BMC Ophthalmology

RESEARCH Open Access

Risk factors for pupil changes in patients with diabetic retinopathy and cataract after phacoemulsification with intraocular lens implantation

Guilan Yi[1,2*] and Hai Yu[1]

Abstract

Background This study aims to identify the risk factors associated with pupillary changes in patients with diabetic retinopathy (DR) and cataract undergoing phacoemulsification with intraocular lens implantation (PHACO + IOL).

Methods This retrospective observational study included patients with DR and cataract who underwent phacoemulsification and intraocular lens implantation between February 2021 and August 2023. Patients were categorized into two groups based on the presence or absence of pupillary changes following surgery.

Results A total of 162 patients were analyzed, with pupillary changes occurring in 33 cases (20.37%). Multivariate logistic regression analysis revealed that a longer duration of diabetes (OR = 2.73; 95% CI: 1.02–7.27, $P = 0.045$), higher lens nucleus grade (OR = 3.95; 95% CI: 1.58–9.89, $P = 0.003$), greater severity of DR (OR = 3.60; 95% CI: 1.40–9.28, $P = 0.008$), and intraoperative posterior lens capsule rupture (OR = 6.41; 95% CI: 1.75–23.47, $P = 0.005$) were significant risk factors for postoperative pupillary changes in DR patients undergoing PHACO + IOL.

Conclusion Phacoemulsification with intraocular lens implantation is an effective treatment for patients with DR and cataract. However, factors such as the duration of diabetes, severity of DR, and intraoperative complications are associated with an increased risk of pupillary changes. Therefore, rigorous blood glucose control, adherence to standardized surgical protocols, and preventive care are recommended to optimize patient outcomes.

Trial registration Not applicable.

Clinical trial number Not applicable.

Keywords Diabetic retinopathy, Cataract, Lens nuclear grading, Proliferative phase, Pupillary changes, Influencing factors

*Correspondence:
Guilan Yi
Guilanyi@163.com
[1]Department of Ophthalmology, Deyang People's Hospital, Deyang, China
[2]Department of Ophthalmology, Deyang People's Hospital, No. 173 Taishan North Road, Jingyang District, Deyang City, Sichuan Province 61800, P.R. China

Introduction

Diabetic retinopathy (DR) is a prevalent microvascular complication of diabetes mellitus, posing substantial risks to both vision and quality of life. It is strongly associated with disease duration, metabolic control, and genetic factors [1–3]. According to recent survey data, DR affects approximately 24–27% of patients with type 1 diabetes and 9–16% of those with type 2 diabetes globally, with 2–16% of type 2 diabetes patients presenting with DR symptoms at initial diagnosis [4]. Besides DR, diabetes is linked to other ocular complications, including optic neuropathy, secondary glaucoma, and cataracts, with the latter frequently co-occurring with DR [5, 6]. Cataracts are responsible for one-sixth of visual impairment cases and one-third of blindness cases, making them a primary contributor to progressive vision loss. Cataract surgery is an important means to improve the vision of patients, especially for patients who also have DR, surgery can not only restore vision, but also provide an opportunity for follow-up retinal treatment. In patients with DR, the presence of cataracts complicates management, as cataracts can hinder fundus visualization and reduce the effectiveness of DR treatment.

Phacoemulsification with intraocular lens implantation (PHACO + IOL) is currently the standard approach for treating cataracts in patients with DR [7]. However, patients with DR may face a number of postoperative complications after PHACO + IOL, in which pupil change is an important clinical problem. Pupil changes can lead to less than ideal vision recovery after surgery, increase patient distress, and may affect subsequent eye care. Clinical observations have shown that some patients with DR and cataracts experience challenges with pupil dilation and postoperative pupil abnormalities, limiting fundus visibility and complicating postoperative monitoring and diagnosis. These issues can adversely impact patient prognosis [8].

The pupillary response is a critical determinant of cataract surgery outcomes and patient safety [9]. In diabetic patients, alterations in pupillary function are frequently associated with autonomic neuropathy, which correlates with prolonged diabetes duration and poor glycemic control. Research indicates that diabetic patients often exhibit limited mydriasis, which can increase the technical challenges of cataract surgery and elevate the risk of complications, such as posterior capsule rupture and vitreous loss. Additionally, postoperative pupillary changes can impact inflammation, intraocular pressure, and accessibility to the posterior segment, thereby influencing the progression of DR. Although studies have explored the relationship between diabetes and cataract, there are still relatively few studies on specific risk factors for pupil changes in patients with DR and cataract after cataract surgery. Therefore, in-depth research in this area not only helps to improve the understanding of postoperative complications in this population, but also provides important guidance for clinicians to optimize surgical strategies and postoperative management to reduce the incidence of pupil changes. This study aims to retrospectively analyze the risk factors for pupillary changes in DR patients undergoing PHACO + IOL. The findings aim to inform evidence-based strategies for effective pupil management and preventive measures in clinical practice.

Materials and methods

Study design and population

A retrospective analysis was conducted on the clinical data of 162 patients with DR and cataracts who underwent PHACO + IOL at our hospital between February 2021 and August 2023. Inclusion criteria: (1) Patients diagnosed with DR with cataracts based on slit lamp microscopy, optical coherence tomography (OCT), and other examinations [10]; (2) Patients who meet the indications for combined surgery and have no contraindications; (3 Age > 18 years; (4) Patients with complete clinical data who underwent surgery in our hospital; (5) Patients with a dilated pupil diameter > 6 mm before surgery; (6) Patients with a preoperative blood glucose level < 8.0 mmol/L; (7) Patients who are conscious, able to communicate, and cooperate with treatment; (8) Patients and their families who understand the research content and agree to provide data and sign an informed consent form. Exclusion criteria: (1) Patients with glaucoma, uveitis, or ocular trauma that can cause pupil dilation; (2) Patients with refractive errors; (3) Patients with coagulation disorders or immune system diseases; (4) Patients with a history of ocular drug treatment; (5) Patients with iridoplegia or other conditions that can affect the pupil; (6) Patients with severe organ dysfunction. This study was approved by the Ethics Committee of Deyang People's Hospital. The procedures were conducted in accordance with the ethical standards set forth by the Committee on Human Experimentation and the Helsinki Declaration of 1964, as revised in 2013. All patients in this study voluntarily joined this study with informed consents.

Preoperative treatment for proliferative diabetic retinopathy (PDR)

As this study is retrospective in nature, we reviewed the medical records of patients diagnosed with proliferative diabetic retinopathy (PDR) who underwent cataract surgery. In the preoperative management of PDR, patients received either laser photocoagulation or intravitreal anti-angiogenic therapy, based on the clinical judgment of the treating ophthalmologist and the severity of the retinopathy. Laser photocoagulation, typically performed with [specific laser system used, e.g., Carl Zeiss Visulas 532], was employed for patients with stable or localized

neovascularization. For patients with more active disease, intravitreal anti-angiogenic therapy (e.g., bevacizumab or ranibizumab) was administered to reduce retinal edema and inhibit neovascularization. The timing of these treatments varied, with some patients receiving the therapy several weeks to months prior to cataract surgery, depending on the clinical situation.

Surgical methods

All patients underwent identical surgical protocols performed by the same surgical team. Routine disinfection work was performed before surgery, and the patient was placed in a supine position. The surgical site was washed with 0.9% sodium chloride injection (manufacturer: Dongguan Puji Pharmaceuticals Co., Ltd.; batch number: National Medical Products Administration approval number H20064587; specification: 500 ml) 15 min before surgery. Local infiltrative anesthesia was performed using 0.5% lidocaine (manufacturer: Huahai Shuanghe Pharmaceutical Co., Ltd.; batch number: National Medical Products Administration approval number H11020943; specification: 5 g). Routine eyelid preparation was carried out. A 3 mm clear corneal incision was made at the 11:00 position above the left eye or the temporal superior position above the right eye. Viscoelastic agent was injected into the anterior chamber, and a 5.5 mm continuous circular capsulotomy was performed. The anterior capsule was hydrodissected to separate the lens nucleus. The phacoemulsification device (Shanghai Huanxi Medical Instrument Co., Ltd.; model: Alcon Centurion) set to twist motion ultrasound mode, with an amplitude of 100%, a flow rate of 35 mL/min, and an irrigation negative pressure of 400 mmHg. The lens nucleus was emulsified in segments and the cortex was aspirated. A foldable intraocular lens was implanted in the capsular bag, and viscoelastic agent was injected. The corneal incision was tightly closed, and tobramycin and dexamethasone ointment (manufacturer: ALCON CUSI, S.A.; batch number: National Medical Products Administration approval number HJ20181126; specification: 3.5 g [tobramycin 10.5 mg, dexamethasone 3.5 mg]) was applied inside the conjunctival sac. The eye was covered with gauze to complete the surgery.

Data collection

Baseline information was retrospectively collected from diabetic retinopathy (DR) patients with cataracts, including age, sex, BMI, duration of diabetes, HbA1c levels (%), preoperative intraocular pressure (mmHg), smoking and alcohol history, lens nuclear grade, DR severity, and incidence of intraoperative posterior capsule rupture. Postoperative records of pupil diameter one week after mydriasis were reviewed. Postoperative complications (hyphema, cystoid macular edema, and fibrinous uveitis) were retrospectively identified through standardized chart review based on clinical documentation and diagnostic coding (ICD-10-CM).

Before surgery, a comprehensive ocular examination was performed on all patients to assess the initial condition of the eye. This included evaluating the anterior chamber angle, the presence of newly formed blood vessels at the pupillary margin, and other relevant anatomical features. Gonioscopy was conducted using a [specific gonioscopy lens model, e.g., Goldmann three-mirror gonioscopy lens], to assess the angle of the anterior chamber. Additionally, any neovascularization at the pupillary margin or iris was recorded during slit-lamp examination and confirmed through anterior segment imaging. The presence of neovascularization and the angle configuration were taken into consideration when determining the surgical approach. Patients were categorized into two groups based on postoperative pupillary response: the pupil-change group (33 cases, 33 eyes) and the no-pupil-change group (129 cases, 129 eyes). Data on visual acuity recovery were also collected retrospectively.

Pupillary changes were defined as postoperative alterations that met at least one of the following criteria [11, 12]: (1) Static diameter deviation ≥ 1.0 mm compared to preoperative measurements under standardized illumination (500 lx, measured using Pentacam HR Scheimpflug imaging); (2) Light reflex impairment with $<20\%$ constriction amplitude upon 1000-lux light stimulation (quantified by NeurOptics PLR-3000 pupillometer); (3) Morphological irregularity confirmed via anterior segment OCT (Heidelberg Spectralis) showing iris adhesion $>30°$ or stromal discontinuity >50 μm. All measurements were performed by two masked technicians, excluding pharmacologically dilated pupils to preserve physiological responsiveness (Figure S1-S4).

Statistical analysis

Statistical analysis was performed using SPSS version 19.0 software (IBM Corp., Armonk, New York, USA). Categorical variables are expressed as numbers and percentages, and the chi-squared (χ^2) test was used for comparison between groups. Multivariate logistic regression was used to identify factors independently associated with pupil change. Variables that were statistically significant in the univariate analyses were included in the multivariate logistic regression models to explore the risk factors for pupil changes in patients with DR and cataracts after PHACO + IOL. Two-sided $P<0.05$ was considered as statistical significance.

Results

Baseline information

This study included a total of 162 patients (162 eyes) with DR and cataracts who underwent PHACO + IOL. Among

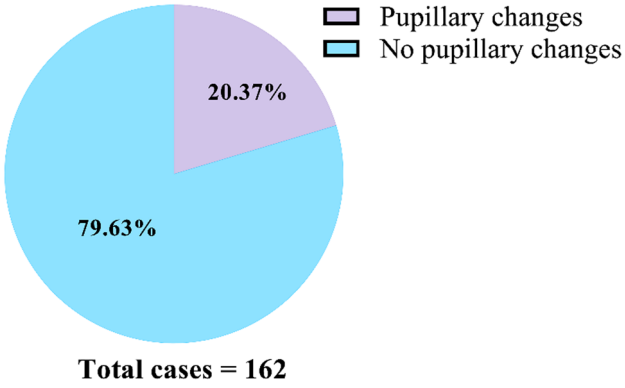

Fig. 1 Incidence of pupillary changes. The purple area indicates the occurrence of pupillary changes and the blue area indicates the percentage of patients without pupillary changes

Table 1 Baseline information of 162 patients with DR and cataract

Chharacteristics	No pupillary change group (*n* = 129)	Pupillary change group (*n* = 33)	*P* value
Gender			
Male	78 (60.47%)	19 (57.58%)	0.918
Female	51 (39.53%)	14 (42.42%)	
Age (years)			
≥ 60	89 (68.99%)	18 (54.55%)	0.174
< 60	40 (31.01%)	15 (45.45%)	
BMI index (kg /m^2)			
> 23.9	45 (34.88%)	14 (42.42%)	0.548
≤ 23.9	84 (65.12%)	19 (57.58%)	
Diabetes duration (years)			
> 10	70 (54.26%)	25 (75.76%)	0.041
≤ 10	59 (45.74%)	8 (24.24%)	
HbA1c level (%)			
> 9	58 (44.96%)	22 (66.67%)	0.042
≤ 9	71 (55.04%)	11 (33.33%)	
Preoperative intraocular pressure (mmHg)			
> 21	37 (28.68%)	16 (48.48%)	0.023
≤ 21	92 (71.32%)	17 (51.52%)	
Smoking history			
Yes	40 (31.01%)	12 (36.36%)	0.705
No	89 (68.99%)	21 (63.64%)	
Alcohol history			
Yes	26 (20.16%)	9 (27.27%)	0.516
No	103 (79.84%)	24 (72.73%)	
Lens nuclear grading			
≥ IV	34 (26.36%)	19 (57.58%)	0.001
< IV	95 (73.64%)	14 (42.42%)	
Severity of DR			
Proliferative stage	53 (41.09%)	24 (72.73%)	0.002
Non-proliferative stage	76 (58.91%)	9 (27.27%)	
Intraoperative posterior capsular rupture of the lens			
Yes	8 (6.20%)	8 (24.24%)	0.006
No	121 (93.80%)	25 (75.76%)	

Table 2 Visual acuity recovery after surgery in patients with DR and cataract

Visual acuity	Preoperative (*n* = 162)	Postoperative (*n* = 162)	*P* value
< 0.1	32 (19.75%)	12 (7.41%)	< 0.001
0.1 ~ 0.5	103 (63.58%)	75 (46.30%)	
0.6 ~ 0.9	27 (16.67%)	67 (41.36%)	
≥ 1.0	0(0.00%)	8 (4.94%)	

Table 3 Multivariate analysis of factors affecting pupillary changes after surgery in patients with DR and cataract

Factors	OR value (95% CI)	*P* value
Diabetic duration	2.73 (1.02–7.27)	0.045
HbA1c level	2.03 (0.80–5.17)	0.135
Preoperative intraocular pressure	2.40 (0.95–6.04)	0.063
Lens nuclear classification	3.95 (1.58–9.89)	0.003
DR severity	3.60 (1.40–9.28)	0.008
Intraoperative posterior capsule rupture of the lens	6.41 (1.75–23.47)	0.005

these, 33 cases (33 eyes) with pupillary changes after surgery were categorized into the pupillary change group, while 129 cases (129 eyes) with no pupillary changes were included in the no-pupillary-change group. The incidence of pupillary changes was 20.37% (Fig. 1). Significant differences were observed between the two groups in terms of the duration of diabetes, HbA1c levels, preoperative intraocular pressure, lens nucleus grading, severity of DR, and intraoperative posterior lens capsule rupture ($P < 0.05$) (Table 1). Postoperative complications were documented in 13/33 (39.4%) cases with pupillary changes compared to 23/129 (17.8%) no-pupillary-change group.

The proportion of patients with postoperative visual acuity < 0.1 and between 0.1 and 0.5 was significantly reduced compared to preoperative levels, while the proportion of patients with visual acuity between 0.6 and 0.9, as well as ≥ 1.0, was significantly increased ($P < 0.05$) (Table 2).

Multivariate logistic regression analysis

Multivariate logistic regression analysis indicated that the duration of diabetes (OR = 2.73; 95% CI: 1.02–7.27, $P = 0.045$), lens nucleus grade (OR = 3.95; 95% CI: 1.58–9.89, $P = 0.003$), DR severity (OR = 3.60; 95% CI: 1.40–9.28, $P = 0.008$), and intraoperative posterior lens capsule rupture (OR = 6.41; 95% CI: 1.75–23.47, $P = 0.005$) were significant risk factors for pupillary changes following surgery in patients with DR and cataract (Table 3).

Discussion

This study demonstrated that the duration of diabetes, lens nucleus grade, DR severity, and intraoperative posterior lens capsule rupture are significant risk factors for

pupillary changes following PHACO + IOL in patients with DR and cataracts. These findings underscore the importance of early identification of these risk factors to enhance surgical management strategies, minimize complication risks, and improve postoperative visual outcomes. The data from this study showed that the proportion of DR with cataract patients with postoperative vision less than 0.1 and 0.1–0.5 significantly decreased compared to before surgery, while the proportion of patients with vision of 0.6–0.9 and ≥ 1.0 significantly increased ($P > 0.05$). This indicates that the combined use of PHACO + IOL treatment is effective in improving the visual function of patients with DR with cataracts. Li X et al. [13]conducted a study on the combined use of drugs, PE, and IOL surgery to treat neovascular glaucoma with cataracts and found that the postoperative visual acuity of patients who underwent combined surgery was significantly better than that before surgery, which is similar to the results of this study. PHACO + IOL can achieve the ideal surgical results of small incisions, short operation time, and rapid visual recovery by quickly emulsifying the cloudy lens and removing the milky-like aged lens with the help of the suction and irrigation system. However, patients with DR with cataracts often have poor mydriasis after surgery, and the small pupil diameter poses a great challenge to cataract surgery and postoperative fundus diagnosis and treatment [14]. Therefore, analyzing the factors affecting pupil changes in patients with DR with cataracts is of great significance for effective clinical intervention.

The results of this study suggest that a longer duration of diabetes may be a risk factor for postoperative pupil changes in patients with DR and cataract. Diabetes is often associated with intraocular microvascular and nerve damage, which can impair pupil function and lead to postoperative pupil changes [15]. The longer the duration of diabetes, the poorer the blood glucose control, increasing the risk of such changes after surgery. Phacoemulsification, a commonly used cataract surgery technique, involves emulsifying and aspirating the cataract using ultrasonic energy, followed by the implantation of an intraocular lens. However, during the procedure, mechanical stimulation or damage to the iris may occur [16]. In DR patients, retinal and iris microvascular lesions may already impair the contractile function of the pupil, making it more susceptible to further disruption during surgery, potentially affecting both pupil response and morphology [16]. A cross-sectional study by Sun S et al. found that a longer duration of diabetes is a risk factor for developing DR, with more severe retinopathy observed as the duration increases. Prolonged diabetes leads to elevated blood glucose levels, chronic eye ischemia, and structural abnormalities in peripheral nerves. Additionally, glycosylation end products formed in a high glucose environment can reduce the elasticity of iris tissue, impairing the pupil's sensitivity to sympathetic stimuli and ultimately hindering its ability to dilate [17]. Therefore, for patients with a long duration of diabetes and poor blood glucose control, stringent management of blood glucose levels before and after surgery is essential to reduce the risk of postoperative complications, including pupil changes. Preoperative evaluation and treatment of retinal lesions, such as laser photocoagulation, may help mitigate the risk of postoperative progression of these lesions. Furthermore, close monitoring of retinal and pupil changes following surgery, along with timely interventions, is crucial for preventing and controlling the progression of both pupil changes and retinal complications.

Although multivariate regression analysis did not identify a significant association between preoperative intraocular pressure (IOP) changes and postoperative pupil changes, a notable difference in preoperative IOP was observed between the pupil-change and no-pupil-change groups. Previous studies have suggested that IOP fluctuations in diabetic patients may be linked to blood-retinal barrier breakdown, which could contribute to the development of postoperative macular edema [18]. Additionally, factors such as the tightness of the surgical incision, repeated insertion and removal of instruments from the anterior chamber, and the height of the perfusion fluid can lead to fluctuations in anterior chamber pressure, thereby affecting pupil response and function. When IOP increases, the blood vessels in the iris and retina constrict. Conversely, when the anterior chamber becomes shallow and IOP decreases, the blood vessels in the iris and retina dilate, causing the vascular endothelial space to expand and increasing the likelihood of intravascular fluid leakage [19]. Therefore, controlling IOP before surgery is essential to reduce the risk of postoperative pupil changes. Research has indicated that in patients with DR, glaucoma, and similar conditions, elevated IOP can lead to structural changes and vascular damage in the ciliary artery and retinal blood vessels [19]. In patients with high IOP, the stability of the ocular environment is compromised, and fluctuations in IOP can cause alterations in ocular perfusion. This exacerbates blood-retinal barrier dysfunction and may result in complications such as anterior chamber adhesion and inflammation, which hinder pupil dilation [20]. In phacoemulsification surgery, managing and stabilizing IOP is crucial for preventing postoperative mydriasis and macular edema. During surgery, maintaining a stable anterior chamber depth and IOP—by adjusting perfusion height and negative pressure—can minimize mechanical stress on the iris and retina, reducing the risk of postoperative pupil changes. In summary, preoperative control of IOP is a critical factor influencing postoperative pupil changes in DR patients

with cataracts. Effective IOP management plays a key role in improving postoperative outcomes.

The grading of lens nucleus hardness (according to the Emery grading standard), ranging from degree I (soft) to degree V (extremely hard), directly impacts the difficulty and energy requirements of phacoemulsification surgery. Harder lens nuclei necessitate more ultrasound energy and time for emulsification, which increases intraocular heat production and alters anterior chamber pressure, potentially affecting pupil response and function. Research has shown that greater lens hardness is an independent risk factor for a reduction in the number of corneal endothelial cells following phacoemulsification. This is thought to be related to mechanical stimulation and thermal damage to intraocular structures during the procedure. A comparative study conducted by Hu E H et al. [21] found that the damage rate of corneal endothelial cells and the hardness of the cell nucleus are related to the level of ultrasonic energy. Patients with higher lens nucleus grading have higher hardness and poorer transparency of cataracts, requiring the release of more ultrasonic energy during PE surgery. In patients with DR and cataracts, lens nucleus hardness may indirectly affect post-surgical pupil morphology and function by influencing the intraocular environment during surgery. Pupil changes are not solely linked to preoperative lens hardness but may also depend on surgical precision, intraocular pressure control, and the postoperative inflammatory response. In summary, lens nucleus grade is a key factor influencing pupil changes after phacoemulsification in DR patients with cataracts. To minimize the risk of postoperative pupil alterations, it is essential to handle the lens nucleus with precision and gentleness during surgery, thereby reducing potential damage to intraocular structures.

Our study identified DR severity as a risk factor for postoperative pupil changes. These findings suggest that the severity of fundus lesions must be fully considered when making surgical plans for patients with DR. The progression of DR is usually accompanied by damage to the retinal microvessels and degeneration of nerve cells, which may lead to abnormal pupil function after surgery [22]. Severe DR may affect the normal response of the pupil, resulting in postoperative dysdilation of the pupil or the occurrence of irregular pupils. In addition, patients with DR may face a higher risk of postoperative complications during surgery, such as postoperative inflammation and retinal detachment, which may also further exacerbate pupil changes [23]. Supporting this, a cross-sectional study by Cui L et al. found that as DR progresses, vascular density at the pupil's edge increases [24]. Neovascularization in the iris during the proliferative stage of DR can disrupt the blood-aqueous barrier function, enhance the degree of aqueous flare, exacerbate inflammation, and cause damage to the morphology and function of the iris, resulting in delayed light reflection and worsening abnormal pupil conditions as DR progresses [25]. Therefore, for patients with proliferative DR with cataracts, attention should be paid to postoperative pupil changes, and photocoagulation therapy should be performed as soon as possible within 2 weeks to 1 month after surgery to control the progression of DR. This finding not only provides a theoretical basis for improving the surgical prognosis of patients with DR, but also points the way for future research and encourages further exploration of the relationship between DR and postoperative complications in order to improve the quality of life and visual function of patients.

The results of this study suggest that posterior capsule rupture during PHACO + IOL may be closely related to postoperative pupil changes in patients with DR combined with cataract. Posterior capsule rupture may lead to intraocular inflammatory reactions, endophthalmitis, intraocular lens displacement, or posterior capsule opacity, all of which may affect the function and morphology of the pupil, resulting in changes such as impaired pupil dilation, irregularity, or adhesions [26, 27]. Relevant studies have shown that due to reasons such as ocular ischemia, unstable intraocular pressure, and decreased ascorbic acid levels in the aqueous humor, posterior capsule rupture and zonular rupture are prone to occur in cataract patients during surgery, which increases the difficulty and duration of the surgery [28]. The patient's iris is damaged, leading to increased anterior chamber inflammation. This may result in lens opacification and abnormal pupil changes. Therefore, for patients with DR with cataracts who experience intraoperative posterior capsule rupture, thorough removal of lens fragments and injection of viscoelastic agents should be performed to prevent lens nucleus dropping [29]. The risk of rupture should be assessed before surgery, and attention should be paid to surgical procedures and drug application. Postoperative pupil changes should be closely monitored. Since the presence of DR Increases the complexity of surgery and the risk of inflammatory response, postoperative management of these patients is particularly important, including the use of anti-inflammatory and pupil constricting drugs to control inflammation and promote pupil recovery. Understanding the relationship between posterior capsule rupture and pupil change is of great significance for optimizing surgical strategy, improving surgical safety and improving postoperative recovery. However, this study has several limitations. It focused only on patients with DR and cataracts who were admitted to our hospital during a specific time frame, resulting in a limited sample size and time period. The retrospective design inherently limits our ability to control for confounding variables and standardize data collection, which

may introduce bias in the analysis of risk factors and outcomes. To address this, comprehensive clinical data were collected as thoroughly as possible. Nevertheless, further research with larger sample sizes and multi-center studies is needed to enhance the clinical efficacy and prognosis of patients with DR and cataracts. In addition, published studies suggest that factors affecting pupil dilation also include medications used by patients. However, since this was a retrospective study, data on patients' preoperative or long-term medication use were not collected. As a result, the potential influence of medication on postoperative pupil changes could not be investigated. Future studies should involve multi-center designs with larger sample sizes to validate the robustness of our findings and explore additional influencing factors.

Conclusion

In summary, PHACO + IOL has shown beneficial effects for patients with DR and cataracts, significantly enhancing visual acuity. This study identified several risk factors for postoperative pupil changes in these patients, including the duration of diabetes, lens nucleus grade, DR severity, and intraoperative posterior capsule rupture. Enhanced communication and collaboration between ophthalmologists and surgeons are essential. Standardization of intraoperative procedures and medication protocols, with particular attention to pupil management, is recommended. Close monitoring of postoperative pupil changes is vital to ensure timely follow-up care and optimized patient outcomes.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12886-025-04080-1.

Supplementary Material 1

Acknowledgements
The authors express their appreciation to staff in Deyang People's Hospital, for their technical assistance.

Author contributions
Guilan Yi: study design, data analysis, drafting the manuscript and revision of the manuscript. Hai Yu: data collection and analysis, drafting the manuscript, investigation. All authors read and approved the final version of the manuscript.

Funding
The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Data availability
All data generated or analyzed in this study are included in the present manuscript.

Declarations

Ethics approval and consent to participate
This study was approved by the Ethics Committee of Deyang People's Hospital. The procedures were conducted in accordance with the ethical standards set forth by the Committee on Human Experimentation and the Helsinki Declaration of 1964, as revised in 2013. All patients in this study voluntarily joined this study with informed consents.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 26 January 2025 / Accepted: 16 April 2025
Published online: 28 April 2025

References

1. Zhang G, et al. Automated multidimensional deep learning platform for referable diabetic retinopathy detection: a multicentre, retrospective study. BMJ Open. 2022;12(7):e060155.
2. García-López C et al. The role of citicoline and coenzyme Q10 in retinal pathology. Int J Mol Sci, 2023. 24(6).
3. Sun L, Liu X, Zuo Z. Regulatory role of miRNA-23a in diabetic retinopathy. Exp Ther Med. 2021;22(6):1477.
4. Pollreisz A, et al. [Diagnosis, treatment and monitoring of diabetic eye disease (Update 2023)]. Wien Klin Wochenschr. 2023;135(Suppl 1):195–200.
5. Zhang X, Sivaprasad S, Ting DSW. Editorial: ocular complications associated with diabetes mellitus. Front Endocrinol (Lausanne). 2023;14:1193522.
6. Lee HA, Park H. Comorbidity network analysis related to obesity in middle-aged and older adults: findings from Korean population-based survey data. Epidemiol Health. 2021;43:e2021018.
7. Shi J, et al. Phase separation of α-crystallin-GFP protein and its implication in cataract disease. Sci Rep. 2023;13(1):4832.
8. Ishigooka G et al. Effects of angiotensin receptor blockers on Streptozotocin-Induced diabetic cataracts. J Clin Med, 2023. 12(20).
9. Fishman SL, et al. The role of advanced glycation end-products in the development of coronary artery disease in patients with and without diabetes mellitus: a review. Volume 24. Molecular Medicine (Cambridge, Mass.); 2018. p. 59. 1.
10. Saldanha IJ, et al. Reliability of the evidence addressing treatment of corneal diseases: A summary of systematic reviews. JAMA Ophthalmol. 2019;137(7):775–85.
11. Grzybowski A, Kanclerz P. Methods for achieving adequate pupil size in cataract surgery. Curr Opin Ophthalmol. 2020;31(1):33–42.
12. Mombaerts I. A pupil called worry: mydriasis in orbital surgery. Clin Neurol Neurosurg. 2025;249:108737.
13. Li X, Zhang D. *Intravitreal Injection of Conbercept Combined with Minimally Invasive Photocoagulation and Phacoemulsification Intraocular Lens Implantation in the Treatment of Neovascular Glaucoma Complicated with Cataract.* J Ophthalmol, 2023. 2023: p. 2834398.
14. Kim H, et al. Improved visibility of illuminated chopper-assisted cataract surgery involving iris challenges. Indian J Ophthalmol. 2023;71(3):757–62.
15. Matuszewski W et al. *Prevalence of Diabetic Retinopathy in Type 1 and Type 2 Diabetes Mellitus Patients in North-East Poland.* Medicina (Kaunas, Lithuania), 2020. 56(4).
16. Hayashi K, Hayashi H. Pupil size before and after phacoemulsification in non-diabetic and diabetic patients. J Cataract Refract Surg. 2004;30(12):2543–50.
17. Sun S, et al. Serum progesterone and retinopathy in male patients with type 2 diabetes: A cross-sectional study. J Diabetes Investig. 2021;12(7):1228–35.
18. Rodrigues FW, et al. Intraocular pressure variation by pneumatic tonometer before and after phacoemulsification. Eur J Ophthalmol. 2018;28(4):393–7.
19. Leal I, et al. Intraocular pressure reduction after Real-world cataract surgery. J Glaucoma. 2020;29(8):689–93.
20. Niro A et al. Association of neuroretinal thinning and microvascular changes with hypertension in an older population in Southern Italy. J Clin Med, 2022. 11(4).

21. Hu EH, et al. Comparative study of safety outcomes following nucleus disassembly with and without the MiLOOP Lens fragmentation device during cataract surgery. Clin Ophthalmol. 2022;16:2391–401.
22. Go JA, Mamalis CA, Khandelwal SS. Cataract surgery considerations for diabetic patients. Curr Diab Rep. 2021;21(12):67.
23. Haddad NMN, et al. Cataract surgery and its complications in diabetic patients. Semin Ophthalmol. 2014;29(5–6):329–37.
24. Cui L, et al. Discrepancies in vessel density and blood flow distribution in different areas of the Iris among pediatric type 1 diabetes mellitus and adult type 2 diabetes mellitus patients. Ophthalmic Res. 2023;66(1):1139–47.
25. Tayyari F, et al. Retinal blood flow and retinal blood oxygen saturation in mild to moderate diabetic retinopathy. Investig Ophthalmol Vis Sci. 2015;56(11):6796–800.
26. Bjerager J, et al. Previous intravitreal injection as a risk factor of posterior capsule rupture in cataract surgery: a systematic review and meta-analysis. Acta Ophthalmol. 2022;100(6):614–23.
27. Zare M, et al. Risk factors for posterior capsule rupture and vitreous loss during phacoemulsification. J Ophthalmic Vis Res. 2009;4(4):208–12.
28. Rao GN, et al. Outcomes of three-piece rigid scleral fixated intraocular lens implantation in subjects with deficient posterior capsule following complications in manual small incision cataract surgery. Heliyon. 2023;9(9):e20345.
29. Hong AR, Sheybani A, Huang AJW. Intraoperative management of posterior capsular rupture. Curr Opin Ophthalmol. 2015;26(1):16–21.

Publisher's note