· Clinical Research ·

Risk prediction model for cataract after vitrectomy surgery: a 2-year study on primary rhegmatogenous retinal detachment

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Received: 2025-03-19 Accepted: 2025-06-17

Abstract

● **AIM:** To establish a risk prediction model for secondary cataract within 2y after pars plana vitrectomy (PPV) in patients with primary rhegmatogenous retinal detachment (RRD).

● **METHODS:** Clinical data of patients with primary RRD treated at the Shenzhen Eye Hospital were retrospectively collected. Twenty-four potential influencing factors, including patient characteristics and surgical factors, were selected for analysis. Independent risk factors for secondary cataract were identified through univariate comparisons and multivariate logistic regression analysis. A risk prediction model was constructed and evaluated using receiver operating characteristic (ROC) curves, area under the ROC curve (AUC), calibration plots, and decision curve analysis (DCA) curves.

● **RESULTS:** The 386 cases (389 eyes) of patients who underwent PPV and had complete surgical records were ultimately included. Within a 2-year longitudinal observation, 41.39% of patients developed cataract secondary to PPV. Logistic regression results identified a history of hypertension [odds ratio (OR)=1.78, 95%CI: 1.002–3.163, *P*=0.049], silicone oil tamponade (OR=3.667, 95%CI: 2.373–5.667, *P*=0.000), and lens thickness (OR=1.978, 95%CI: 1.129–3.464, *P*=0.017) as independent risk factors for cataract secondary to PPV. The constructed nomogram achieved AUC=0.6974. Calibration plots indicated good agreement between predicted and observed outcomes, while DCA curves demonstrated the model's clinical utility.

● **CONCLUSION:** By incorporating a history of hypertension, vitreous substitute type, and lens thickness, this study constructs a prediction model with moderate discriminative ability. This model offers a valuable tool for clinicians to identify high-risk patients early, potentially allowing for more timely interventions and improved patient outcomes.

● **KEYWORDS:** rhegmatogenous retinal detachment; pars plana vitrectomy; cataract; prediction model; longitudinal study

DOI:10.18240/ijo.2025.11.12

Citation: Gong D, Ma DH, Zhang Q, Dang KR, Yang WH, Wang JT. Risk prediction model for cataract after vitrectomy surgery: a 2-year study on primary rhegmatogenous retinal detachment. *Int J Ophthalmol* 2025;18(11):2106-2115

INTRODUCTION

Rhegmatogenous retinal detachment (RRD) is an ophthalmic emergency characterized by incomplete vitreous detachment pulling the retinal layers, leading to full-thickness retinal tears. If not promptly intervened with surgery, it can result in permanent visual impairment[1]. Studies indicate an annual incidence of RRD ranging from 6.3/100 000 to 17.9/100 000[2], with an increasing trend over the years[3]. Common risk factors for RRD include myopia, trauma, and hereditary collagen abnormalities[4-6].

Currently, surgery is the primary treatment for RRD[7]. Scleral buckling (SB), pars plana vitrectomy (PPV), and pneumatic retinopexy (PR) are the most commonly used surgical methods for treating RRD. With the rapid advancement of minimally invasive surgical techniques, visualization technologies, and biomaterials[8-9], precise identification and release of retinal tears, along with the removal of other potential traction risks during PPV, result in a higher rate of retinal reattachment and improved visual function compared to SB and PR procedures. This has made PPV the mainstream choice for RRD treatment[10].

Despite its advantages, a notable complication for some patients with RRD with preserved lens function is the rapid development of cataracts post-PPV, necessitating subsequent cataract surgery[11-14]. Addressing this issue, combining Phacoemulsification (Phaco) with PPV presents advantages, providing better intraoperative visualization, more complete vitreous removal, convenient laser treatment, and broader vitreous filling, thereby reducing the risk of RRD recurrence[15]. However, combined surgery has drawbacks, including longer surgical times and additional risks of postoperative complications such as corneal edema and refractive errors, as well as the loss of natural lens accommodation and resulting refractive disparities due to the loss of accommodation in the operated eye[16-17]. Consequently, the choice between standalone PPV surgery and combined surgery for patients with RRD with preserved lens function remains an unresolved clinical issue.

In medical research, researchers often use “prediction models” to assess the risk of an individual developing a certain disease in the future. Specifically, statistical models are established through statistical analysis, incorporating various influencing factors of the disease to predict the probability of future occurrence of a specific outcome event in a population with certain characteristics[18]. Clinical prediction model studies provide effective tools for physicians and researchers. Currently, there is limited research on prognosis-related prediction models for RRD and PPV. Gao *et al*[19] identified risk factors for the occurrence of proliferative vitreoretinopathy (PVD) in patients after RRD surgery using logistic regression. They developed a nomogram predicting the probability of being PVR-free at 4, 5, and 6mo postoperatively. Catania *et al*[20] used preoperative and postoperative ultra-wide field and autofluorescence fundus imaging, combined with deep learning algorithms, to automatically predict the risk of late recurrence of RRD. The findings demonstrated that the deep learning (DL) model can accurately predict late recurrence of RRD, helping to optimize follow-up strategies. In a prospective observational study, researchers applied multivariate logistic regression analysis and identified preoperative lens tilt and lens decentration as predictive factors for clinically significant intraocular lens tilt [area under the receiver operating characteristic (ROC) curve (AUC)=0.82, 95% confidence interval (CI): 0.76–0.88] and decentration (AUC=0.84, 95%CI: 0.78–0.89) following PPV, and subsequently developed a nomogram[21]. Additionally, Shi *et al*[22] conducted a retrospective analysis of diabetic retinopathy patients to identify risk factors for neovascular glaucoma after PPV, constructing a predictive model. They found that posterior capsular defects, preoperative vascular endothelial growth factor, glycated hemoglobin, aqueous humor interleukin-6, and interleukin-10 were independent risk factors, and the model demonstrated high predictive accuracy. Furthermore, Fan *et al*[23] developed a risk prediction model for elevated intraocular pressure following silicone oil tamponade, which may provide valuable insights for reducing the incidence of high intraocular pressure after PPV combined with silicone oil tamponade. To our knowledge, there is currently no research on predicting the risk of cataract secondary to PPV.

Therefore, the main purpose of this study is to construct a risk prediction model to forecast the risk of secondary cataract occurring within 2y after PPV surgery in patients with RRD. By comprehensively analyzing multiple risk factors related to the ocular health of patients with RRD, we aim to explore and identify key variables associated with the development of cataract secondary to PPV. The goal is to provide clinicians with a simple and practical predictive tool to quantify the risk of cataract secondary to PPV formation in patients with RRD, thereby assisting in the design of personalized surgical interventions and enhancing treatment outcomes and patient satisfaction.

PARTICIPANTS AND METHODS

Ethical Approval This study was conducted in accordance with the Declaration of Helsinki and was approved by the Medical Ethics Committee of Shenzhen Eye Hospital (Approval Number: 2024KYPJ056). Informed consent was waived due to the retrospective nature of the study. All personal identifiers were anonymized to protect patient privacy. Patients or members of the public were not involved in the design, conduct, reporting, or dissemination plans of this research. The study utilized retrospective clinical data, and all aspects of the research, including study design and analysis, were conducted by the research team without direct involvement from patients or the public.

Technical Flowchart of the Study The main workflow of this research is illustrated in Figure 1.

Participants A retrospective collection of primary RRD patients treated at the Shenzhen Eye Hospital from September 1, 2020, to August 31, 2021, was conducted. The inclusion and exclusion criteria established for the study were strictly followed, resulting in the inclusion of 386 patients (389 eyes). All personal identifiers were anonymized to protect patient privacy.

In this study, cataract grading was performed using the clinically established LOCS III system, specifically the CNP classification (C for cortical, N for nuclear, and P for posterior subcapsular cataracts). The grading was based on the subjective assessment of the primary surgeon through slit-lamp examination. The same grading system and criteria were consistently applied both preoperatively and postoperatively by the operating surgeon to ensure consistency and reduce potential bias.

Inclusion criteria: 1) diagnosis of “primary rhegmatogenous retinal detachment” confirmed through a comprehensive ophthalmic examination; 2) underwent PPV for retinal reposition surgery; 3) all cases that underwent silicone oil implantation used silicone oil with the same density of 0.97 g/cm³; 4) complete surgical records available; 5) preoperative crystalline lens intact and transparent, without significant cataract; 6) postoperative medication included standard topical anti-inflammatory and anti-infective regimen, with glucocorticoid eye drops discontinued within 2–4wk after surgery; 7) regular follow-up for over 2y postoperatively.

Exclusion criteria: 1) patients with severe eye diseases, such as corneal diseases, scleral diseases, glaucoma, uveitis, retinal vascular diseases, macular diseases, retinal pigment degeneration, orbital diseases, *etc*., in the affected eye; 2) history of significant ocular trauma; 3) crystalline lens significantly opaque before retinal reposition surgery or previously underwent lens extraction; 4) simultaneous lens extraction during retinal reposition surgery; 5) severe clinical data deficiency; 6) patients lost to follow-up postoperatively.

Study Variables A review of relevant literature on Medline, EMBASE, and Web of Science, using keywords such as “Rhegmatogenous Retinal Detachment”, “pars plana vitrectomy”, and “secondary cataract”, determined the study variables. A total of 24 factors, including patient characteristics, surgical factors, and the occurrence of secondary cataract within 2y of follow-up, were selected.

Since all PPV surgeries were performed by experienced lead surgeons, the operating surgeon was not included as a covariate in this study.

Data Coding All categorical variables, including gender, laterality, visual acuity, hypertension history, diabetes history, vitreous substitute type, and secondary cataract within 2y of follow-up, were coded. The assigned values are presented in Table 1.

Statistical Analysis The original data were cleaned to remove outliers, and missing values were imputed using multiple imputation. The extent of missing data across variables was evaluated prior to imputation. Specifically, the percentage of missing data for each variable was assessed, and missing values were handled accordingly. The multiple imputation process involved creating multiple imputed datasets (specified as five in this study) to account for the uncertainty associated with missing values. Each dataset was analyzed separately, and the results were then combined to provide a final estimate. This approach allowed us to incorporate the variability and reduce the bias that could result from missing data. The imputation was performed using the standard SPSS multiple imputation procedure, which includes specifying the imputation model, running the imputation, and checking the convergence and consistency of the imputed datasets. Descriptive statistics were applied to continuous variables based on their distribution, and categorical variables were presented as counts (%). Single-factor analysis and logistic regression were used to eliminate variables with limited predictive ability. Post-hoc power analyses were conducted using the powerLogisticCon function from the powerMediation R package for binary predictors and pwr.t.test from the pwr package for the continuous predictor to assess the statistical power of key variables identified in the logistic regression model[24-25]. Akaike Information Criterion and Bayesian Information Criterion have now been calculated for the multivariable logistic regression model to evaluate the

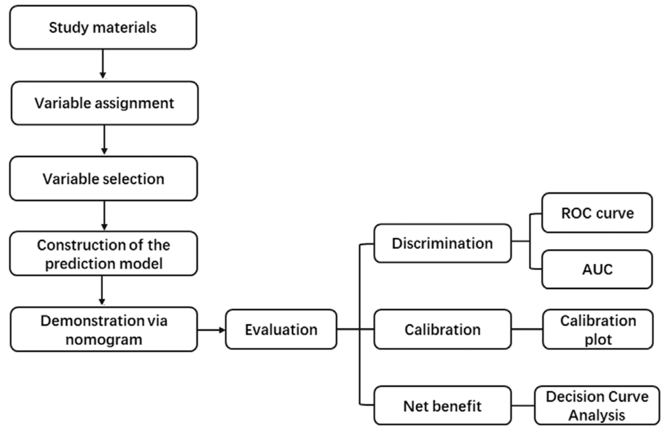

Figure 1 Workflow of this study ROC: Receiver operating characteristic; AUC: Area under the ROC curve.

Table 1 Variable coding instructions

Variable	Variable type	Coding instructions
Age	Numeric	-
BMI (body mass index)	Numeric	-
IOP (intraocular pressure)	Numeric	-
SBP (systolic blood pressure)	Numeric	-
DBP (diastolic blood pressure)	Numeric	-
Surgery time	Numeric	-
AL (axial length)	Numeric	-
ACD (anterior chamber depth)	Numeric	-
LT (lens thickness)	Numeric	-
WTW (white-to-white distance)	Numeric	-
CCT (central corneal thickness)	Numeric	-
ALT (alanine aminotransferase)	Numeric	-
AST (aspartate aminotransferase)	Numeric	-
BUN (blood urea nitrogen)	Numeric	-
Cr (creatinine)	Numeric	-
Ua (uric acid)	Numeric	-
GLU (fasting blood glucose)	Numeric	-
Gender	Categorical	1=Male; 2=Female
Laterality	Categorical	1=Right eye; 2=Left eye
Visual acuity (BCVA)	Categorical	1=BCVA≥0.8; 2=0.3≤BCVA<0.8; 3=0.05≤BCVA<0.3; 4=BCVA<0.05
HBP (hypertension history)	Categorical	0=No; 1=Yes
Diabetes (diabetes history)	Categorical	0=No; 1=Yes
Vitreous substitute	Categorical	1=Gas; 2=Silicone oil
Secondary cataract (2y of follow-up)	Categorical	0=No; 1=Yes

BCVA: Best-corrected visual acuity.

model's goodness-of-fit and complexity. Logistic regression was employed to construct the prediction model, and a nomogram was created to predict the incidence rate. ROC curves and AUC were used to evaluate the discriminatory ability of the nomogram. Bootstrap methods were applied for internal validation of the model's calibration, and decision curve analysis (DCA) was used to assess the clinical net benefit of the prediction model[26].

All data were statistically analyzed using SPSS version 26.0 and R version 4.2.3 software. A *P*-value less than 0.05 was considered statistically significant.

RESULTS

Incidence of Secondary Cataract Within 2y In a retrospective longitudinal analysis of 386 patients (389 eyes) included in this study who underwent PPV, the occurrence of postoperative secondary cataract was defined based on clinical examination findings indicating lens opacity that significantly affected vision in the operated eye. A total of 161 eyes were diagnosed with cataract secondary to PPV, resulting in an incidence rate of 41.39%. Patients with secondary cataract were defined as the occurrence group (n=161), and the remaining as the non-occurrence group (n=228).

Comparative Analysis Between the Two Groups Using SPSS software, a comparative statistical analysis of relevant variables between the two groups revealed significant differences in age, hypertension histoty (HBP), Vitreous Substitute, and les thickness (LT; P<0.05), as shown in Table 2.

Multivariate Logistic Regression Analysis Setting the occurrence of secondary cataract within two years as the dependent variable, the four variables with significant differences between the two groups (age, HBP, vitreous substitute, and LT) were included in the multivariate logistic regression. The results showed that HBP, vitreous substitute, and LT (3 variables) were independent influencing factors for the occurrence of post-PPV secondary cataract in patients with RRD within two years (P<0.05), as shown in Table 3.

Post-hoc power analyses were performed on three key predictors. The analysis for hypertension [odds ratio (OR)=1.78, exposure proportion p_1=0.167, total n=389] yielded a statistical power of 0.989, indicating adequate sensitivity to detect the observed association. For vitreous substitute (OR=3.667, p_1=0.473, n=389), the power reached 1.000, demonstrating an excellent capacity to identify group differences. In contrast, the power for the continuous predictor LT (Cohen's d=0.225, with approximately 194.5 subjects per group) was 0.600, suggesting limited ability to detect small-to-moderate effects and highlighting the need for larger samples in future studies to confirm this finding.

Construction of Nomogram Prediction Model Using the "rms" package in RStudio, a nomogram prediction model for predicting the occurrence of secondary cataract within two years in patients with RRD after PPV was constructed based on the variables selected from the multivariate logistic regression analysis, as shown in Figure 2. The nomogram assigns a score to each predictive indicator, and the total score corresponds to the predicted probability of a patient developing secondary cataract within two years.

Evaluation of the Nomogram Prediction Model

Discrimination The discrimination result showed an AUC of 0.6974 (Figure 3), indicating that the model had a moderate ability to distinguish between the occurrence and non-occurrence of post-PPV secondary cataract.

Internal validation of the prediction model Bootstrap method was used for internal validation of the prediction model. With 500 resampling iterations, the calibration curve (Figure 4) demonstrated good consistency between predicted and observed results, indicating good model calibration.

Clinical Decision Curve Analysis This study employed DCA to assess the clinical net benefit of the prediction model. In the decision curve plot, the solid red line represents the model's prediction of the occurrence of secondary cataract within two years in patients. For comparison, horizontal and diagonal lines represent two extreme scenarios. The blue dashed line represents the situation where all samples are negative, and no interventions are administered, resulting in a net benefit of 0. The green diagonal line represents the scenario where all samples are positive, and everyone receives intervention, yielding a net benefit in the form of a negatively sloped line. DCA results of this study demonstrate that the DCA curve of the nomogram model generates a net benefit, as illustrated in Figure 5.

DISCUSSION

This study originated from a concern about postoperative complications following PPV, especially a relatively weak understanding of secondary cataract. Therefore, we conducted a retrospective analysis of clinical data from 386 cases (389 eyes) of patients with RRD after PPV. We selected 24 potential influencing factors, mainly focusing on patient characteristics and surgical factors, for a comprehensive multilevel data analysis. In the 2-year follow-up data, we observed that 41.39% of patients developed secondary cataract. Factors such as age, history of hypertension, vitreous substitute type, and LT showed significant correlations with the occurrence of cataracts. Through multifactorial logistic regression analysis, we identified a history of hypertension, silicone oil as the vitreous substitute, and LT as independent influencing factors.

Previous studies suggest that age might be a factor influencing the occurrence of secondary cataract after PPV. Reports by Rey *et al*[27] indicate that among patients with transparent lenses during PPV, elderly individuals require Phaco surgery

Table 2 Analysis of distribution differences between the two groups

Variable	Secondary cataract occurrence		Statistical value	P
	Occurrence group (n=161)	Non-occurrence group (n=228)		
Age (y)	51.60±11.52	48.80±11.42	2.373	0.018[a]
Gender				
1 (male)	104 (40.2%)	155 (59.8%)	0.346	0.556
2 (female)	57 (43.8%)	73 (56.2%)		
BMI	24.60±4.17	23.93±3.68	1.671	0.096
Laterality				
1 (left)	82 (39.6%)	125 (60.4%)	0.429	0.513
2 (right)	79 (43.4%)	103 (56.6%)		
Visual				
1 (BCVA≥0.8)	17 (36.2%)	30 (63.8%)	1.159	0.763
2 (0.3≤BCVA<0.8)	27 (41.5%)	38 (58.5%)		
3 (0.05≤BCVA<0.3)	36 (39.1%)	56 (60.9%)		
4 (BCVA<0.05)	81 (43.8%)	104 (56.2%)		
IOP	12.03±3.08	12.57±3.15	-1.665	0.097
SBP	125.78±14.55	123.67±15.49	1.356	0.176
DBP	76.41±9.39	75.71±9.57	0.711	0.478
HBP				
0 (no)	124 (38.3%)	200 (61.7%)	7.014	0.008[b]
1 (yes)	37 (56.9%)	28 (56.9%)		
Diabetes				
0 (no)	146 (40.3%)	216 (59.7%)	1.814	0.178
1 (yes)	15 (55.6%)	12 (44.4%)		
Vitreous substitute				
1 (gas)	56 (27.3%)	149 (72.7%)	34.158	0.000[c]
2 (silicone oil)	105 (57.1%)	79 (42.9%)		
Time	73.44±31.60	71.21±33.91	0.657	0.511
AL	25.43±2.17	25.53±2.35	-0.410	0.682
ACD	3.23±0.42	3.28±0.44	-1.154	0.249
LT	4.46±0.40	4.37±0.39	2.227	0.027[a]
WTW	12.02±0.44	12.00±0.47	0.504	0.614
CCT	545.11±35.70	545.49±32.87	-0.107	0.915
ALT	21.00 (16.00, 31.00)	21.00 (15.25, 30.00)	-0.520	0.603
AST	20.00 (17.00, 24.00)	20.00 (17.00, 24.00)	-0.075	0.940
BUN	4.90±1.20	4.97±1.38	-0.503	0.616
Cr	69.65±15.35	71.28±16.64	-0.983	0.326
Ua	373.77±96.94	368.76±107.68	0.471	0.638
GLU	5.67 (5.30, 6.67)	5.67 (5.21, 6.87)	-0.304	0.761

[a]Independent samples *t*-tests; [b]Chi-square tests; [c]Mann-Whitney *U* test. BMI: Body mass index; BCVA: Best-corrected visual acuity; IOP: Intraocular pressure; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HBP: Hypertension history; AL: Axial length; ACD: Anterior chamber depth; LT: Lens thickness; WTW: White-to-white distance; CCT: Central corneal thickness; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; BUN: Blood urea nitrogen; Cr: Creatinine; Ua: Uric acid; GLU: Fasting blood glucose.

significantly earlier (average 12mo) than younger patients (average 41mo). Observational research by Thompson[28], similarly demonstrates that the average rate of lens nucleus sclerosis is significantly faster in patients over 50 years old after vitrectomy compared to those under 50 years old (0.812 grades/year *vs* 0.13 grades/year). In our study, we observed that the age of patients in the group experiencing complications within two years (51.60±11.52y) was significantly higher than that of patients in the group without complications (48.80±11.42y). This indicates that the development of cataracts after PPV occurs more rapidly in elderly patients. In a prospective study, researchers reported that posterior subcapsular opacities were more common in patients under 50 years old among those developing secondary cataract after PPV[29]. The reason for this might be that the density of the lens nucleus in older patients has already increased, leading to faster

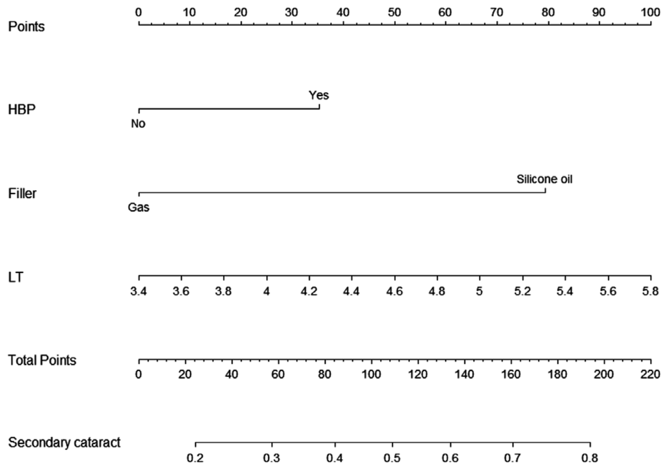

Figure 2 Nomogram prediction model for secondary cataract occurrence after PPV in patients with RRD PPV: Pars plana vitrectomy; RRD: Rhegmatogenous retinal detachment; LT: Lens thickness; HBP: Hypertension history.

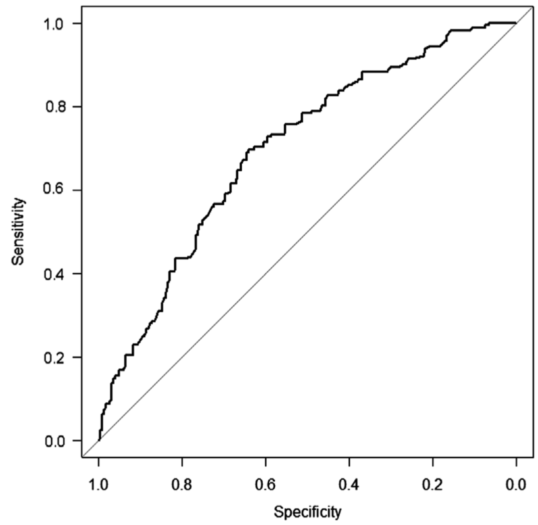

Figure 3 Receiver operating characteristic curve for the nomogram model.

Table 3 Multivariate logistic regression results

Variable	*B*	*P*	Exp(B)	95% confidence interval for Exp(B)
HBP	0.577	0.049	1.78	1.002-3.163
Vitreous substitute	1.299	0.000	3.667	2.373-5.667
LT	0.682	0.017	1.978	1.129-3.464

Multivariate logistic regression analysis was conducted with the occurrence of secondary cataract within two years as the dependent variable. $P<0.05$ was considered statistically significant. HBP: Hypertension history; LT: Lens thickness.

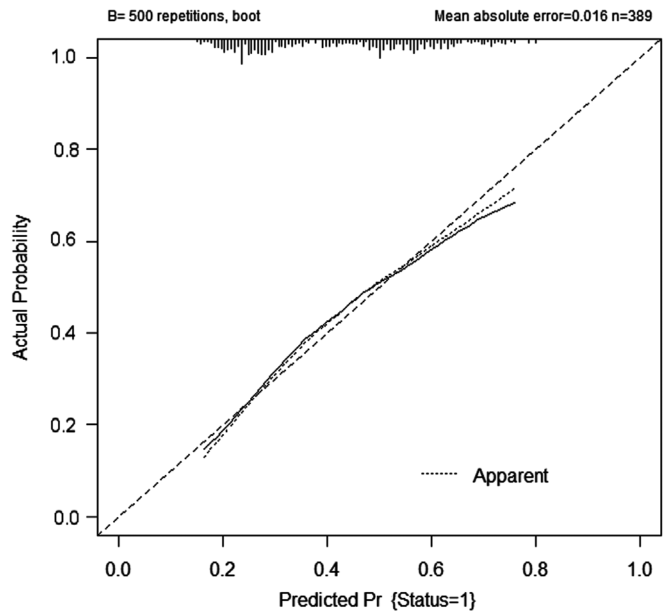

Figure 4 Calibration curve for internal validation.

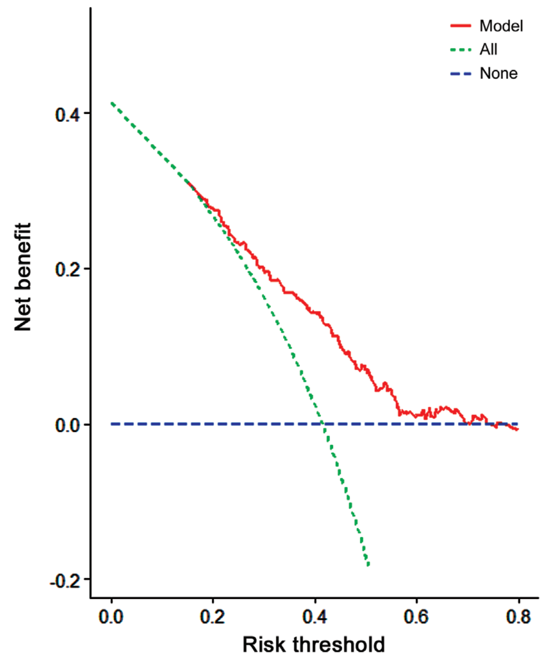

Figure 5 Decision curve analysis curve for the nomogram model.

development of lens nucleus opacity. In contrast, relatively younger patients are more likely to experience posterior subcapsular opacities due to the impact of PPV surgery on the lens's nutritional and supportive functions from the vitreous. Despite significant differences in age distribution in this study, age was excluded as an independent influencing factor in the multifactorial logistic regression model. Therefore, further exploration is needed to understand the relationship between age and secondary cataract after PPV.

In the population post-PPV, we observed for the first time a higher risk of secondary cataract in patients with hypertension. Specifically, the OR for the occurrence of secondary cataract within two years after PPV in patients with hypertension was 1.78 (95%CI: 1.002–3.163, P=0.049). This result indicates that, compared to patients without hypertension, those with hypertension have a 78% higher risk of developing secondary cataract within 2y. Epidemiological studies and Meta-analyses in the past have consistently shown a significant increase in the risk of cataracts in hypertensive populations[30]. Recent findings from a Mendelian randomization study on the European population also suggest a causal relationship between systolic blood pressure (SBP) levels and age-related cataracts. Specifically, for every 10 mm Hg increase in SBP, the individual's cataract risk increases by 13%[31]. However, the specific mechanisms are not yet well understood, and it is suggested that hypertension may involve inflammatory pathways in the pathological development of cataract[30,32]. Additionally, research indicates that hypertension may induce conformational changes in lens capsule proteins, exacerbating cataract formation[33]. In a metallomics study of aqueous humor in cataract surgery patients, researchers found that the levels of tin, ruthenium, and titanium metals in the aqueous humor of hypertensive patients were different from the control group (non-hypertensive). It's noteworthy that the concentration of Sn in the aqueous humor of hypertensive patients was significantly elevated compared to normal individuals[34]. Sn is not an essential element for humans, and organic tin compounds can disrupt intracellular Ca^{2+} homeostasis, affecting signaling pathways and inducing protein apoptosis, disaggregation, and degradation[35]. However, due to the limitations of the current study, we were not able to clearly understand whether these metal elements are correlated with lens degeneration in hypertensive patients and the specific causal relationship.

The logistic regression results of this study revealed that the use of silicone oil for vitreous cavity tamponade is an independent influencing factor for secondary cataract within two years after PPV surgery (OR=3.667, 95%CI: 2.373–5.667, *P*=0.000). The purpose of using vitreous substitutes, such as silicone oil, after PPV is to fill the vitreous cavity, providing intraocular tension and promoting retinal reattachment and healing. Silicone oil and gas are commonly used for medium to long-term tamponade effects. Silicone oil, as a vitreous substitute, is a polymer of polydimethylsiloxane, possessing advantages such as transparency, low surface tension, buoyancy, antimicrobial properties, and low toxicity. However, it also carries the potential for severe complications, including retinal toxicity, glaucoma, epiretinal membrane, and optic neuropathy[36-38]. Due to its efficacy in promoting retinal stabilization, reducing the risk of re-detachment, and preventing bleeding, silicone oil is still the preferred choice in clinical practice for patients with long-term tamponade requirements, especially in cases of severe retinal trauma[39-41]. Numerous studies have indicated that cataract formation is one of the most common complications after PPV surgery with silicone oil tamponade due to its toxic effects on lens cells[42-44]. In a prospective randomized controlled trial, researchers observed lens specimens from patients previously treated with silicone oil tamponade under various microscopes. They discovered abnormal deposits on the collagen surface and degeneration and apoptosis changes in lens epithelial cells. This study suggests that silicone oil may contribute to apoptosis and histopathological changes in lens epithelial cells, which persist even after silicone oil removal[45].

Compared to silicone oil tamponade, the data from this study indicates a significantly lower risk of cataract occurrence within two years after combined PPV and gas tamponade. Numerous research findings currently support the safety and effectiveness of combined PPV and gas tamponade in treating relatively simple cases of primary RRD, with a high success rate in achieving retinal anatomical reattachment[46-47]. However, further research is still needed to validate the efficacy of this surgical approach for more complex cases, such as giant retinal tears.

According to the results of logistic regression, this study reports for the first time that LT is an independent risk factor for the occurrence of postoperative cataracts in patients with primary RRD after PPV (OR=1.978, 95%CI: 1.129–3.464, *P*=0.017). Specifically, for each 1 mm increase in LT, the risk of developing cataracts within two years increases by 97.8%. The potential reasons for this association may be attributed to the susceptibility of a thicker lens to physical damage during PPV surgery. Additionally, the postoperative nutritional supply to the lens may be relatively insufficient, and a thicker lens with higher nutritional demands may be more prone to opacification. Further research is needed to explore the specific relationship between LT and the occurrence of postoperative cataracts.

Based on the research findings, this study further developed a nomogram prediction model, incorporating multiple patient characteristics, to enable physicians to more accurately assess the risk of postoperative cataracts. The model's discriminative ability was evaluated by the AUC value, which was 0.6974, indicating a moderate discriminatory capacity. Internal validation using the Bootstrap method demonstrated satisfactory calibration for the nomogram model constructed in this study. Additionally, the results of DCA also indicated that the model has some clinical utility. Given the relative scarcity of research on predictive models for postoperative complications and efficacy assessment following PPV, we are unable to make direct comparisons of the efficacy of our model with others. However, a moderate discriminative ability may still be suboptimal for a predictive model.

Although this study has made some progress in exploring the risk of secondary cataract following PPV, there are still some limitations. First, this research is a single-center study, which has certain limitations that may affect the generalizability of the results. Second, the study only considered some potential influencing factors, and there are other factors that might affect the occurrence of secondary cataract that were not taken into account. Future research could explore more potential predictive factors, such as genetic factors and fundus lesions.

Additionally, for some findings, such as the association between LT and cataracts, this study has not provided an in-depth explanation of the underlying mechanisms. Future research could reveal the biological and pathological mechanisms of these associations through more experiments and basic research. Moreover, due to the limited number of cases operated by a single surgeon, this study included patients treated by different surgeons. Although all surgeons were experienced, variations in surgical technique and lens protection ability could have influenced the results. Future studies with a uniform surgical operator or stratified analyses by surgeon may help reduce this bias. Lastly, while the predictive model constructed in this study has a certain level of discrimination and calibration, its moderate discriminative ability may still need improvement. Future research could explore more advanced modeling methods, such as machine learning and artificial intelligence techniques, to enhance the predictive accuracy and applicability of the model[48].

In summary, future research efforts could focus on expanding sample sizes, delving deeper into potential factors, elucidating discovered mechanisms, and employing advanced technological approaches to continually refine the prediction and understanding of the risk of postoperative cataracts following PPV. These endeavors will contribute to enhancing the accuracy of clinical prediction models and providing a more reliable basis for the prevention and management of post-PPV cataracts.

In conclusion, this study conducted a retrospective analysis of 386 cases (389 eyes) with primary RRD undergoing PPV over a 2-year follow-up period, systematically exploring the relationship between the occurrence of secondary cataract and potential influencing factors. Through multifactorial logistic regression analysis, a prediction model was constructed, identifying a history of hypertension, silicone oil filling, and LT as independent influencing factors. While the model demonstrated moderate discriminative ability, it exhibited satisfactory calibration and clinical utility in internal validation and decision curve analysis.

In summary, this study provides clinical insights into understanding and predicting post-PPV secondary cataract. The research results offer valuable references for clinical practice, contributing to the enhancement of patient management, the formulation of personalized treatment strategies, and early interventions for high-risk patients.

ACKNOWLEDGEMENTS

The authors would like to thank all colleagues and staff at Shenzhen Eye Hospital for their support in this research.

Authors' Contributions: Gong D contributed to data acquisition, analysis, and drafting of the manuscript. Yang WH designed the research, supervised the project, and revised the manuscript. Zhang Q contributed to data acquisition, analysis, and drafting of the manuscript. Dang KR contributed to data acquisition, analysis, and drafting of the manuscript. Ma DH designed the research, supervised the project, and revised the manuscript. Wang JT designed the research, supervised the project, and revised the manuscript. All authors have read and approved the final manuscript.

Data Availability Statement: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Due to patient confidentiality and ethical restrictions, individual-level data cannot be shared publicly.

Foundations: Supported by the Shenzhen Science and Technology Program (No.JCYJ20220818103207015); the SanMing Project of Medicine in Shenzhen (No. SZSM202311012).

Conflicts of Interest: Gong D, None; **Ma DH,** None; **Zhang Q,** None; **Dang KR,** None; **Yang WH,** None; **Wang JT,** None.

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