

# Retrospective Study of Nd:YAG Capsulotomy Following Phacoemulsification

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## ABSTRACT

### BACKGROUND

Posterior Capsular Opacification (PCO) or After Cataract is one of the most common delayed postoperative complications of uncomplicated phacoemulsification cataract surgery, which occurs due to the migration of lens epithelial cells (LECs) on the posterior capsule. PCO is primarily treated by Nd:YAG capsulotomy which involves creating an opening in the posterior capsule, thereby improving vision. Our aim was to evaluate the incidence of Posterior Capsular Opacification (PCO) in different types of foldable IOLs and also to estimate the duration between phacoemulsification surgery and PCO formation requiring Nd:YAG capsulotomy.

### METHODS

This retrospective study included all patients who had undergone Nd:YAG capsulotomy after uncomplicated phacoemulsification surgery with foldable IOL implantation in the past 5 years. Thirteen types of acrylic foldable IOLs were analysed for the incidence and time taken for PCO formation after phacoemulsification surgery.

### RESULTS

A total of 28149 eyes of 27779 patients, with mean age of 69±7.27 years, underwent uncomplicated phacoemulsification with foldable IOL implantation during the study period. 1.3% (354) eyes of 182 males and 162 females underwent Nd:YAG capsulotomy for clinically significant PCO. The overall incidence of hydrophobic and hydrophilic IOLs showing PCO formation was 0.73% and 2.4% respectively, the difference being statistically significant ( $p=0.042$ ). Individually, the IOL with the highest incidence of PCO formation was SENSAR, 3.75% (AR40e) followed by ULTIMA, 3.47% (ULTIMA AC) while SENSAR-1 (AABOO) and Tecnis1 (ZCBOO) had the lowest incidence of PCO. PCO was seen significantly higher in square edge optic designs compared with round edge ( $p=0.017$ ), while there was no statistically significant difference between single- and three-piece designs ( $p=0.21$ ). PCO was significantly higher in IOLs with optic diameter of 6 mm when compared to 5.5 mm ( $p=0.016$ ). The average duration between phacoemulsification surgery and Nd:YAG capsulotomy was 32±3 months, the duration being significantly less for hydrophilic (27±4 months) than hydrophobic (35±3 months) ( $p=0.041$ ).

### CONCLUSIONS

The incidence of PCO formation was more and earlier with hydrophilic than with hydrophobic IOLs. It was more frequently seen with square edge optic design. However, lens design, single-piece or three-piece did not seem to influence the rate of PCO formation.

### KEY WORDS

Posterior Capsular Opacification (PCO), Hydrophilic and Hydrophobic Intraocular Lenses (IOLs)

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## BACKGROUND

Secondary cataract, also known as posterior capsule opacification (PCO), is the most common complication after cataract surgery, resulting from migration and proliferation of residual lens epithelial cells (LECs) on to the central posterior capsule, leading to decrease in visual function. The incidence of PCO has been estimated to be between 18% to 50% in various studies.<sup>1,2,3</sup> The treatment of PCO is typically neodymium yttrium-aluminium-garnet (Nd:YAG) laser posterior capsulotomy. Currently the most commonly used IOLs in practice are the hydrophobic acrylic Intraocular Lenses (IOLs).<sup>2</sup> These polymers of acrylate are foldable under room temperature, have very low water content and a high refractive index. They unfold in a controlled fashion and have been shown to have capsular biocompatibility. On the other hand, hydrophilic acrylic lenses belong to a heterogeneous material group and have a high water content. These lenses are cut in the dehydrated state and then hydrated and stored in solution. The water content between IOLs varies widely and can be as high as 38%.<sup>4,5</sup>

Hydrophobic material lenses have been reported to have low rates of PCO compared to hydrophilic materials.<sup>(6)</sup> It was proposed that bio adhesive nature of hydrophobic acrylic IOLs may account for its reduced PCO formation by helping it adhere to the capsule and sequestering the IOL in the bag.<sup>6</sup> Various other properties of IOLs are also known to play role in PCO formation. The IOLs with square edge optic create a sharp bend in the posterior capsule that mechanically inhibits the cell migration to the posterior capsule where as IOLs with round edge optics are unable to create such bend, thus, losing their effectiveness to prevent the PCO formation.<sup>6</sup> Hence, PCO formation was shown to be low with square compared to round optic lens.<sup>7</sup> Large IOL optic was also shown to be associated with less PCO.<sup>8,9,10</sup> On the basis of contact inhibition, recently, the consensus has been made that the relationship between the IOL optic and the anterior capsule plays an integral role in PCO development.<sup>10</sup>

Different practical approaches to prevent PCO formation have been suggested, however the exact mechanism of PCO formation has not yet been established. At present, the IOL optic design and lens material are the important factors that are known to play a role in occurrence of PCO. Previous studies have mainly analysed and compared occurrence of PCO in hydrophobic versus hydrophilic, silicon versus PMMA versus acrylic, square edge versus round edge and single-piece versus three-piece models of intraocular lenses.<sup>9,10</sup> However, the aim of the present study was to perform an overall review of incidence of PCO leading to YAG capsulotomy in a high volume cataract surgery centre and comparing different types of foldable lenses in terms of their incidence, duration and various properties such as material, type, design and size in a large retrospective case series.

## METHODS

This was a retrospective study involving all patients who had undergone Nd:YAG capsulotomy after uncomplicated

phacoemulsification surgery with foldable IOL implantation in our institution from 1<sup>st</sup> Jan 2009 to 31<sup>st</sup> Dec 2013. All surgeries were performed by 3 experienced cataract surgeons who followed standard surgical technique for phacoemulsification.

The inclusion criteria were age >40 years, uncomplicated phacoemulsification, Continuous Curvilinear Capsulorrhexis (CCC), in the bag foldable IOL implantation, absence of primary PCO and PCO causing clinically significant diminution of vision, grade 2 and above with TETZ PCO grading system Patients who had coexisting conditions such as uncontrolled diabetes, pseudoexfoliation, uveitis and trauma, which are known to accelerate the process of PCO formation were excluded from the study. We also excluded eyes with coexisting glaucoma, corneal or retinal pathology and multifocal IOL implants.

The degree of opacification was assessed using distant direct ophthalmoscopy, direct visualization by slit lamp and a decrease in BCVA after surgery PCO was graded as per the TETZ PCO scoring system and eyes with grade 2 and above were advised to undergo YAG capsulotomy.<sup>11</sup> Clinically significant PCO was defined as a reduction in BCVA of more than 2 lines in Snellen's visual acuity chart.<sup>11</sup> An informed consent was obtained from all patients before the procedure was performed. Pupil was dilated using mydriatics (Itrop plus-Cipla, Solan- Himachal Pradesh).

### Procedure of YAG Capsulotomy

The equipment used was Zeiss Visulas 3 Nd:YAG laser with a frequency of 1064 nm, spot size of 50 microns and power range from 1 to 2 mJ. The laser was delivered through a slit lamp. Eye was anaesthetized using topical 0.5% proparacaine (Paracaine- Sunways, Ahmedabad). Patients chin was positioned on the chin rest and forehead touched to the head rest. The patient was instructed to fixate on the illuminated fixation target. The machine is set to posterior offset. This was followed by delivery of laser with the laser shots being placed along the tension lines on the posterior capsule. A cruciate opening, beginning at 12 o'clock in the periphery and progressing towards the 6 'O' clock position, followed by cutting across from 3 to 9 o'clock position was made. The size of capsulotomy aimed was 4 to 6 mm depending on pupillary dilatation. Any residual tags were removed, and free-floating fragments avoided. Post procedure, antibiotic steroid eye drops (Ofacin DX – Microlabs Limited.) were prescribed for 4 times a day for one week. No intra operative complications occurred during the procedure for any of the eyes. Post procedure, 4 patients had raised intraocular pressure, which was managed with topical antiglaucoma medications. There were no major complications like hyphema, macular oedema or vitreous in anterior chamber post procedure.

### Data Analysis

Data was analysed using the PASW 17.0 (Predictive Analysis Software) (SPSS Inc, Chicago, Illinois, USA), Chi square test and the paired t test. A p value of <0.05 was considered significant.

**RESULTS**

A total of 28149 eyes of 27779 patients, underwent uncomplicated phacoemulsification with foldable IOL implantation during the study period. A total of 354 eyes of 344 patients with mean age of 69±7.27 years underwent Nd:YAG capsulotomy of which 182(53%) were males and 162(47%) were females. The incidence of Nd:YAG capsulotomy in this series was found to be 1.3%. The incidence of YAG capsulotomy was higher in hydrophilic IOLs compared to hydrophobic IOLs, and the difference was found to be statistically significant. (Table 1). Table 2 enumerates characteristics of the various foldable lenses along with their incidence of YAG capsulotomy. The IOLs with the highest frequency of YAG capsulotomy were SENSAR, (3.75%, Model AR40e) followed by ULTIMA (3.47%) and RYCF( 2.4%) while SENSAR 1, TECNIS 1 and ACRIOL lenses had the lowest frequency of YAG capsulotomy being 0%, 0.15% and 0.2% respectively.

Total number of foldable IOLs implanted	28149
Number of hydrophobic IOLs implanted	19441
Number of hydrophilic IOLs implanted	8708
No. of eyes requiring YAG capsulotomy	354(1.3%)
No. of hydrophobic IOLs YAGed	143 (0.73%)
p Value	0.137
No. of hydrophilic IOLs YAGed	211 (2.4%)
p Value	0.042

**Table 1. Details of Foldable IOLs that Required YAG Capsulotomy**

IOL Type (Model)	Material	Design	Edge	Optic Size	Number of IOLs Implanted	Number of IOLs with PCO Formation	Percentage	Duration of PCO Formation (Months)	p Value
ACRIOL (AS 6)	HPo Acr	1 piece	Square edge	6 mm	906	2	0.2	33±3	0.141
ACRYSOF (SN60AT, SA60AT)	HPo Acr	1 piece	Square edge	5.5 mm	3268	8	0.25	31±3	0.154
ACRYSOF IQ (SN6AD1, MN6AD1)	HPo Acr	1 piece	Round interrupted	5.5 mm	846	2	0.23	29±4	0.156
CLARIFLEX (CLRFLX A, CLRFLX B, CLRFLX C)	HPo Acr	3 piece	Square	5.5 mm	656	6	0.9	28±3	0.042
HOYA (PC 60 R, PS AF 1)	HPo Acr	3 piece	Round interrupted	6 mm	2078	13	0.63	28±4	0.092
RYCF (SQ RYCF)	HPi Acr	1 piece	Square	6 mm	1544	37	2.4	30±3	0.032
SENSAR (AR40M, AR40E, AR40e)	HPo Acr	3 piece	Square	6 mm	2645	84	3.75	35±3	0.025
SENSAR 1 (AAB00)	HPo Acr	1 piece	Square	6 mm	3583	0	0	-	0
TECNIS 1 (ZCBO0)	HPo Acr	1 piece	Square	6 mm	4494	7	0.15	36±3	0.733
TECNIS ACRYLIC (ZCT400)	HPo Acr	3 piece	Square	6 mm	1182	26	2.2	38±3	0.214
TECNIS CL	HPi Acr	1 piece	Square	5.5 mm	2282	18	0.79	32±2	0.113
ULTIMA (ULTIMA AC)	HPi Acr	1 piece	Square	6 mm	1980	69	3.47	28±3	0.036
ZEISS (CT ASPHINA409M, 509M 809M)	HPi Acr	1 piece	Square	6 mm	2583	17	0.66	29±3	0.198

**Table 2a. Incidence of PCO Formation in Different IOL Designs and Materials Studied**

HPi Acr- Hydrophilic Acrylic. HPo Acr- Hydrophobic Acrylic

IOL Type	Number of IOL Implanted	Number of IOL with PCO Formation	%
ACRYFOLD	180	26	14.4
AUROLAB	23	1	4.6
CEEON	2	1	50
CENTRYFOLD	6	1	16.7
NASPRO	252	28	11.1
SI 40	12	4	33.3
STAAR	8	3	37.5
OCUFLEX	29	1	3.5

**Table 2b. IOL Design and PCO Formation**

(Note: The IOLs in table 2b have not been used for statistical analysis because of their low numbers (<500) which may give false results)

IOL Type (Model)	Pre YAG BCVA (logMAR)	Post YAG BCVA (logMAR)	p
ACRIOL	0.30±0.04	0.00±0.00	0.043
ACRYSOF	0.25±0.03	0.00±0.01	0.069
ACRYSOF IQ	0.25±0.01	0.00±0.01	0.083
CLARIFLEX	0.20±0.02	0.10±0.02	0.101
HOYA	0.50±0.01	0.10±0.00	0.032
RYCF	0.30±0.02	0.10±0.01	0.054
SENSAR	0.60±0.01	0.00±0.01	0.027
TECNIS 1	0.80±0.02	0.00±0.02	0.010
TECNIS ACRYLIC	0.50±0.02	0.10±0.01	0.038
TECNIS CL	0.50±0.01	0.10±0.02	0.023
ULTIMA	0.60±0.03	0.10±0.03	0.034
ZEISS	0.50±0.02	0.00±0.02	0.022

**Table 3. Visual Outcomes after YAG Capsulotomy**

The average duration between phacoemulsification surgery and Nd:YAG capsulotomy was 32±3 months, the duration being less for hydrophilic (27±4 months) than hydrophobic (35±3 months), the duration being statistically significant (p 0.041) PCO was seen significantly higher in square edge optic designs compared with round edge (p=0.017), while there was no statistically significant difference between single and three-piece designs (p=0.21). PCO was significantly higher in IOLs with optic diameter of 6 mm when compared to 5.5 mm (p=0.016) Table 3 shows the visual outcomes post YAG capsulotomy with various foldable lenses. All models of lenses implanted showed improvement in BCVA post procedure while the improvement was statistically significant in 5 models of hydrophobic and 3 models of hydrophilic foldable lenses.

**DISCUSSION**

YAG capsulotomy is the most common and preferred modality to treat PCO, although surgical capsulotomy has also been described.<sup>12</sup> Most of the previous studies have compared rates of PCO formation between PMMA, Silicon and acrylic intraocular lenses.<sup>13,14</sup> However, our study focused mainly on analysis of various models (13 models) of acrylic foldable lenses in terms of PCO formation aNd:YAG capsulotomy. We also analysed the average duration for PCO formation following phacoemulsification with various designs and materials of foldable IOLs implanted and their outcomes following YAG Capsulotomy. Various objective methods have been described in literature for assessment of PCO. However, in this study we used TETZ PCO scoring combined with subjective assessment for estimation of severity of PCO. This is an easy and routinely performed grading system in our setting.

Various studies done previously have established that the incidence of PCO was more in hydrophilic compared to hydrophobic foldable IOLs.<sup>15,16,17,18,19</sup> Our results were in concordance with these studies as we also found a statistically significant difference in the rate of PCO formation between

these two materials of foldable IOLs. This may be due to the high water content of hydrophilic IOLs which facilitates lens epithelial cells (LEC) ingrowth.

However, in this study, SENSAR (AR40e) had the maximum incidence of PCO (3.75%), possibly due to the fact that SENSAR is a 3-piece hydrophobic foldable IOL with rigid haptics, which causes stretching of the posterior capsule. This leads to the appearance of corrugations in the posterior capsule which form channels that lead to the increased migration of LECs and thereby increasing the incidence of PCO in these IOLs. On the other hand, hydrophilic IOLs (ZEISS - CT ASPHINA 409M, 509M, 809M) had a low incidence of PCO in our study, possibly due to its 4-point fixation, thereby obstructing the migration of LECs and decreasing PCO formation.<sup>20</sup>

The square -edge design of the lens has been shown to be associated with less incidence of PCO since it may act as a mechanical barrier to lens epithelial cell migration onto the posterior capsule.<sup>21,22,23</sup> Studies have confirmed that the rectangular shape of the IOL rim of hydrophobic IOLs with its sharp edges, in combination with the acrylic material, was the main reason for the reduced formation of PCO.<sup>24</sup> Optic diameter is also known to influence the formation of PCO, the incidence being lower in IOLs with larger optic diameter.<sup>25</sup> On the contrary, we found a higher rate of PCO in square edge lenses and IOLs with larger optic diameter. This may be due to the fact that most of the lenses implanted in the study period had square edge design and large optic diameter (6 mm), hence leading to statistically significant difference compared to round edge and small optic diameter (5.5 mm).

Previous studies have not established a strong correlation between lens design and PCO,<sup>26,27</sup> although some studies found that three-piece foldable lenses were associated with higher PCO rates compared to single piece.<sup>28,29</sup> However in this study, lens design did not seem to influence the incidence of PCO formation. The average duration between phacoemulsification surgery and Nd:YAG capsulotomy was found to be 32±3 months, the duration being significantly shorter for hydrophilic IOLs compared to hydrophobic IOLs, which was in accordance with studies comparing time taken for PCO formation between hydrophobic and hydrophilic lenses.<sup>30,31</sup> YAG capsulotomy may be associated with significant complications as reported in various studies.<sup>32</sup> However, in this series it was found to be a safe procedure, as suggested by very low complication rate (0.012%), most of the complications being short term and managed medically with topical medications.

Previous studies have suggested good visual outcomes in terms of BCVA, functional vision, improvement in contrast and aberrations after YAG capsulotomy.<sup>33</sup> We also found satisfactory visual outcomes after YAG, as we observed a statistically significant improvement in BCVA following the procedure. However, functional vision, contrast and aberrations could not be evaluated due to retrospective nature of the study and non-availability of respective data. However, this study had some limitations. One limitation of the study was that it we could not account for subjects who were lost to follow up, who underwent YAG elsewhere and who were operated in the last 1 year of the study period. Hence, it was difficult to estimate the true incidence of PCO and YAG capsulotomy in this series.

Another limitation was that we did not consider the influence of anterior or posterior capsule polishing, size of capsulorrhexis and IOL overlap during surgery due to unavailability of this information. These factors may have correlation with PCO formation as suggested in literature.<sup>34,35</sup> The results of this study reinforce the already known fact that hydrophobic IOLs have low incidence of PCO compared to hydrophilic, and hence should be preferred. Since most of the hydrophobic acrylic IOLs currently available are designed to have a square optic edge, this should be an ideal combination further reducing the chances of PCO. We saw contradictory findings in this study in relation to the optic edge design with the incidence of PCO being significantly higher in square edge compared to round edge design. This may suggest that a square edge may not always offer additional protection against PCO. These results may be of significance since the study involved a large cohort and had a long duration of 5 years. These observations may be investigated further with well-designed randomised comparison studies between hydrophobic acrylic lenses with and without square edge optic design involving large sample size and a longer follow-up.

## CONCLUSIONS

The study showed that the incidence of PCO formation was more and earlier with hydrophilic than with hydrophobic IOLs in view of the bioadhesive nature of the hydrophobic IOLs. Therefore, hydrophobic IOLs are the most preferred IOLs for implantation post phacoemulsification. It was more frequently seen with square edge optic design. However, lens design, single-piece or three-piece did not seem to influence the rate of PCO formation.

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