reduced incidence and severity of PCO.

The findings of the present study strongly support the role of square-edged PMMA IOLs in reducing PCO formation. The sharp posterior optic edge acts as a mechanical barrier against lens epithelial cell migration, thereby minimizing posterior capsule opacification. Similar conclusions were drawn by Nagrale P et al.,[1] Joshi RS et al.,[10] and Maedel S et al.[19] Nevertheless, factors such as surgical technique, cortical cleanup, capsulorhexis size, in-the-bag IOL fixation, and postoperative inflammation also influence PCO formation, as highlighted by Abhilash B et al[21] and Pinnamaneni S et al.[11]

The present study demonstrates that square-edged PMMA IOLs are superior to round-edged PMMA IOLs in reducing the incidence and severity of posterior capsular opacification while providing better postoperative visual outcomes. Considering their cost-effectiveness and accessibility, square-edged PMMA IOLs represent a valuable option for cataract surgery, particularly in resource-limited settings where PMMA lenses continue to be widely used.

LIMITATIONS

The present study has certain limitations that should be considered while interpreting the findings. Firstly, the sample size of 100 patients, although adequate for comparison between the two groups, was relatively small, which may limit the generalizability of the results to the larger population. Secondly, the follow-up period of six months may not have been sufficient to assess the long-term incidence and progression of posterior capsular opacification, as PCO can continue to develop several years after cataract surgery. Thirdly, modern intraocular lenses such as acrylic foldable IOLs were not included in the study because of financial constraints and limited affordability among the study population. Inclusion of newer IOL materials could have provided a broader comparison of postoperative outcomes and PCO incidence.

CONCLUSION

In conclusion, both round-edged and square-edged PMMA intraocular lenses provided satisfactory visual outcomes following uneventful small incision cataract surgery in patients with senile cataracts. However, square-edged PMMA IOLs

were associated with a lower incidence and severity of posterior capsular opacification, highlighting the importance of IOL edge design in preventing this common postoperative complication. Patients implanted with square-edged IOLs also achieved better best-corrected visual acuity and experienced less visual deterioration compared to those with round-edged IOLs. Although Elschnig's pearl type was the most common form of PCO in both groups, it was less visually significant in the square-edge group. Therefore, owing to their better clinical outcomes, cost-effectiveness, and reduced PCO formation, square-edged PMMA IOLs may be considered a preferable option, particularly in resource-limited settings.

REFERENCES

1. Nagrale P, Rao SA, Vairat S. Role of 360 square edged pciol in preventing PCO. Journal of Evidence based Medicine and Healthcare 2014;1(16):2023-35.
2. Davis G. The evolution of cataract surgery. Missouri Medicine 2016;113(1):58-62.
3. Ram J, Pandey SK, Apple DJ, et al. Effect of in-the-bag intraocular lens fixation on the prevention of posterior capsule opacification. Journal of Cataract & Refractive Surgery 2001;27(7):1039-46.
4. Singh Bhangra J. A Review of Posterior Capsular Opacification. CRO Journal Published online June 23, 2023. Available at: https://clinicaloptometry.scholasticahq.com/article/82056-a-review-of-posterior-capsular-opacification. Last accessed as on August 30,2024.
5. Gu X, Chen X, Jin G, et al. Early-Onset Posterior Capsule Opacification: Incidence, Severity, and Risk Factors. Ophthalmol Ther 2022;11(1):113-23.
6. Schaumberg DA, Dana MR, Christen WG, et al. A systematic overview of the incidence of posterior capsule opacification. Ophthalmology 1998;105(7):1213-21.
7. Raj SM, Vasavada AR, Johar SR, et al. Post-operative capsular opacification: a review. Int J Biomed Sci 2007;3(4):237-50.
8. Pandey SK, Apple DJ, Werner L, et al. Posterior capsule opacification: a review of the aetiopathogenesis, experimental and clinical studies and factors for prevention. Indian Journal of Ophthalmology 2004;52(2):99-112.
9. Mudhol RR, Shetti SA, Dodamani DK. Square-edge intraocular lens versus conventional round-edge intraocular lens in prevention of posterior capsule opacification: a randomized clinical trial. Journal of the Scientific Society 2016;43(1):6-10.
10. Joshi RS, Rasal AV. Posterior capsular opacification and Nd: YAG capsulotomy rates in patients implanted with square-edged and non-square-edged intraocular lenses in manual small-incision cataract surgery: a randomized controlled study. Indian Journal of Ophthalmology 2023;71(9):3219-23.
11. Pinnamaneni S, Sandeep. K, Usha M. S., Comparative evaluation of PCO development in various methods of cataract surgeries and with different type of IOL implantation. Indian J Clin Exp Ophthalmol 2018;4(3):304-308.
12. Goudinho SJ, Deeba F, Jacob JM. Incidence of posterior capsular opacification after small incision cataract surgery with PC IOL implantation using biconvex round edge PMMA IOL and square edge PMMA IOL. International Journal of Medical and Applied Sciences 2013;2(1):46-59.
13. Tarafder AS, Kader MA, Karim SR. Small Incision Cataract Surgery (SICS) with Posterior Chamber Intraocular Lens (PCIOL) Implantation is the Preferred Method of Community-Based Cataract Surgery: Study of 100 Cases. TAJ: Journal of Teachers Association 2009;22(1):132-5.
14. Shweta B, Dheeraj B, Sanjay M. A Comparative Evaluation of Posterior capsular Opacification with Square Edged and Round Edged PMMA Intraocular Lens in Small Incision Cataract Surgery in rural areas of North Maharashtra. JMSCR 2019;7(2):216-23.
15. Nishi O, Yamamoto N, Nishi K, et al. Contact inhibition of migrating lens epithelial cells at the capsular bend created by a sharp-edged intraocular lens after cataract surgery. Journal of Cataract & Refractive Surgery 2007;33(6):1065-70.
16. Azzam HA, Abdelgawad AA, Sakr AM. Effect of Square-Edge versus Round-Edge Foldable Intraocular Lens in Prevention of Posterior Capsule Opacification. International Journal of Medical Arts 2024;6(5):4415-20.
17. Brar GS, Grewal DS, Ram J, et al. Square-edge polymethylmethacrylate intraocular lens design for reducing posterior capsule opacification following paediatric cataract surgery: initial experience. Clin Exp Ophthalmol 2008;36(7):625-30.
18. Haripriya A, Chang DF, Vijayakumar B, et al. Long-term posterior capsule opacification reduction with square-edge polymethylmethacrylate intraocular lens: randomized controlled study. Ophthalmology 2017;124(3):295-302.
19. Maedel S, Evans JR, Harrer-Seely A, et al. Intraocular lens optic edge design for the prevention of posterior capsule opacification after cataract surgery. Cochrane Database Syst Rev 2021;8(8):CD012516.
20. Naga Suresh V, Radhika R. A study of incidence of posterior capsular opacification after cataract surgery with square edge PMMA intra ocular lens. Indian Journal of Clinical and Experimental Ophthalmology 2016;2(3): 178-81.
21. Abhilash B, Babu M. Comparison of incidence of early posterior capsule opacification (PCO) following manual small incision cataract surgery in patients who were implanted rigid PMMA IOL under air, BSS and viscoelastics. Int J Med Ophthalmol 2021;3(1):15-9.