BMC Ophthalmology

RESEARCH Open Access

Posterior capsule opacification treatment using Nd: YAG laser capsulotomy: 36 months retrospective analysis

Andrius Montrimas[1,2*], Jorė Rinkevičiūtė[3] and Reda Žemaitienė[1,2]

Abstract

Background The study aimed to identify factors influencing the time from cataract surgery to PCO treatment with Neodymium: Yttrium-Aluminium-Garnet (Nd: YAG) laser.

Methods For PCO risk factors analysis the retrospective study included 1045 eyes treated for PCO using Nd: YAG laser capsulotomy in the Hospital of Lithuanian University of Health Sciences (HLUHS) Kaunas Clinics with reduced best-corrected distance visual acuity (BCDVA) and opacity in the central 3 mm zone. Eyes with no comorbidities were categorized into groups according to the intraocular lense (IOL) implanted and the time from cataract operation to Nd: YAG capsulotomy was compared. Tests used for statistical analysis: Shapiro-Wilk, Kruskal-Wallis, Mann-Whitney, one-way independent ANOVA, Pearson's or Spearman's correlation coefficient, and multivariable linear regression.

Results A total of 918 patients (1045 eyes) were included. The median time from cataract surgery to capsulotomy was 39.0 (27.4–54.6) months (min. 2; max. 174), did not differ between men and women, and was shorter for junior surgeons (25.8 (19.8–35.1) months) compared to senior surgeons (39.6 (27.8–55.3) months) ($p < 0.001$). Seven factors affecting the time from cataract surgery to Nd: YAG capsulotomy were found: IOL model, surgeon's experience, BCDVA after surgery, capsular tension ring, pseudoexfoliation, BCDVA before capsulotomy and exudative age-related macular degeneration (adjusted $R^2 = 0.452$; $p < 0.001$). The IOL model was the only factor with a strong correlation. The median time from cataract surgery to capsulotomy differed between all IOL groups: Acriva UD613 group 31.5 (23.0–38.0) months, Johnson&Johnson Tecnis ZCB00 group 41.0 (33.5–66.5) months, Bausch&Lomb Envista MX60 group 45.0 (38.5–54.5) months, and Alcon Acrysof IQ SN60WF group 53.0 (41.5–79.5) months.

Conclusions The IOL model seems to have the greatest influence on the time from cataract surgery to Nd: YAG capsulotomy. Acrylic hydrophobic IOLs with a square optical edge have different times from cataract surgery to Nd: YAG capsulotomy. Hydrophobic acrylic IOL seems to have a longer time from cataract surgery to Nd: YAG capsulotomy compared to hydrophilic acrylic IOL with a hydrophobic surface.

Keywords Nd:YAG capsulotomy, Posterior capsule opacification, Risk factors, Cataract surgery, Intraocular lens

*Correspondence:
Andrius Montrimas
andrius.montrimas@kaunoklinikos.lt
[1]Department of Ophthalmology, Faculty of Medicine, Medical Academy, Lithuanian University of Health Sciences, Kaunas 50161, Lithuania
[2]Department of Ophthalmology, Hospital of Lithuanian University of Health Sciences Kaunas Clinics, Kaunas, Lithuania
[3]Faculty of Medicine, Medical Academy, Lithuanian University of Health Sciences, Kaunas, Lithuania

Background

Posterior capsule opacification, is a late postoperative complication of uncomplicated cataract surgery that develops due to the proliferation, growth, migration, and transdifferentiation of lens epithelial cells (LEC) remaining on the anterior capsule after surgery [1, 2] The prevalence of PCO has been significantly reduced in recent years and it develops much later, but it remains the most common late postoperative complication of uncomplicated cataract surgery [3, 4] PCO leads to a decrease in best-corrected distance visual acuity, impaired contrast sensitivity and stereo vision, ghosting, haloes, and psychological problems for patients, making this problem important not only from a medical but also from a socio-economical perspective [5, 6] Neodymium: Yttrium-Aluminium-Garnet (Nd: YAG) laser capsulotomy is considered the modern standard of care for PCO in adults. Although it is a non-invasive, relatively simple, and quick procedure, it also imposes additional costs on the healthcare system, seems to influence the choroidal vascularity index, and rarely complicates with IOL dislocation or damage, uveitis, increase in intraocular pressure, cystic macular edema, and retinal tear or detachment [7–9] For this reason, PCO risk factors are analyzed to develop better prevention measures. The most important modifiable PCO risk factors are the cataract surgery technique and the IOL model [10, 11] Although acrylic hydrophobic IOLs with a square optical edge slow down the development of PCO, they still have differences [12–16] Therefore, the present study aimed to identify factors influencing the time from cataract surgery to PCO treatment with Nd: YAG laser and to compare it among four IOL models.

Methods

A permission No. BE-2-30 was obtained from the Kaunas Regional Biomedical Research Ethics Committee before the start of the study. A total of 2398 cases (eyes) who underwent Nd: YAG capsulotomy at the Department of Opthalmology of HLUHS Kaunas Clinics between January 2019 and December 2021 (i.e. 36 months) for a diagnosis of PCO, coded H26.4 in the International Classification of Diseases, were retrospectively selected. The exclusion criteria for the study were the following:

1. Lack of relevant information for the study;
2. Surgery performed in other medical institutions;
3. Patients‘ age less than 65 years at the time of cataract surgery;
4. Implantation of a non-monofocal IOL;
5. IOL implantation site is other than the lens capsule bag;
6. Nd: YAG capsulotomy was performed for more than one time;
7. BCDVA did not improve after Nd: YAG capsulotomy;
8. Fibrotic form of PCO;
9. PCO development earlier than 2 months after surgery;
10. Intraoperative or postoperative cataract surgery complications;
11. Eye surgery during or after cataract surgery.

After applying the exclusion criteria, 1045 eyes were included in the study. The medical history, cataract surgery, and Nd: YAG capsulotomy protocols of these cases were analyzed and the following information was collected: patient gender, age at the time of cataract surgery, eye operated on, concomitant ocular and systemic diseases, date of the surgery, the surgeon who performed the surgery, operative and postoperative complications, IOL power and model, BCDVA before and after cataract surgery as well as before and after Nd: YAG capsulotomy. Myopia was determined by the diopters of the implanted IOL, and myopic eyes were defined as eyes with an IOL power less than or equal to 19D.

Patients‘ complaints of worsening BCDVA after cataract surgery and objectively observed opacities on the posterior lens capsule in the central 3 mm area during the laser procedure were considered to be appropriate criteria for the treatment of PCO with Nd: YAG capsulotomy (Ellex Ultra Q™ - YAG Laser from Lumibird Medical). The capsulotomy was performed using the cruciate pattern with an average of 53.6 mJ of energy used.

Cataract surgery was performed using conventional surgical techniques in all eyes: lens phacoemulsification and implantation of an artificial IOL into the capsular bag. The IOL model was selected by the operating surgeon. 9 different IOLs were used for patients included in the study (Table 1). Postoperative treatment included a combination of antibiotic (Levofloxacin 0.5% or chloramphenicol 0.2%) and hormone drops (Dexamethasone 0.1%) two to four weeks after surgery. Surgeons operating for 5 or more years were considered experienced surgeons and surgeons operating for less than 5 years as junior surgeons.

All eyes included in the study were used for the analysis of risk factors for PCO. Subsequently, eyes without underlying ocular diseases implanted with the four most common IOLs (Acriva UD613; Bausch & Lomb Envista MX60; Johnson & Johnson Tecnis ZCB00; Alcon SN60WF) were selected and divided into groups according to the implanted IOL model (257 eyes in total). These IOL models were chosen for the analysis because they were used at our department during the same period of time, while other IOL models were not, for example, Alcon Clareon was started to use in our department only at the end of 2020, which would have biased the results.

Table 1 Characteristics of the IOL models included in the study

Parameter	Alcon Acrysof IQ SN60WF	Alcon Acrysof IQ SN60AT	Alcon Clareon	J&J Tecnis ZCB00	B&L Envista MX60	Acriva UD613	Hanita Seelens AF	Biotech Eyecryl Plus 600	Aquafold CBF32
IOL length (mm)	13.0	13.0	13.0	13.0	12.5	13.0	13.0	12.5	12.5
Optic diameter (mm)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Optical shape	Both-sided asymmetric aspherical	Both-sided asymmetric aspherical	Both-sided asymmetric aspherical	Both-sided asymmetric aspherical	Both-sided asymmetric aspherical	Both-sided asymmetric aspherical	Both-sided asymmetric aspherical	Spherical	-
Optical edge	Square	Square	Square	Square	Square	Square	Square	Square	Square
Optics and haptics material	Hydrophobic acrylic	Hydrophobic acrylic	Hydrophobic acrylic	Hydrophobic acrylic	Hydrophobic acrylic	Hydrophilic acrylic with hydrophobic surface	Hydrophilic acrylic	Hydrophilic acrylic	Hydrophilic acrylic
Shape of haptics	C-loop	C-loop	C-loop	C-loop	C-loop	C-loop	C-loop	C-loop	C-loop

J&J– Johnson&Johnson; B&L– Bausch&Lomb;

The time from cataract surgery to Nd: YAG capsulotomy was compared between these IOL groups only.

The data was organized and analyzed using Microsoft® Excel (Microsoft Co., Redmon, Redmond, United States) and statistical analysis was performed using IBM SPSS Statistics V29.0 software. Normal variables were described by their mean and standard deviation, while the median and interquartile range were used for the non-normal variables. The Kolmogorov-Smirnov and Shapiro-Wilk criterion were used to test the normality of the variable distribution. For quantitative variables that did not satisfy the conditions for a normal distribution, the values were compared using the non-parametric Kruskal-Wallis or Mann-Whitney criterion, depending on the number of samples, and for those that did satisfy the conditions for a normal distribution, the values were compared using a one-way independent ANOVA criterion. The strength of the association between the different attributes was assessed by Pearson's or Spearman's correlation coefficient. Multivariable linear regression was used to estimate the predictive model of risk factors for PCO. To assess the IOL model as a risk factor, the IOL models were grouped into categorical variables in ascending order depending on their median values of time from cataract surgery to Nd: YAG capsulotomy in each group. The statistical significance level was p-value < 0.05.

Results

Description of the study participants

A total of 918 patients (1045 eyes) were included in the study, 76.0% of whom were female. The mean age of all subjects at the time of cataract surgery was 75.58±5.7 years. 541 left eyes (51.8%) and 504 right eyes (48.2%) were operated on. 997 eyes (95.4%) were operated on by experienced surgeons. 67 eyes (6.4%) had a capsular tension ring (CTR) implanted during cataract surgery. The median time from cataract surgery to Nd: YAG capsulotomy was 39.0 (27.4–54.6) months (min. 2; max. 174), and the median time was significantly shorter in the group of junior surgeons (25.8 (19.8–35.1) months) compared to the group of experienced surgeons (39.6 (27.8–55.3) months) ($p < 0.001$). The median decimal BCDVA after cataract surgery was 1.0 (0.9–1.0), and the average BCDVA before and after Nd: YAG capsulotomy was 0.4±0.2 and 0.7±0.3 respectively. There was no statistically significant difference in age at the time of cataract surgery between men and women. We also found no differences when comparing postoperative BCDVA, BCDVA before Nd: YAG capsulotomy, and the time from cataract surgery to Nd: YAG capsulotomy between the sexes. Meanwhile the frequency of CTR implantation was statistically significantly higher in males than in females ($p < 0.003$).

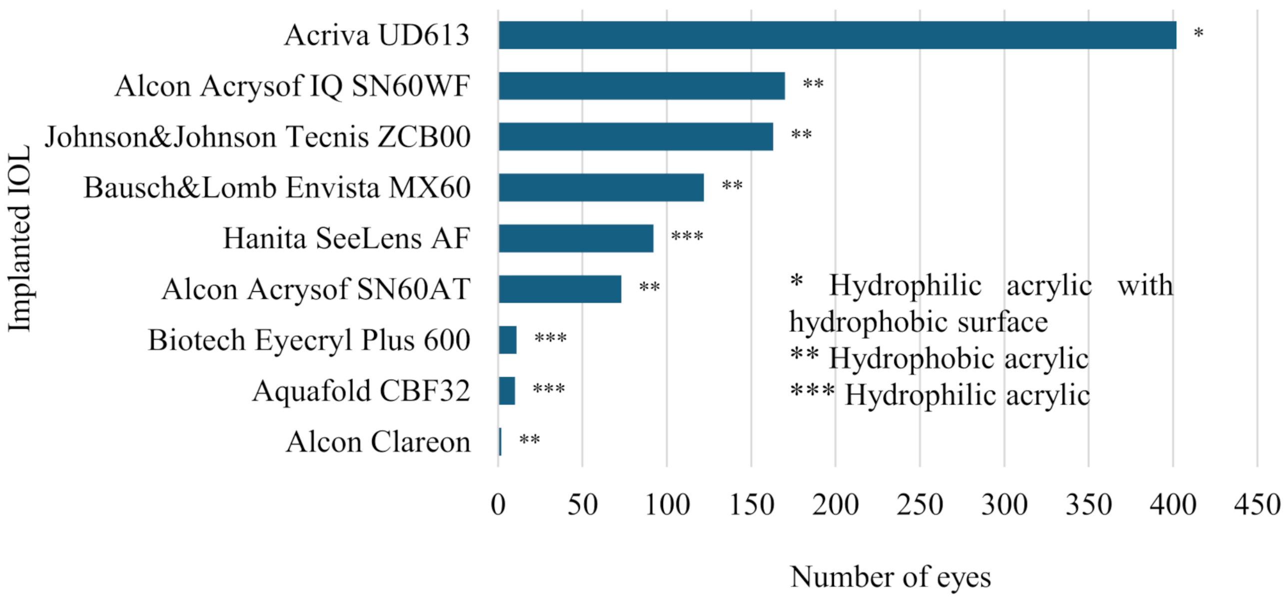

Fig. 1 Distribution of implanted IOL models for patients treated with Nd: YAG capsulotomy

Table 2 Comorbidities of patients treated with Nd: YAG capsulotomy

Comorbidity	Total *n* (%)	Women *n* (%)	Men *n* (%)	*p* value*
Uveitis	2 (0.2)	0 (0.0)	2 (0.8)	-**
Open-angle glaucoma	280 (26.9)	206 (25.8)	74 (29.8)	0.215
Angle-closure glaucoma	18 (1.7)	16 (2.0)	2 (0.8)	0.204
Pseudoexfoliation syndrome	243 (23.3)	174 (21.8)	69 (27.8)	0.051
Retinitis Pigmentosa	2 (0.2)	2 (0.3)	0 (0.0)	-**
Diabetes mellitus	81 (7.8)	62 (7.8)	19 (7.7)	0.952
Proliferative diabetic retinopathy	9 (0.9)	7 (0.9)	2 (0.8)	0.915
Non-proliferative diabetic retinopathy	10 (1.0)	8 (1.0)	2 (0.8)	0.780
Exudative AMD	67 (6.4)	50 (6.3)	17 (6.9)	0.744
Dry AMD	375 (35.9)	290 (36.4)	85 (34.3)	0.545
Myopia	214 (20.5)	166 (20.8)	48 (19.4)	0.616
Central retinal vein thrombosis	5 (0.5)	4 (0.5)	1 (0.4)	-**

The most common IOL implanted was Acriva UD613 IOL in 402 eyes (38.5%) and the least common during the study period was Alcon Clareon in 2 eyes (0.2%) (Fig. 1). Acrylic hydrophobic IOLs were implanted in 530 eyes (51.0%), acrylic hydrophilic IOLs with a hydrophobic surface were implanted in 402 eyes (38.0%), and acrylic hydrophilic IOLs were implanted in 113 eyes (11.0%).

Eye comorbidities were diagnosed in 797 eyes (76.0%), of which the most frequent were (Table 2): dry age-related macular degeneration (AMD) in 35.9% (375 eyes), open-angle glaucoma in 26.9% (280 eyes), and pseudoexfoliation syndrome (PEX) in 23.3% (243 eyes).

AMD - age-related macular degeneration; *Compared males and females; **Too few subjects with this feature;

Risk factors for PCO

A total of 17 potential risk factors for PCO were analyzed. Time from cataract surgery to Nd: YAG capsulotomy was statistically significantly correlated with six factors: IOL model, CTR, surgeon's experience, postoperative BCDVA, PEX, and diabetes mellitus (DM). The IOL model was the only factor with a strong correlation of >0.5, whereas the other factors had a low correlation coefficient of <0.3. A positive correlation was found between the time from cataract surgery to Nd: YAG capsulotomy and the IOL model, surgeon's experience, and postoperative BCDVA, i.e. higher experience of a surgeon, better postoperative BCDVA and certain IOL models lead to a longer time from surgery to Nd: YAG capsulotomy. In contrast, a negative correlation was found between the time from surgery to Nd: YAG capsulotomy and the presence of CTR, PEX and DM, i.e. patients who had a CTR implanted and suffered from DM or PEX had a shorter time from cataract surgery to Nd: YAG capsulotomy (Table 3).

Table 3 Correlations between risk factors and the time from cataract surgery to Nd: YAG capsulotomy

Risk factor	Correlation coefficient	*p*-value
Uveitis	-0.049	0.113
Open-angle glaucoma	0.046	0.139
Angle-closure glaucoma	-0.008	0.793
Pseudoexfoliation syndrome	-0.135	< 0.001
Retinitis pigmentosa	-0.006	0.852
Diabetes mellitus	-0.083	0.007
Exudative AMD	-0.053	0.088
Dry AMD	-0.005	0.867
Myopia	-0.041	0.189
Central retinal vein thrombosis	-0.011	0.715
Gender	-0.045	0.150
Surgeon's experience	0.166	< 0.001
IOL model	0.600	< 0.001
IOL power in diopters	0.038	0.216
CTR	-0.175	< 0.001
BCDVA after surgery	0.094	0.003
BCDVA before Nd: YAG capsulotomy	-0.036	0.242

AMD– age-related macular degeneration; IOL– intraocular lens; CTR– capsular tension ring; BCDVA– best corrected visual acuity;

Meanwhile, multivariable linear regression identified two additional independent factors affecting the time from cataract surgery to Nd: YAG capsulotomy: BCDVA before Nd: YAG capsulotomy and exudative AMD, while DM did not show any statistically significant correlation. (Table 4).

Analysis of different intraocular lens groups

After the selection of subjects without ocular comorbidities, four groups were formed according to the most often IOL implanted (Acriva UD613; Bausch&Lomb Envista MX60; Johnson&Johnson Tecnis ZCB00; Alcon Acrysof IQ SN60WF), a total of 257 eyes (Table 5). No differences were observed between genders or the frequency of CTR implantation in the IOL groups. Patients in the Acriva UD613 group were statistically significantly more likely to be operated on by junior surgeons compared to the other groups. Also, patients in the Acriva UD613 group were older at the time of cataract surgery (75.6 ± 6.6 yrs) than in the Alcon Acrysof IQ SN60WF group (71.8 ± 4.2 yrs) ($p < 0.001$), and the BCDVA prior to the Nd: YAG capsulotomy in the Acriva UD613 group was 1–2 Snellen table lines lower than in the other groups ($p < 0.001$) (Table 5).

The median of time from cataract surgery to Nd: YAG capsulotomy differed between all four IOL groups ($p < 0.001$) and increased between groups in the following manner: 31.5 (23.0–38.0) months in the Acriva UD613 group, 41.0 (33.5–66.5) months in the Johnson&Johnson Tecnis ZCB00 group, 45.0 (38.5–54.5) months in the Bausch&Lomb Envista MX60 group, 53.0 (41.5–79.5) months in the Alcon Acrysof IQ SN60WF group (Fig. 2).

Table 4 Independent risk factors for time from cataract surgery to Nd: YAG capsulotomy

Independent factor	Coefficient b	Standard error of coefficient	Standardised b coefficient	*p* value	Confidence intervals
Constant	1.532	4.048	-	-	-6.412;9.476
IOL model	9.403	0.350	0.637	< 0.001	8.715;10.090
CTR	-9.820	2.699	-0.086	< 0.001	-15.115;-4.524
Surgeon's experience	7.404	3.240	0.054	0.022	1.047;13.761
PEX	-5.363	2.949	-0.045	0.069	-11.150;0.424
BCDVA before Nd: YAG capsulotomy	-9.041	2.936	-0.079	0.002	-14.803;-3.279
BCDVA after surgery	7.735	3.148	0.066	0.014	1.558;13.912
Exudative AMD	-3.234	1.588	-0.048	0.042	-6.349;-0.118

IOL– intraocular lens; CTR– capsular tension ring; PEX– pseudoexfoliation syndrome; AMD– age-related macular degeneration; BCDVA– best corrected visual acuity;

Table 5 Comparison of different IOL groups without concomitant eye diseases

Factor	Acriva UD613 (*n* = 126)	B&L Envista MX60 (*n* = 41)	J&J Tecnis ZCB00 (*n* = 45)	Alcon Acrysof IQ SN60WF (*n* = 45)	*p* value
Age at the time of cataract surgery*, years	75.7 ± 6.6	73.1 ± 5.4	74.3 ± 4.7	71.8 ± 4.2	< 0.001 (between 1–4)
BCDVA after surgery **	1.0 (0.9–1.0)	1.0 (1.0–1.0)	1.0 (1.0–1.0)	1.0 (0.7–1.0)	0.547
BCDVA before Nd: YAG capsulotomy *	0.3 ± 0.2	0.3 ± 0.2	0.5 ± 0.2	0.5 ± 0.3	< 0.001 (between 1–2,1–3,1–4, 2–4)
BCDVA after Nd: YAG capsulotomy **	1.0 (0.6–1.0)	1.0 (1.0–1.0)	1.0 (1.0–1.0)	1.0 (0.6–1.0)	0.050
Time from surgery to Nd: YAG capsulotomy **, months	31.5 (23.0–38.0)	45.0 (38.5–54.5)	41.0 (33.5–66.5)	53.0 (41.5–79.5)	< 0.001

BCDVA– best corrected visual acuity; Nd: YAG - Neodymium: Yttrium-Aluminium-Garnet; J&J - Johnson&Johnson; B&L - Bausch&Lomb; * Mean ± SD; **Median (Q1 - Q3)

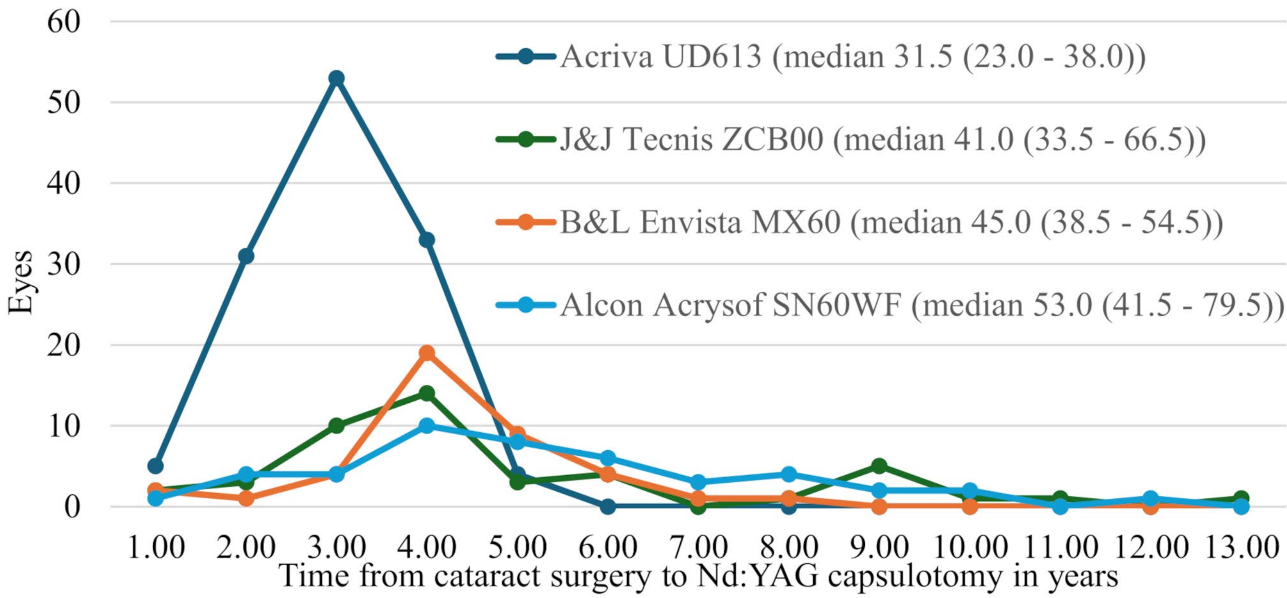

Fig. 2 Comparison of time from cataract surgery to Nd: YAG capsulotomy in different IOL groups

Discussion

PCO is a multifactorial condition, the development of which may be determined by a number of factors related to the patient, cataract surgery technique or implanted IOL. In this retrospective study of 1045 eyes, seven independent factors were found to influence the time from cataract surgery to Nd: YAG capsulotomy: the IOL model, greater surgeon‘s experience and better postoperative BCDVA seem to prolong the time from cataract surgery to Nd: YAG capsulotomy, whereas CTR implants, the presence of PEX or exudative AMD, and better BCDVA before Nd: YAG capsulotomy reduce the time.

The association between the implanted IOL model and the time from cataract surgery to Nd: YAG capsulotomy found in our study confirms the results obtained in other studies, where Alcon Acrysof IQ SN60WF or SA60AT seem to stand out with the lowest rates of PCO [13, 14, 17–25]. To our knowledge, no articles have been published on the incidence of PCO in the Acriva UD613 IOL group. The Acriva UD613 IOL stood out for having a surface with hydrophobic properties, but the acrylic material from which it was made consisted of two components (2-Oxyethylmethacrylate and 2-Hydroxymethacrylate) with both hydrophobic and hydrophilic properties, whereas the other lenses were fully hydrophobic. This may have led to Acriva UD613 having the worst results among the four IOL groups. Ong et al. found that fibronectin binds better to the Alcon Acrysof IQ acrylic compared to Johnson & Johnson Tecnis ZCB00 or other IOLs tested, and Linnola's "Sandwich Theory" suggests that bioactive agents (that promote binding) promote the formation of a single LEC layer that connects the IOL to the posterior capsule of the lens, preventing further LEC growth [21, 26]. This may be one of the reasons why the Alcon Acrysof IQ IOL has the lowest incidence of PCO in many studies. Although all IOLs in our study declare a square edge of 360 degrees, studies have shown that the steepness of the edge varies between IOLs and that hydrophilic lenses tend to have a rounder edge, which may have an impact on the development of PCO [27]. The geometrical properties of the haptics, the C-loop shape, and the optic-haptic junction are also very important [28]. A.F. Borkenstein et al. investigated the properties of haptics and optic-haptic junctions of five IOLs (Alcon AcrySof IQ SN60WF, Zeiss CT LUCIA 621PY, Bausch&Lomb EnVista MX60, Johnson&Johnson Tecnis ZCB00, and Hoya Vivinex XY1) on compression simulators. The authors found that the geometrical properties of the IOL haptics and the optic-haptic junction differed for all IOLs studied, resulting in different IOL haptics contact areas and angles with posterior lens capsule in different capsule bag sizes [29]. Other less important factors in the development of PCO are the size of the optical zone, so that the anterior edge of the capsulorhexis overlaps with the optical zone, and the aspheric surface of the IOL, which increases the contact between the IOL and the capsule [30, 31]. All four IOLs we studied are aspheric with an optical zone of 6 mm, so the role of this factor remains unclear in our study.

In our study, the implantation of a CTR increased the incidence of PCO, which is largely contradictory to the literature, where CTR seems to reduce or have no impact on PCO development [32, 33]. In our clinic CTR is usually implanted in complicated cases, thus our result may be distorted by other features important for the development of PCO, which we could not evaluate i.e.– uneven or large-diameter capsulorhexis, capsulorhexis margin crack, or a significant defect in the zonules of Zinn during surgery. These conditions affect the ability of the surgeon to safely polish the posterior capsule and remove all cortical layers of the lens or the viscoelastic material remaining behind the IOL.

Another independent factor identified in our study was the surgeon's experience. We found that patients operated on by junior surgeons required Nd: YAG capsulotomy treatment for PCO significantly earlier than those operated on by experienced surgeons. Few studies have defined low-experience surgeons differently and attempted to assess the impact on the development of PCO, thus the results are inconclusive. One study found that the incidence of PCO in the group of junior surgeons was statistically significantly higher while another did not observe any differences [13, 34]. The main reasons for the earlier Nd: YAG capsulotomy in the junior surgeons' group may be the inadequate removal of the cortical layers of the lens and the viscoelastic material or a larger anterior capsulorhexis than in the experienced surgeons' group [34].

We found that PEX is an independent risk factor, shortening the time to Nd: YAG capsulotomy. Few studies have looked at this factor, but our results confirm the results of two other retrospective articles that PEX is a risk factor for PCO [35, 36]. The shorter time to Nd: YAG capsulotomy in patients with PEX may be explained by several factors: firstly, the pupil dilates poorly in these patients, which makes it more difficult to remove the cortical layers of the lens during surgery [36]. These eyes may also have impaired fluid blood barrier function, a pro-inflammatory environment, and tissue hypoxia in the anterior chamber, which can stimulate the accelerated development of PCO [36, 37]. Another important factor may be the instability of the zonules, which may lead to a more difficult surgical procedure and, postoperatively, to lens capsule folds, disturbed IOL/capsule contact, and more rapid migration of the LEC [36]. Meanwhile, A. E. Ostern et al. compared the incidence of PCO and Nd: YAG capsulotomy 6 to 7 years postoperatively and found no differences between patients with and without PEX. The authors attributed these results to an improved surgical technique (all patients were operated using phacoemulsification technique and small corneal incisions), which reduced inflammation, and to Alcon AcrySof IQ MA60BM IOLs used in the study, which have polymethylmethacrylate (PMMA) haptics forming a 10-degree angle with the optic [38].

Exudative AMD was also observed as an independent risk factor in our study. H.C. Chen et al. also observed a correlation between AMD and Nd: YAG capsulotomy, which they attributed to the pro-inflammatory state of the eye in this disease [39]. We suggest that the shorter time to Nd: YAG capsulotomy in this group of patients may have been due to several factors, in particular, patients with exudative AMD regularly go to ophthalmologist appointments, which leads to an earlier diagnosis of PCO. Secondly, PCO makes it more difficult to view the eye fundus, which is important for tracking AMD. Finally, in these patients, it is difficult to differentiate between the cause of the visual impairment: AMD or PCO. For these reasons, laser treatment of PCO could have been performed earlier than usual in these cases.

Although BCDVA may not be a risk factor for the development of PCO, the retrospective study design made it essential to include this variable in the multivariate analysis to obtain more accurate results.

The retrospective nature of this study had advantages but also disadvantages. The main advantage was, that due to a retrospective analysis, we were able to record Nd: YAG capsulotomy cases as long as 13 years after the surgery and this allowed us to reflect on the specificities of a large center. However, the results of our study may have been influenced by the fact that we could not assess the centration of the anterior capsulorhexis in relation to the IOL and the integrity of the capsulorhexis, the patients were operated on by different surgeons, which could have led to different outcomes, PCO was diagnosed by an ophthalmologist without using a specific classification system, only patients who underwent Nd: YAG capsulotomy at our hospital were included and we could not choose which IOLs to include, as the models of IOLs implanted are constantly changing, which left some of the newest IOLs out of the study, or only isolated cases were included (e.g. the Alcon Clareon, that our clinic started to use at the end of 2020). However, as B. Johansson states in her study: the quality and reliability of data from a retrospective study depends on the functionality of the healthcare system in which the study was performed and the likelihood that patients were not treated too early or too late [40]. So we believe, that our tertiary center is well suited for this type of study because we have a high patient flow, relatively short waiting times for Nd: YAG capsulotomy (up to 3 months), long follow-up times, the treatments are covered by the national health insurance fund, and the specialists are not obliged to perform the procedures earlier because of financial incentives.

Conclusions

In conclusion, seven independent factors affecting the time from cataract surgery to Nd: YAG capsulotomy were found (CTR, PEX, BCDVA before capsulotomy, exudative AMD, IOL model, surgeon's experience and BCDVA after cataract surgery) but the IOL model had the greatest influence. The median of time from cataract surgery to Nd: YAG capsulotomy differed between all four IOL groups without comorbidities and increased between groups in the following manner: Acriva UD613 group, Johnson&Johnson Tecnis ZCB00 group, Bausch&Lomb Envista MX60 group, and Alcon Acrysof IQ SN60WF group. Hydrophobic acrylic IOL seem to have a longer time from cataract surgery to Nd: YAG capsulotomy compared to hydrophilic acrylic IOL with a hydrophobic surface.

Abbreviations

AMD	Age-related macular degeneration
BCDVA	Best-corrected distance visual acuity
CTR	Capsule tension ring
DM	Diabetes mellitus
HLUHS	Hospital of Lithuanian University of Health Sciences
IOL	Intraocular lense
LEC	Lens epithelial cells
Nd:YAG	Neodymium: Yttrium-Aluminium-Garnet
PCO	Posterior capsule opacification
PEX	Pseudoexfoliation syndrome

Acknowledgements
not applicable.

Author contributions
AM analyzed and interpreted the patient data and was a major contributor to writing the manuscript. JR analyzed and interpreted the patient data. RZ interpreted the patient data and substantively revised the manuscript. All authors read and approved the final manuscript.

Funding
Article processing charge (APC) is covered by our institution.

Data availability
the datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
Kaunas Regional Biomedical Research Ethics Committee issued permission No. BE-2-30 to perform the analysis without informed consent from the participants due to the retrospective nature of the study and the large number of cases. The study was conducted in compliance with the Helsinki Declaration.

Consent for publication
not applicable.

Competing interests
The authors declare no competing interests.

Received: 27 January 2025 / Accepted: 27 March 2025
Published online: 10 April 2025

References

1. Apple DJ, Solomon KD, Tetz MR, Assia EI, Holland EY, Legler UFC, et al. Posterior capsule opacification. Surv Ophthalmol. 1992;37:73–116.
2. Wormstone IM. Posterior capsule opacification: A cell biological perspective. Exp Eye Res. 2002;74:337–47.
3. Terveen D, Berdahl J, Dhariwal M, Meng Q. Real-World cataract surgery complications and secondary interventions incidence rates: an analysis of US medicare claims database. J Ophthalmol. 2022;1–7.
4. Chang A, Kugelberg M. Posterior capsule opacification 9 years after phacoemulsification with a hydrophobic and a hydrophilic intraocular lens. Eur J Ophthalmol. 2017;27:164–8.
5. Van Bree MCJ, Kruijt B, Van Den Berg TJTP. Real-world scenes captured through posterior capsule opacification specimens: simulation of visual function deterioration experienced by PCO patients. J Cataract Refract Surg. 2013;39:144–7.
6. Menon GJ, Wong KK, Bundhun T, Ewings P, Twomey JM. The effect of Nd:YAG laser posterior capsulotomy on stereoacuity. Eye. 2007;23:186–9.
7. Karahan E, Er D, Kaynak S. An overview of Nd:YAG laser capsulotomy. Med Hypothesis Discovery Innov Ophthalmol. 2014;3:45.
8. Raulinajtys-Grzybek M, Grabska-Liberek I, Opala A, Słomka M, Chrobot M. Budget impact analysis of lens material on the posterior capsule opacification (PCO) as a complication after the cataract surgery. Cost Eff Resource Allocation. 2020;18:1–12.
9. Icoz M, Tarım B, Icoz SGG. The effect of Nd:YAG laser applied in the posterior capsule opacification on retinal and choroidal structures. Photodiagnosis Photodyn Ther. 2023;43.
10. Wu S, Tong N, Pan L, Jiang X, Li Y, Guo M et al. Retrospective analyses of potential risk factors for posterior capsule opacification after cataract surgery. J Ophthalmol. 2018;1–7.
11. Donachie PHJ, Barnes BL, Olaitan M, Sparrow JM, Buchan JC. The Royal college of ophthalmologists' National ophthalmology database study of cataract surgery: report 9, risk factors for posterior capsule opacification. Eye. 2022;37:1633–9.
12. Zemaitiene R, Jasinskas V, Auffarth GU. Influence of three-piece and single-piece designs of two sharp-edge optic hydrophobic acrylic intraocular lenses on the prevention of posterior capsule opacification: a prospective, randomised, long-term clinical trial. Br J Ophthalmol. 2006;91:644.
13. Reda, Zemaitienė. Vytautas Jašinskas. Prevention of posterior capsule opacification with 3 intraocular lens models: a prospective, randomized, long-term clinical trial. Medicina. 2011;47(11):595–9.
14. Ursell PG, Dhariwal M, O'Boyle D, Khan J, Venerus A. 5 Year incidence of YAG capsulotomy and PCO after cataract surgery with single-piece monofocal intraocular lenses: a real-world evidence study of 20,763 eyes. Eye. 2019;34:960–8.
15. Lee Y, Kim JS, Kim BG, Hwang JH, Kang MJ, Lee JH, et al. Comparison of the incidence of Nd:YAG laser capsulotomy based on the type of intraocular lens. Medicina. 2023;59:2173.
16. Belda JI, Dabán JP, Elvira JC, O'Boyle D, Puig X, Pérez-Vives C, et al. Nd:YAG capsulotomy incidence associated with five different single-piece monofocal intraocular lenses: a 3-year Spanish real-world evidence study of 8293 eyes. Eye. 2021;36:2205–10.
17. Werner L, Intraocular, Lenses. Overview of designs, materials, and pathophysiologic features. Ophthalmology. 2021;128:74–93.
18. Henry P, Donachie J, Sparrow JM, Buchan JC. Feasibility study of Post-cataract Posterior Capsule Opacification National Ophthalmology Database Audit. 2021.
19. Cooksley G, Lacey J, Dymond MK, Sandeman S. Factors affecting posterior capsule opacification in the development of intraocular lens materials. Pharmaceutics. 2021;13.
20. Pérez-Vives C. Biomaterial influence on intraocular lens performance: An overview. J Ophthalmol. 2018;2018.
21. Linnola RJ. Sandwich theory: Bioactivity-based explanation for posterior capsule opacification. J Cataract Refract Surg. 1997;23:1539–42.
22. Sharon Y, Livny E, Mimouni M, Weinberger D, Bahar I. Laser capsulotomy following cataract surgery: comparing time to capsulotomy with implantation of two broadly used intraocular lenses. Indian J Ophthalmol. 2017;65:144.
23. Sim DA, Lindfield D, Shah A. A comparison of time delay to Nd:YAG capsulotomy Post–Cataract surgery with PMMA, silicon, and hydrophobic acrylic lenses; implications for posterior capsular opacification research. Invest Ophthalmol Vis Sci. 2006;47:2546–2546.
24. Johansson B. Glistenings, anterior/posterior capsular opacification and incidence of Nd:YAG laser treatments with two aspheric hydrophobic acrylic intraocular lenses– a long-term intra-individual study. Acta Ophthalmol. 2017;95:671–7.
25. Cullin F, Busch T, Lundström M. Economic considerations related to choice of intraocular lens (IOL) and posterior capsule opacification frequency– a comparison of three different IOLs. Acta Ophthalmol. 2014;92:179–83.
26. Ton Van C, Tran THC. Incidence of posterior capsular opacification requiring Nd:YAG capsulotomy after cataract surgery and implantation of enVista® MX60 IOL. J Fr Ophtalmol. 2018;41:899–903.
27. Ong M, Wang L, Karakelle M. Fibronectin adhesive properties of various intraocular lens materials. Invest Ophthalmol Vis Sci. 2013;54:819–819.

28. Vock L, Crnej A, Findl O, Neumayer T, Buehl W, Sacu S, et al. Posterior capsule opacification in silicone and hydrophobic acrylic intraocular lenses with Sharp-edge optics six years after surgery. Am J Ophthalmol. 2009;147:683–90.
29. Nanavaty MA, Zukaite I, Salvage J. Edge profile of commercially available square-edged intraocular lenses: part 2. J Cataract Refract Surg. 2019;45:847–53.
30. Meacock WR, Spalton DJ, Boyce JF, Jose RM. Effect of optic size on posterior capsule opacification: 5.5 mm versus 6.0 mm acrysof intraocular lenses. J Cataract Refract Surg. 2001;27:1194–8.
31. Biber JM, Sandoval HP, Trivedi RH, Fernández de Castro LE, French JW, Solomon KD. Comparison of the incidence and visual significance of posterior capsule opacification between multifocal spherical, monofocal spherical, and monofocal aspheric intraocular lenses. J Cataract Refract Surg. 2009;35:1234–8.
32. Borkenstein AF, Borkenstein EM. Geometry of acrylic, hydrophobic IOLs and changes in Haptic–Capsular bag relationship according to compression and different well diameters: A bench study using computed tomography. Ophthalmol Ther. 2022;11:711–27.
33. Zhang K, Dong Y, Zhao M, Nie L, Ding X, Zhu C. The effect of capsule tension ring on posterior capsule opacification: A meta-analysis. PLoS ONE. 2021;16.
34. Haripriya A, Ramulu PY, Schehlein EM, Shekhar M, Chandrashekharan S, Narendran K, et al. The Aravind pseudoexfoliation study: 5-Year postoperative results. The effect of intraocular lens choice and capsular tension rings. Am J Ophthalmol. 2020;219:253–60.
35. Fong CSU, Mitchell P, Rochtchina E, Cugati S, Hong T, Wang JJ. Three-Year incidence and factors associated with posterior capsule opacification after cataract surgery: the Australian prospective cataract surgery and Age-related macular degeneration study. Am J Ophthalmol. 2014;157:171–e1791.
36. Abela-Formanek C, Amon M, Schauersberger J, Schild G, Kolodjaschna J, Barisani-Asenbauer T, et al. Uveal and capsular biocompatibility of 2 foldable acrylic intraocular lenses in patients with uveitis or pseudoexfoliation syndrome: comparison to a control group. J Cataract Refract Surg. 2002;28:1160–72.
37. Küchle M, Amberg A, Martus P, Nguyen NX, Naumann GOH. Pseudoexfoliation syndrome and secondary cataract. Br J Ophthalmol. 1997;81:862–6.
38. Naumann GOH, Schlötzer-Schrehardt U, Küchle M. Pseudoexfoliation syndrome for the comprehensive ophthalmologist: intraocular and systemic manifestations. Ophthalmology. 1998;105:951–68.
39. Chen HC, Lee CY, Sun CC, Huang JY, Lin HY, Yang SF. Risk factors for the occurrence of visual-threatening posterior capsule opacification. J Transl Med. 2019;17:1–8.
40. Østern AE, Sæthre M, Sandvik G, Drolsum L. Posterior capsular opacification in patients with pseudoexfoliation syndrome: a long-term perspective. Acta Ophthalmol. 2013;91:231–5.

Publisher's note