ORIGINAL ARTICLE

UDC: 617.7-089
DOI: https://doi.org/10.2298/VSP231208087T

The effect of three different acrylic intraocular lenses on the glistening formation

Uticaj tri različita akrilna intraokularna sočiva na formiranje *glistening*-a

Dušan Todorović*†, Sunčica Srećković*†, Nenad Petrović*†, Mirko Resan‡, Goran Damjanović§, Željko Todorović‖¶, Tatjana Šarenac Vulović*†

University Clinical Center Kragujevac, *Clinic for Ophthalmology, ‖Clinic for Hematology, Kragujevac, Serbia; University of Kragujevac, Faculty of Medical Sciences, †Department of Ophthalmology, ¶Department of Internal Medicine, Kragujevac, Serbia; ‡University of Defence, Faculty of Medicine of the Military Medical Academy, Belgrade, Serbia; §University Clinical Center of Serbia, University Eye Clinic, Belgrade, Serbia

Abstract

Background/Aim. One of the postoperative complications of phacoemulsification is the formation of fluid-filled microvacuoles inside the implanted intraocular lens (IOL). This condition is known as 'glistening'. The aim of this study was to determine the incidence of glistening formation after the implantation of three different acrylic IOLs during the two-year follow-up period. **Methods.** Cataract surgery was performed in 93 patients (93 eyes) with developed senile cataracts. According to the implanted IOL, patients were equally divided into three groups: group with single-piece hydrophilic (SPHphil) acrylic IOL, group with single-piece hydrophobic (SPHphob) acrylic IOL, and group with three-piece hydrophobic (TPHphob) acrylic IOL. The presence of glistening was measured five times: 1, 6, 12, 18, and 24 months after phacoemulsification. **Results.** Statistically significantly lower glistening incidence was recorded in the SPHphil group compared to the SPHphob and TPHphob group, six months after phacoemulsification ($p < 0.05$). That difference was even higher one year after the cataract surgery ($p < 0.01$) and remained at that level until the end of the study. During the whole follow-up period, no statistically significant difference was recorded among SPHphob and TPHphob groups ($p > 0.05$). **Conclusion.** The presence of glistening was recorded in all groups. Our results strongly suggest that the progression of glistening was the most pronounced in the first postoperative year. However, a very low glistening incidence associated with SPHphil IOL could be particularly beneficial in patients expected to develop increased postoperative inflammation.

Key words:
cataract; lenses, intraocular; ophthalmologic surgical procedures; phacoemulsification.

Apstrakt

Uvod/Cilj. Jedna od postoperativnih komplikacija fakoemulzifikacije je formiranje mikrovakuola ispunjenih tečnošću unutar implantiranog intraokularnog sočiva (IS). Ovo stanje poznato je kao *glistening*. Cilj rada bio je da se utvrdi incidencija stvaranja *glistening*-a posle implantacije tri različita akrilna IS tokom dve godine praćenja. **Metode.** Operacija katarakte izvršena je kod 93 bolesnika (93 oka) sa razvijenom formom senilne katarakte. Prema implantiranom IS, bolesnici su podeljeni u tri jednake grupe: grupu sa jednodelnim hidrofilnim (JDHfil) akrilnim IS, grupu sa jednodelnim hidrofobnim (JDHfob) akrilnim IS i grupu sa trodelnim hidrofobnim (TDHfob) akrilnim IS. Prisustvo *glistening*-a mereno je pet puta: 1, 6, 12, 18 i 24 meseca nakon fakoemulzifikacije. **Rezultati**. Statistički značajno niža incidencija *glistening*-a zabeležena je u grupi JDHfil, u poređenju sa bolesnicima grupe JDHfob i TDHfob, šest meseci posle fakoemulzifikacije ($p < 0,05$). Ta razlika bila je još veća godinu dana posle operacije katarakte ($p < 0,01$) i ostala je na tom nivou do kraja studije. Tokom čitavog perioda praćenja nije zabeležena statistički značajna razlika među grupama JDHfob i TDHfob ($p > 0,05$). **Zaključak.** Prisustvo *glistening*-a zabeleženo je u svim grupama. Naši rezultati snažno sugerišu da je progresija *glistening*-a bila najizraženija u prvoj postoperativnoj godini. Međutim, veoma niska incidencija *glistening-a* povezana JDHfil IS može biti posebno korisna kod bolesnika kod kojih se očekuje razvoj povećane postoperativne inflamacije.

Ključne reči:
katarakta; sočiva, intraokularna; hirurgija, oftalmološka, procedure; fakoemulzifikacija.

Correspondence to: Dušan Todorović, University Clinical Center Kragujevac, Clinic for Ophthalmology, Zmaj Jovina 30, 34 000 Kragujevac, Serbia. E-mail: drdusantodorovic@yahoo.com

Introduction

Cataract surgery (CS) is the most commonly performed surgery worldwide [1, 2]. Phacoemulsification has represented a standard technique for CS in the last few decades [3, 4]. It is known that this technique decreased the intraoperative and postoperative complications rate compared to previously used intracapsular and extracapsular cataract extraction [5]. Moreover, phacoemulsification provides far better recovery of the postoperative visual function [6, 7]. However, this procedure also has some limitations and possible complications. One of the complications is the formation of fluid-filled microvacuoles inside the implanted intraocular lens (IOL). This condition is known as 'glistening' [8]. Glistening occurs in the postoperative period (POP) and can cause light scattering as well as decreased visual acuity (VA) and glare by changing the refractive index between IOL and aqueous humor. These symptoms can cause dissatisfaction and even fear in patients in the POP, especially if the patients know that the CS was performed without complications [9]. The high frequency of uneventful phacoemulsification, along with increased life expectancy of patients, the increased number of lens surgeries performed on younger patients, and the existence of numerous ocular comorbidities are factors that support the development of glistening in the POP [10]. Knowing that the only way to treat developed glistening is the IOL exchange gives this condition even more importance.

Glistening was mentioned for the first time in 1984 after the implantation of polymethyl methacrylate (PMMA) IOL [10]. So far, many studies have confirmed the presence of glistening in all materials used in the production of IOLs, including PMMA, silicone, hydrogel, and hydrophobic and hydrophilic acrylate [9, 11, 12].

According to their chemical structure, IOLs are polymers. During polymerization, small interspaces occur where the monomers are not ideally bound. Because of this, different parts characterized by higher and lower density are created inside the IOL. The water diffuses within the IOL and tends to accumulate precisely in the parts with lower density, such as in the cavities in which the monomers are not ideally bound to each other. These hollow spaces filled with fluid are clinically manifested as glistening [13] (Figure 1). The degree of water absorption depends on the IOL material and temperature [14]. When the IOL is surrounded by warm water, glistening does not form. Due to the drop in temperature, there is a supersaturation of the water inside the polymer and the glistening is formed [15]. In addition to the influence of the IOL material, more frequent glistening development was found in patients with glaucoma, uveitis, and IOLs of higher diopter strength [16]. Moreover, patients with a longer POP, as well as those who underwent combined cataract and glaucoma surgery, i.e., phacotrabeculectomy, had a higher incidence of glistening formation [17].

Glistening can be diagnosed during a detailed patient examination with a biomicroscope. Due to the change in the IOL optical property, a small percentage of light is reflected towards the biomicroscope, which enables the visualization of glistening [18]. The diameter of the clinically visible vacuole averages from 1 to 20 μm. Miyata et al. [19] graded glistening in the following way: grade 0 – no glistening; grade I – 50 vacuoles/mm^2; grade II – 51–100 vacuoles/mm^2; grade III – 100–200 vacuoles/mm^2.

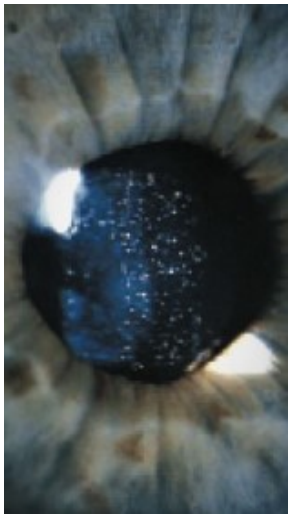

Fig. 1 – Biomicroscope image of implanted acrylic intraocular lens with developed glistening.

It is well-known that phacoemulsification leads to the occurrence of postoperative inflammation due to blood-aqueous barrier breakdown [2]. Long-term usage of antiglaucoma eye drops and the presence of uveitis or diabetes mellitus also contribute to intraocular inflammation, and thus the development of glistening. Current approaches in glistening reduction refer to the choice of an adequate surgical technique and IOL type, as well as the treatment of ocular comorbidities, in order to decrease postoperative inflammation [20–22].

The aim of this study was to determine the incidence of glistening formation after the implantation of three different acrylic IOLs during the two-year follow-up period.

Methods

The study was conducted at the Clinic for Ophthalmology of the University Clinical Center Kragujevac. It was designed as a prospective, randomized clinical study that lasted two years. The study was carried out according to the Declaration of Helsinki and approved by the Ethics Committee of the University Clinical Center Kragujevac (No. 01/17/1829, from May 25, 2017). Initially, all the patients gave their written consent to participate in the study. The research included 93 patients with senile cataracts. All the patients were operated on by one experienced surgeon using the same surgical technique and followed for 24 months after the phacoemulsification. A complete ophthalmological examination was performed one day before the surgery, on the first postoperative day, and 1, 6, 12, 18, and 24 months after the phacoemulsification. It included the measurement of VA and intraocular pressure, biomicroscope examination, keratometry, ophthalmoscopy,

ocular ultrasonography, and ultrasound biometry. The development of glistening was measured five times: 1, 6, 12, 18, and 24 months after CS. In this study, we applied the glistening gradation that Miyata et al. [19] performed using high-resolution images made at the biomicroscope.

The study included participants of both sexes, older than 65 years, with a confirmed diagnosis of senile cataract. Patients with presenile, traumatic, complicated, iatrogenic, congenital, and all other types of cataracts were excluded from the study. Those with a history of previous intraocular surgery and eye injuries or patients with corneal diseases, glaucoma, strabismus, uveitis, and retinal diseases could not participate in the study. Patients with complications during and after phacomemulsification, as well as those patients suffering from systemic autoimmune diseases, were excluded. Therefore, only patients with developed senile cataracts, without any underlying ocular condition, scheduled to be operated on by one surgeon using the same surgical technique were included in the study. Depending on the type of IOL which was going to be implanted during CS, the 93 patients (i.e., 93 eyes) were equally randomized into three groups: first group – single-piece hydrophilic acrylic IOL (SPHphil) (Eyecryl plus 600, Biotech visioncare, Luzern, Switzerland); second group – single-piece hydrophobic acrylic IOL (SPHphob) (AcrySof SA60AT, Alcon-Couvreur NV, Puurs, Belgium); third group – three-piece hydrophobic acrylic IOL (TPHphob) (AcrySof MA60AC, Alcon-Couvreur NV, Puurs, Belgium).

These IOLs were chosen because the Clinic for Ophthalmology, where the study was conducted, is part of the University Clinical Center, which belongs to the Public Health System and possesses exactly these three types of IOLs implanted in all patients who underwent CS.

All the surgeries were performed under local anesthesia, using topical tetracaine. Adequate mydriasis was achieved preoperatively using topical phenylephrine and tropicamide (2.5% phenylephrine, 0.5% tropicamide, Pharmacy "Zaječar", Zaječar, Serbia). The Phaco machine used in all surgeries was Stellaris Elite™ (Bausch & Lomb). The skin of the eyelids and periorbites was cleansed with a 10% solution of povidone-iodide, and the conjunctival fornix was washed with a 5% solution of povidone-iodide. After placing blepharostat and self-adhesive sterile compress, CS was started by creating two lateral paracentesis 1.5 mm wide at 2 and 10 o'clock. If necessary, trypan blue (0.06% ophthalmic solution 1 mL, Sidapharm, Thessaloniki, Greece) was used for better visualization of the anterior lens capsule. A cohesive viscoelastic (Bio-Hyalur plus, Biotech visioncare) was injected into the anterior chamber, and a "clear cornea" incision 2.75 mm wide was made at 12 o'clock. Continuous capsulorhexis, hydrodissection, and nucleus rotation followed. The lens phacofragmentation technique was "divide and conquer", after which the lens fragments were aspirated. Aspiration of the remaining epicortex and polishing of the posterior lens capsule were performed using bimanual irrigation and aspiration. The anterior chamber and capsular bag were filled with cohesive hyaluronate and IOL was implanted in the capsular bag. Viscoelastic was aspirated from the anterior chamber of the eye and the capsular bag. A diluted solution of cefuroxime (Nilacef®, Hemofarm AD, Vršac, Serbia; 1 mg/0.1 mL of balanced saline) was injected into the anterior chamber. Corneal incision wounds were hydrated. Postoperatively, topical dexamethasone-tobramycin (Tobradex®, Alcon-Couvreur NV, Puurs, Belgium) was administrated six times a day for one week, then four times a day for another three weeks, and nepafenac (Nevanac®, Alcon-Couvreur NV, Puurs, Belgium) was administrated four times a day for two weeks.

In the follow-up period, the influence of the patient's sex and age was also analyzed due to their possible effect on glistening formation. Therefore, each group was further divided into patients aged 65 to 75 and patients over 76, as well as male and female patients. The presence of clinical signs of glistening in the form of glare was also analyzed in the study.

Statistical analysis

SPSS Statistics 24.0 (IBM Corp., Armonk, NY, USA) was used in statistical analysis. The significance at different time intervals during the research was tested with the Student's *t*-test or by the Wilcoxon equivalence test in cases where the distribution was not normal. The incidence of glistening grades according to the IOL type was done using the Chi-Square test (χ^2) test and ANOVA ($p < 0.05$ value was accepted as statistically significant).

Results

The study included 93 patients (i.e., 93 eyes) equally divided into three groups (n = 31 each) according to the type of implanted IOL. In the first postoperative month, one patient from the third group died, so the total number of the followed participants was 92. Of that number, 48 (52.2%) patients were male and 44 (47.8%) were female. No statistically significant differences between the sexes were noticed in all groups ($\chi^2 = 0.17$, $df = 1$, $p > 0.05$).

Demographic characteristics of patients are shown in Table 1. The mean age of the patients was 73.5 ± 5.95 years (range 65–87). No statistically significant difference was observed in the mean age of the patients among the groups ($F = 0.26$, $df = 2$, $p > 0.05$).

During the study glistening was noticed in 43 patients (46.7%). Of that number, 20 (21.7%) patients were male and 23 (25%) female. No statistically significant differences between the sexes were recorded in glistening formation ($p > 0.05$).

One month after the surgery, 94.6% of patients had glistening grade 0, while only 5.4% had glistening grade I. During the first postoperative year, a statistically significant difference was noticed in every following visit compared to the previous one ($p < 0.05$). From that moment until the end of the research, no statistically significant glistening progression was observed ($p > 0.05$) (Table 2).

Two years after phacoemulsification, glistening was not recorded in 53.3% of patients (grade 0), while 18.5% of

Table 1

Demographic characteristics of patients with senile cataracts according to the type of implanted acrylic intraocular lens

Parameter	Groups			p^a
	SPHphil (n = 31)	SPHphob (n = 31)	TPHphob (n = 30)	
Sex				
male	14	17	17	> 0.05
female	17	14	13	
Age, years				
mean ± SD	72.94 ± 6.12	73.42 ± 5.39	74.03 ± 6.44	> 0.05
min–max	65–86	65–85	65–87	

SPHphil – single-piece hydrophilic; SPHphob – single-piece hydrophobic; TPHphob – three-piece hydrophobic; SD – standard deviation; min – minimum; max – maximum.
[a]ANOVA.

Table 2

Progression of glistening in patients with senile cataracts during the follow-up period

Time after the cataract surgery	Glistening grade				p^a
	0	I	II	III	
1 month	87 (94.6)	5 (5.4)	0 (0)	0 (0)	
6 months	60 (65.2)	18 (19.6)	10 (10.9)	4 (4.3)	< 0.05*
12 months	49 (53.3)	18 (19.6)	15 (16.3)	10 (10.9)	
18 months	49 (53.3)	17 (18.5)	16 (17.4)	10 (10.9)	> 0.05
24 months	49 (53.3)	17 (18.5)	16 (17.4)	10 (10.9)	

Values are given as numbers (percentages) of patients.
***statistically significant during the first 12 months; [a] Chi-Square test.**

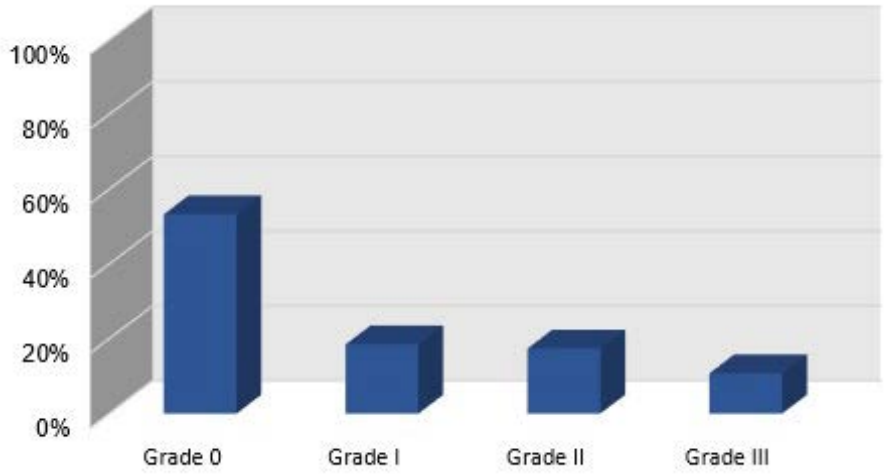

Fig. 2 – Incidence of glistening grades at the end of the research [1].
Note: [1] – two years after phacoemulsification.

patients had grade I, 17.4% had grade II, and 10.9% had grade III glistening (Figure 2).

Glistening expressed in grades according to the IOL type during the follow-up period is presented in Table 3.

The analysis of glistening depending on the IOL type one month after the CS showed no statistically significant difference among the groups ($p > 0.05$) (Table 4).

Six months after phacoemulsification the lowest frequency of glistening grades was recorded in the SPHphil group. Intergroup analysis revealed the existence of a significant difference in glistening between the SPHphil and SPHphob groups ($\chi^2 = 45.45$, $df = 28$, $p < 0.05$), as well as between SPHphil and TPHphob groups ($\chi^2 = 33.56$, $df = 29$, $p < 0.05$). The difference among the SPHphob and TPHphob groups was not significant ($\chi^2 = 2.47$, $df = 6$, $p > 0.05$).

One year after the CS, the difference was statistically significant between SPHphil and SPHphob groups ($\chi^2 = 55.74$, $df = 12$, $p < 0.01$), as well as between SPHphil and TPHphob groups ($\chi^2 = 47.21$, $df = 28$, $p < 0.01$). The difference between the groups with implanted hydrophobic IOLs was not statistically significant ($\chi^2 = 4.54$, $df = 6$, $p > 0.05$).

In the last two measurements, 18 and 24 months after CS, the results have not changed significantly compared with the results recorded on the 12th postoperative month. The

Table 3

Glistening according to the acrylic intraocular lens (IOL) type during the follow-up period

Time after the CS/IOL type	Glistening grade			
	0	I	II	III
1 month				
SPHphil	30 (96.8)	1 (3.2)	0 (0)	0 (0)
SPHphob	29 (93.5)	2 (6.5)	0 (0)	0 (0)
TPHphob	28 (93.3)	2 (6.7)	0 (0)	0 (0)
6 months				
SPHphil	22 (71.0)	6 (19.4)	3 (9.6)	0 (0)
SPHphob	19 (61.3)	6 (19.4)	4 (12.8)	2 (6.5)
TPHphob	19 (63.3)	6 (20)	3 (10.0)	2 (6.7)
12 months				
SPHphil	20 (64.5)	6 (19.4)	3 (9.6)	2 (6.5)
SPHphob	14 (45.2)	5 (16.1)	7 (22.6)	5 (16.1)
TPHphob	15 (50.0)	7 (23.3)	5 (16.7)	3 (10.0)
18 months				
SPHphil	20 (64.5)	5 (16.1)	4 (12.9)	2 (6.5)
SPHphob	14 (45.2)	5 (16.1)	7 (22.6)	5 (16.1)
TPHphob	15 (50.0)	7 (23.3)	5 (16.7)	3 (10.0)
24 months				
SPHphil	20 (64.5)	5 (16.1)	4 (12.9)	2 (6.5)
SPHphob	14 (45.2)	5 (16.1)	7 (22.6)	5 (16.1)
TPHphob	15 (50.0)	7 (23.3)	5 (16.7)	3 (10.0)

CS – cataract surgery. For other abbreviations, see Table 1.
Values are given as numbers (percentages) of patients.

Table 4

Statistical significance of glistening depending on the IOL type and the time of measurement

Time after the CS	SPHphil vs. SPHphob	SPHphil vs. TPHphob	SPHphob vs. TPHphob
1 month	$p > 0.05$	$p > 0.05$	$p > 0.05$
6 months	$p < 0.05$*	$p < 0.05$*	$p > 0.05$
12 months	$p < 0.01$**	$p < 0.01$**	$p < 0.05$
18 months	$p < 0.01$**	$p < 0.01$**	$p > 0.05$
24 months	$p < 0.01$**	$p < 0.01$**	$p > 0.05$

For abbreviations, see Tables 1 and 2. Chi-Square test.
***statistically significant; **highly statistically significant.**

Table 5

Glistening depending on sex in each group during the follow-up period

IOL type/Glistening grade	Months				
	1	6	12	18	24
SPHphil					
0	14/16	9/13	8/12	8/12	8/12
I	0/1	3/3	3/3	3/2	3/2
II	0/0	2/1	2/1	2/2	2/2
III	0/0	0/0	1/1	1/1	1/1
SPHphob					
0	16/13	10/9	7/7	7/7	7/7
I	1/1	4/2	3/2	3/2	3/2
II	0/0	2/2	4/3	4/3	4/3
III	0/0	1/1	3/2	3/2	3/2
TPHphob					
0	16/12	11/8	9/6	9/6	9/6
I	1/1	4/2	4/3	4/3	4/3
II	0/0	1/2	3/2	3/2	3/2
III	0/0	1/1	1/1	1/2	1/2

For abbreviations, see Table 1. Values are given as numbers of patients (males/females). Chi-Square test.
No statistically significant influence of patients' sex was recorded in glistening development in all groups ($p > 0.05$).

difference between the SPHphil group and the other two groups remained highly statistically significant ($p < 0.01$), while no significant difference was measured between the hydrophobic groups ($p > 0.05$) (Table 4).

The glistening formation was also analyzed depending on the patient's sex (Table 5) and age (Table 6). During all measurements, no statistically significant influence of the patient's sex and age was recorded in glistening development in all groups.

Table 6

Glistening depending on patients' age in each group during the follow-up period

IOL type/Glistening grade	1 month		6 months		12 months		18 months		24 months	
	65–75	76–86	65–75	76–86	65–75	76–86	65–75	76–86	65–75	76–86
SPHphil										
0	17	13	12	10	11	9	11	9	11	9
I	1	0	2	4	2	4	2	3	2	3
II	0	0	2	1	2	1	2	2	2	2
III	0	0	0	0	1	1	1	1	1	1
SPHphob										
0	15	14	11	8	8	6	8	6	8	6
I	1	1	3	3	2	3	2	3	2	3
II	0	0	1	3	5	2	5	2	5	2
III	0	0	1	1	3	2	3	2	3	2
TPHphob										
0	13	15	8	11	7	8	7	8	7	8
I	2	0	3	3	4	3	4	3	4	3
II	0	0	2	1	2	3	2	3	2	3
III	0	0	1	1	1	2	1	2	1	2

For abbreviations, see Table 1. Values are given as numbers of patients. Chi-Square test.
No statistically significant influence of patients' age was recorded in glistening development in all groups ($p > 0.05$).
Note: Patients were classified into two age groups: 65–75 and 76–86 years of age.

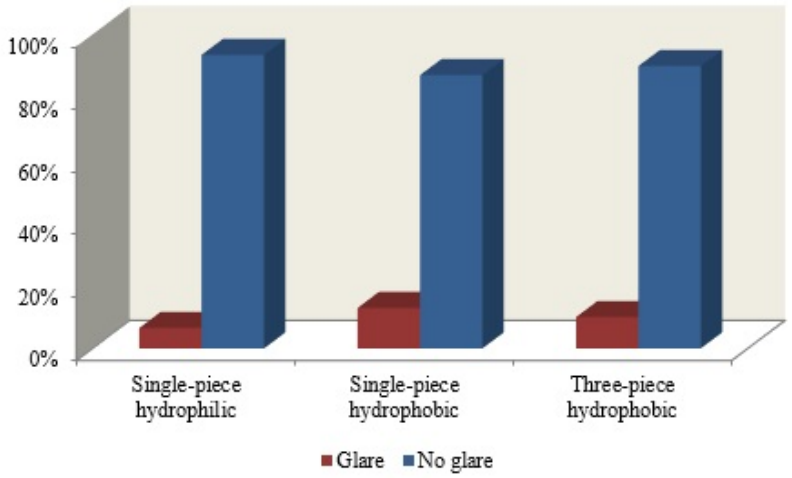

Fig. 3 – The incidence of glare according to the intraocular lens type.

Clinical signs of glistening in the form of glare were present in 9 (9.8%) patients. Four patients with glare were in the SPHphob group, three in TPHphob, and two in the SPHphil group. No significant difference in glare was observed among the groups ($\chi^2 = 0.73$, $df = 2$, $p > 0.05$) (Figure 3). All patients who had glare belonged to glistening grades II and III.

Discussion

Glistening is the formation of fluid-filled microvacuoles inside IOL. It is believed that the water content in the structure of the IOL is the most important predictive factor in glistening development. Miyata et al. [19] first examined the mechanism of glistening formation. IOL was immersed in a bottle of physiological saline *in vitro* at 50 °C. The polymers from which IOLs are made absorb water when they are in an aqueous medium. The amount of liquid that IOL would absorb depended on the characteristics of the IOL material and temperature. After spending 2 hrs at 50 ˚C, the IOL was immersed in a bottle of saline at 35 ˚C. Due to temperature difference, water oversaturation within the IOL followed, forming the microvacuoles, i.e., glistening. This process simulated an accelerated pace of the glistening formation *in vivo* in the eye. Although intraocular conditions are characterized by very small temperature fluctuations, glistening can develop even over a prolonged period of time. Kato et al. [23] demonstrated that a temperature change of only 3 ˚C causes glistening formation. Due to the difference in the refractive index between IOL and fluid-filled microvacuoles, light scattering occurs, which can be clinically manifested more often by the appearance of glare than by decreased contrast sensitivity or VA [15, 24]. Glare can be the reason for patients' dissatisfaction after CS. Nowadays, phacoemulsification is performed more often in younger patients. Hence, glare can affect the patient's ability to work and lead to numerous problems in everyday life, such as reading, writing, walking, driving a car, taking prescribed therapy, and many other activities. This

way, glistening can affect the quality of vision and complete quality of life in the POP [24, 25].

In our study, the incidence of glistening was measured depending on the type of implanted IOL, as well as the occurrence of glare. During the two-year period of the study, the presence of glistening was noticed in 43 (46.7%) patients. Researchers are not unanimous about the incidence of glistening, and its occurrence in previous studies varies widely [26–31]. Examining the incidence of acrylic hydrophobic IOLs, Colin et al. [32] discovered glistening in 86.5% of patients. However, in a study published in 2018, Ton Van and Tran [33] did not prove the presence of glistening during the three years of follow-up after the implantation of the enVista® MX60 IOL (Bausch & Lomb) on a sample of 245 eyes. It has been proven that IOL material has a great influence on glistening development. Although acrylic IOLs have primacy in CS today due to their optical and immunological characteristics, Rønbeck et al. [34] found a statistically significantly higher incidence of glistening in these IOLs compared to PMMA and silicone.

Our results indicate that glistening formation started in the first postoperative month. In the following months, the progression of glistening was observed, with a significant difference until the 12th postoperative month, after which the progression was almost interrupted. During the research, a difference was noticed between IOLs made of hydrophilic and hydrophobic acrylate. Eyecryl plus 600 IOL contains 26% of the fluid. This percentage is significantly higher compared to hydrophobic acrylate IOLs (the percentage of liquid does not exceed 1%). Therefore, it is believed there was a higher water absorption and consequent glistening development in these IOLs. From the sixth postoperative month to the end of the study, a statistically significantly lower incidence of glistening was observed in the SPHphil group compared to the hydrophobic groups. On the other hand, the difference recorded between hydrophobic IOL groups was not significant. That difference between IOLs made of the same material can be explained by the different structures of monomers used in the production of these IOLs. During the polymerization of these monomers, cavities are formed. These cavities, in which glistening will be formed later, are different in morphology and quantity, depending on the IOL type. Many studies suggest that not only IOL material but also manufacturing technique, IOL packaging, IOL diopter, duration of the follow-up period, ocular disease, and patient age have a huge impact on glistening formation. Omar et al. [35] reported an *in vitro* study comparing glistening development in AcrySof acrylic hydrophobic IOLs based on AcryPack and Wagon Wheel packing systems. Glistening was recorded in both IOL types. However, IOLs packaged in Wagon Wheel did not form glistening when they were kept under constant temperature, while IOLs based on AcryPack displayed significantly more microvacuoles. IOL diopter can also have an influence on glistening formation.

Some studies reported that less glistening was developed in lower IOL diopters [12, 26, 27]. It can be explained by the fact that IOL thickness is directly correlated with the IOL diopter. Therefore, fluid has more space to accumulate in the thicker IOLs presented in higher IOL diopters. Researchers are quite unanimous in saying that glistening increases with time and that its incidence depends on the study duration [23, 36]. Analyzing our results, after the intensive formation of glistening in all groups during the first postoperative year, a quite small degree of glistening progression was noticed during the last 12 months. These results are in contrast with the study by Wilkins and Olson [37], which recorded the progression of glistening continuously until the end of the third postoperative year. Interruption of progression is thought to occur when all cavities in the IOL polymer become filled with glistening. In our research, that period was 12 months. From that moment until the end of the study, glistening progression was seen in only one patient with hydrophilic IOL. Glistening formation is associated with different ocular comorbidities such as glaucoma, uveitis, or retinal diseases. In these conditions, the degree of intraocular inflammation and blood-aqueous barrier breakdown is increased, which in the POP contributes to the occurrence of glistening. Schweitzer et al. [38] and Colin and Orignac [39] separately showed the impact of glaucoma on the increased incidence of glistening. In glaucoma patients, in addition to the disease itself, various materials present in antiglaucoma medications can affect the permeability of the blood-aqueous barrier.

Glistening formation has decreased a lot in recent years with the use of modern materials and technologies in the production of IOLs. Nowadays, a large number of studies in ophthalmology are based on the implantation of IOLs, known as glistening-free IOLs. These IOLs are characterized by outstanding optical characteristics, with the absence of glistening formation [40, 41]. They are made of new monomers that bond significantly better during the polymerization process, limiting the formation of spaces where liquid could accumulate in the POP.

We examined the influence of sex and age on glistening development. Statistical analysis did not determine the influence of sex on the development of glistening in any group. It is in accordance with numerous previous studies where no gender dominance has been proven in the development of glistening [17, 18, 29]. Furthermore, our results did not show the influence of patients' age on the development of glistening. This can be explained by the fact that only patients with senile cataracts, over 65 years of age, without ocular comorbidities participated in our study. For that reason, a relatively similar inflammatory response to CS could be expected in all patients, and the development of glistening depended on the type of IOLs.

Our study had certain limitations, such as the number of patients, the follow-up period of two years, the usage of only three types of acrylate in the implanted intraocular lens, the absence of ocular complications, and cataract surgery performed only in people older than 65 years. However, our results can represent an excellent starting point for future research examining the development of glistening in younger patients with ocular comorbidities who will be implanted with an intraocular lens made of more modern materials.

Conclusion

In conclusion, we found the existence of glistening in all types of tested acrylic intraocular lenses. Our study has shown a huge impact of hydrophobic material on the glistening formation. On the other hand, no effect of the intraocular lens design was recorded on the glistening development. Our results also pointed out that the progression of glistening was the most intensive during the first postoperative year. Knowing that there is still no effective treatment for developed glistening, we believe that the best treatment is prevention, and the main role in that prevention is the selection of an adequate intraocular lens.

Acknowledgement

The study is part of a doctoral dissertation titled "The influence of material and design of intraocular lens on the posterior capsule opacification development in patients who underwent cataract surgery by the phacoemulsification method" defended at the Faculty of Medical Sciences, University of Kragujevac, Serbia.

R E F E R E N C E S

1. *Villegas EA, Manzanera S, Lago CM, Hervella L, Sawides L, Artal P.* Effect of Crystalline Lens Aberrations on Adaptive Optics Simulation of Intraocular Lenses. J Refract Surg 2019; 35(2): 126–31.
2. *Narayan A, Evans JR, O'Brart D, Bunce C, Gore DM, Day AC.* Laser-assisted cataract surgery versus standard ultrasound phacoemulsification cataract surgery. Cochrane Database Syst Rev 2023; 6(6): CD010735.
3. *Fernández-Muñoz E, Chávez-Romero Y, Rivero-Gómez R, Aridjis R, Gonzalez-Salinas R.* Cumulative Dissipated Energy (CDE) in Three Phaco-Fragmentation Techniques for Dense Cataract Removal. Clin Ophthalmol 2023; 17: 2405–12.
4. *Pirogova ES, Fabrikantov OL, Nikolashin SI.* Femtolaser-assisted phacoemulsification of intumescent cataract. Vestn Oftalmol 2022; 138(1): 13–22. (Russian)
5. *Hu J, Zhao C, Luo Y, Kong J, Shi W, Wang T.* Real-time corneal thickness changes during phacoemulsification cataract surgery. Graefes Arch Clin Exp Ophthalmol 2023; 261(6): 1609–18.
6. *Coppola M, Marchese A, Rabiolo A, Cicinelli MV, Knutsson KA.* Comparison of two popular nuclear disassembly techniques for cataract surgeons in training: divide and conquer versus stop and chop. Int Ophthalmol 2019; 39(9): 2097–102.
7. *Nikose AS, Saha D, Laddha PM, Patil M.* Surgically induced astigmatism after phacoemulsification by temporal clear corneal and superior clear corneal approach: a comparison. Clin Ophthalmol 2018; 12: 65–70.
8. *Tripathy K, Sridhar U.* Optical coherence tomography of intraocular lens glistening. Indian J Ophthalmol 2019; 67(1): 138–9.
9. *Chassain C, Chamard C.* Posterior capsule opacification, glistenings and visual outcomes: 3 years after implantation of a new hydrophobic IOL. J Fr Ophtalmol 2018; 41(6): 513–20. (French)
10. *Fernández-Vigo JI, Macarro-Merino A, De Moura-Ramos JJ, Alvarez-Rodriguez L, Burgos-Blasco B, Novo-Bujan J,* et al. Comparative study of the glistening between four intraocular lens models assessed by OCT and deep learning. J Cataract Refract Surg 2024; 50(1): 37–42.
11. *Yildirim TM, Schickhardt SK, Wang Q, Friedmann E, Khoramnia R, Auffarth GU.* Quantitative evaluation of microvacuole formation in five intraocular lens models made of different hydrophobic materials. PLoS One 2021; 16(4): e0250860.
12. Fernández-Vigo JI, Serrano González-Peramato MT, Nunila Gómez-de-Liaño C, Sánchez-Guillén I, Fernández-Vigo JÁ, Macarro-Merino A. Glistening on intraocular lenses: A review. Arch Soc Esp Oftalmol (Engl Ed) 2023; 98(9): 493–506.
13. *Wang Q, Yildirim T, Schickhardt SK, Łabuz G, Khoramnia R, Merz PR,* et al. Quantification of the In Vitro Predisposition to Glistening Formation in One Manufacturer's Acrylic Intraocular Lenses Made in Different Decades. Ophthalmol Ther 2021; 10(1): 165–74.
14. *Gupta PC, Balamurugan R, Ram J.* Multimodal imaging of glistening IOL. Saudi J Ophthalmol 2018; 32(4): 358–9.
15. *Xiang Y, Jin R, Zhang Y, Li K, Liu G, Song X,* et al. Foldable Glistening-Free Acrylic Intraocular Lens Biomaterials with Dual-Side Heterogeneous Surface Modification for Postoperative Endophthalmitis and Posterior Capsule Opacification Prophylaxis. Biomacromolecules 2021; 22(8): 3510–21.
16. *Kawai K.* An evaluation of glistening and stability of intraocular lens material manufactured by different methods. Eur J Ophthalmol 2021; 31(2): 427–35.
17. *Auffarth GU, Brézin A, Lignereux F, Khoramnia R, Yildirim TM, Kohnen T,* et al. Randomized multicenter trial to assess posterior capsule opacification and glistenings in two hydrophobic acrylic intraocular lenses. Sci Rep 2023; 13(1): 2822.
18. *Argay A, Vamosi P.* The assessment of the impact of glistening on visual performance in relation to tear film quality. PLoS One 2020; 15(10): e0240440.
19. *Miyata A, Uchida N, Nakajima K, Yaguchi S.* Clinical and experimental observation of glistening in acrylic intraocular lenses. Jpn J Ophthalmol 2001; 45(6): 564–69.
20. *Ortega-Prades G, Hervás Hernándis JM, Duch-Samper AM.* Glistening on intraocular lens. Anterior segment optic coherence tomography image. Arch Soc Esp Oftalmol (Engl Ed) 2024; 99(6): 269.
21. *Bhattacharjee H, Bhattacharjee K, Das D, Javeri H, Buragohain S.* Raman Spectroscopy of six explanted acrylic hydrophobic foldable intraocular lenses with glistening. Indian J Ophthalmol 2022; 70(8): 2872–6.
22. *Kanclerz P, Grzybowski A.* Glistenings might be associated with disability glare. Eur J Ophthalmol 2022; 32(1): NP296.
23. *Kato K, Nishida M, Yamane H, Nakamae K, Tagami Y, Tetsumoto K.* Glistening formation in an AcrySof lens initiated by spinodal decomposition of the polymer network by temperature change. J Cataract Refract Surg 2001; 27(9): 1493–8.
24. *Błachnio K, Dusińska A, Szymonik J, Juzwiszyn J, Bestecka M, Chabowski M.* Quality of Life after Cataract Surgery. J Clin Med 2024; 13(17): 5209.
25. *Grzybowski A, Markeviciute A, Zemaitiene R.* A narrative review of intraocular lens opacifications: update 2020. Ann Transl Med 2020; 8(22): 1547.
26. *Tandogan T, Auffarth GU, Son HS, Merz P, Choi CY, Khoramnia R.* In-vitro glistening formation in six different foldable hydrophobic intraocular lenses. BMC Ophthalmol 2021; 21(1): 126.
27. *Mao Y, Liu H, Long Gu F, Wu MX, Wang Y.* The molecular design of performance-enhanced intraocular lens composites. Biomater Sci 2022; 10(6): 1515–22.
28. *Stanojcic N, Hull CC, Mangieri E, Little N, O'Brart D.* A new software for automated counting of glistenings in intraocular lenses *in vivo*. Int J Ophthalmol 2023; 16(8): 1237–42.

29. *Yildirim TM, Fang H, Schickhardt SK, Wang Q, Merz PR, Auffarth GU*. Glistening formation in a new hydrophobic acrylic intraocular lens. BMC Ophthalmol 2020; 20: 186.
30. *Borghesi S, Colciago S, Zeri F, Scialdone A, Tavazzi S*. In vitro glistening formation in IOLs: automated method for assessing the volumetric density and depth distribution of microvacuoles. J Cataract Refract Surg 2020; 46(8): 1178–83.
31. *Khoramnia R, Yildirim TM, Łabuz G, Mayer CS, Auffarth GU*. Opacification of intraocular lenses: laboratory and clinical findings. Ophthalmologe 2021; 118(7): 633–42. (German)
32. *Colin J, Praud D, Touboul D, Schweitzer C*. Incidence of glistenings with the latest generation of yellow-tinted hydrophobic acrylic intraocular lenses. J Cataract Refract Surg 2012; 38(7): 1140–6.
33. *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(10): 899–903.
34. *Rønbeck M, Behndig A, Taube M, Koivula A, Kugelberg M*. Comparison of glistenings in intraocular lenses with three different materials: 12-year follow-up. Acta Ophthalmol 2013; 91(1): 66–70.
35. *Omar O, Pirayesh A, Mamalis N, Olson RJ*. In vitro analysis of AcrySof intraocular lens glistenings in AcryPak and Wagon Wheel packaging. J Cataract Refract Surg 1998; 24(1): 107–13.
36. *Łabuz G, Knebel D, Auffarth GU, Fang H, van den Berg TJ, Yildirim TM,* et al. Glistening Formation and Light Scattering in Six Hydrophobic-Acrylic Intraocular Lenses. Am J Ophthalmol 2018; 196: 112–20.
37. *Wilkins E, Olson RJ*. Glistenings with long-term follow-up of the Surgidev B20/20 polymethylmethacrylate intraocular lens. Am J Ophthalmol 2001; 132(5): 783–5.
38. *Schweitzer C, Orignac I, Praud D, Chatoux O, Colin J*. Glistening in glaucomatous eyes: visual performances and risk factors. Acta Ophthalmol 2014; 92(6): 529–34.
39. *Colin J, Orignac I*. Glistenings on intraocular lenses in healthy eyes: effects and association. J Refract Surg 2011; 27(12): 869–75.
40. *Khoramnia R, Naujokaitis T, Baur ID, Hassel O, Henningsen N, Reitemeyer E,* et al. Functional Outcomes After Refractive Lens Exchange With Implantation of a Glistening-Free Diffractive Trifocal Intraocular Lens. Am J Ophthalmol 2024; 268: 296–305.
41. *Packer M, Williams JI, Feinerman G, Hope RS*. Prospective multicenter clinical trial to evaluate the safety and effectiveness of a new glistening-free one-piece acrylic toric intraocular lens. Clin Ophthalmol 2018; 12: 1031–9.

Received on December 8, 2023
Revised on September 21, 2024
Revised on October 21, 2024
Accepted on October 31, 2024
Online First December 2024