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Recurrent rhegmatogenous retinal detachment: incidence, established and emerging risk factors, and clinical outcomes

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Abstract

Background Recurrent rhegmatogenous retinal detachment (RRD) remains a significant cause of visual morbidity despite advances in surgical techniques, and its determinants and clinical course are not yet fully defined. This study aimed to evaluate the incidence, risk factors, and outcomes of recurrent RRD in a large cohort at an Italian tertiary referral center.

Methods This retrospective study included patients with primary RRD who underwent pars plana vitrectomy, scleral buckling, or both. Associations between clinical and intraoperative variables and recurrent RRD were analysed using multivariable logistic regression.

Results A total of 209 eyes from 209 patients were included. The overall recurrence rate was 21.1%, with 52.3% of recurrences occurring within the first six postoperative weeks. Multivariate logistic regression identified proliferative vitreoretinopathy (PVR grade B or higher) (OR = 4.68, $p = 0.006$), high myopia (OR = 4.25, $p = 0.002$), preoperative glaucoma (OR = 4.08, $p = 0.014$), and systemic hypertension (OR = 2.72, $p = 0.031$) as independent predictors of recurrence. Final best-corrected visual acuity was significantly worse in eyes with recurrence ($p < 0.001$). Eyes with recurrent retinal detachment showed a significantly higher prevalence of cystoid macular edema.

Conclusions This study confirms PVR and high myopia as risk factors for recurrent RRD and suggests preoperative glaucoma and systemic hypertension as additional predictors of recurrence. These findings highlight the importance of risk stratification in guiding individualized surgical planning, intensified early postoperative surveillance, and long-term follow-up to reduce recurrence and preserve visual outcomes.

Keywords Rhegmatogenous retinal detachment, Recurrent retinal detachment, Risk factor, Proliferative vitreoretinopathy

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Background

Rhegmatogenous retinal detachment (RRD) is one of the most common vision-threatening ophthalmic emergencies, affecting approximately 10.5-14.1 individuals per 100,000 each year [1, 2]. Over the past decades, remarkable advances in vitreoretinal surgery have substantially improved anatomical success rates and visual outcomes. Nevertheless, recurrent retinal detachment (re-RD) continues to represent a major clinical challenge, occurring in nearly one-quarter of cases despite technically successful initial repair [3–7]. For both surgeons and patients, recurrence often marks the beginning of a more complex clinical course, characterized by repeated interventions, greater surgical difficulty, and poorer visual recovery. The pathogenesis of re-RD is multifactorial and remains only partially understood. Previous studies have identified several ocular and surgical factors associated with recurrence, including aphakia, choroidal detachment, uveitis, hypotony, high myopia, incomplete vitreous removal, multiple or large retinal breaks, extensive retinal involvement, delayed surgical treatment, inadequate retinopexy, pneumatic retinopexy, and a history of multiple retinal procedures [8–14]. However, these findings have not always been consistent, likely reflecting the heterogeneity of study populations, surgical techniques, and analytical approaches. Among the mechanisms implicated in recurrence, proliferative vitreoretinopathy (PVR) is widely recognized as the principal driver of surgical failure and re-detachment [15, 16]. Yet, the biological processes that trigger and sustain the fibroinflammatory cascade leading to PVR and re-RD remain incompletely elucidated.

In this context, the present study aimed to evaluate the incidence of re-RD in a real-world cohort of patients with primary RRD treated with pars plana vitrectomy (PPV), scleral buckle (SB), or a combined surgical approach. In addition, we sought to investigate both ocular and systemic risk factors associated with recurrence, as well as the final anatomical and functional outcomes of these patients.

Methods

Study design, ethics and setting

This retrospective observational study received approval from the Area Vasta Emilia Centro Ethical Committee (approval code: 559/2025/Oss/AOUFe). It was conducted at the tertiary referral center Arcispedale Sant'Anna University Hospital, Ferrara, Italy, and included all consecutive patients aged ≥ 18 years who underwent surgical repair for primary RRD between January 2021 and December 2024. The study adhered to the tenets of the Declaration of Helsinki. Patient confidentiality was maintained through complete de-identification of all collected data.

Patient selection

Inclusion criteria comprised patients who achieved initial anatomical retinal reattachment after primary RRD repair using PPV, SB, or a combination of both during the study period, with a minimum follow-up of 12 months. No patients underwent pneumatic retinopexy. Exclusion criteria comprised primary surgical failure, non-rhegmatogenous retinal detachment, previous ocular trauma, prior PPV performed for epiretinal membrane, macular hole, dislocated nuclear material, or dislocated intraocular lens, and a history of complicated cataract surgery. Patients with choroidal hemorrhage, age-related macular degeneration, retinal vein occlusion, diabetic retinopathy, inherited vitreoretinal dystrophies, connective tissue disorders, retinoschisis, retinal coloboma, Coats disease, intraocular inflammation, or ocular infection were also excluded. Furthermore, patients with incomplete medical records or insufficient follow-up were not included in the study.

Outcome measures

The primary outcome measures were the incidence of re-RD following successful primary retinal detachment repair and the identification of risk factors associated with recurrence. Re-RD was defined as a new retinal separation occurring after documented anatomical success of a previous RRD repair. Clinically, patients presented with the abrupt onset of new visual symptoms. The diagnosis was confirmed by fundus examination and OCT demonstrating a full-thickness retinal detachment associated with a newly identified retinal break and/or tractional membrane [6, 7]. Secondary outcome measures included final anatomical retinal attachment status and visual outcomes.

Data collection and variables

Patient data were retrospectively collected from electronic medical records. Recorded variables included demographic characteristics (age, sex, and laterality), systemic comorbidities, refractive status, axial length, preexisting glaucoma, and history of prior ocular surgery. Systemic comorbidities analyzed included hypertension, diabetes mellitus, and dyslipidemia. According to the 2024 European Society of Cardiology (ESC) guidelines, hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg [17]. Diabetes mellitus was diagnosed based on abnormal fasting plasma glucose, abnormal 2-hour plasma glucose during an oral glucose tolerance test, and/or elevated glycated hemoglobin (HbA1c) levels [18]. Dyslipidemia was defined by abnormalities in the lipid profile, including elevated low-density lipoprotein cholesterol, non-high-density lipoprotein cholesterol, triglycerides, and/or lipoprotein(a) levels [19]. High myopia was defined

as a preoperative spherical equivalent of -6 diopters or greater, or an axial length > 26 mm, according to the criteria proposed by Flitcroft et al. [20]. Axial length measurements were obtained using the IOLMaster 700 (Carl Zeiss Meditec). Pre-existing glaucoma was identified based on documented glaucomatous visual field defects in the medical records.

Baseline RRD characteristics included extent of detachment (number of involved quadrants), detachment location (superior, inferior, or total), number, location, and size of retinal breaks, macular status (macula-on or macula-off), lens status (phakic or pseudophakic), and concomitant macular hole or non-diabetic vitreous hemorrhage. In cases of diagnostic uncertainty, macular involvement was confirmed by optical coherence tomography (OCT). PVR grade B or higher was classified according to the Retina Society classification system [21]. Time to surgery was defined as the interval between symptom onset, specifically the appearance of visual field defects and/or floaters, and surgical intervention.

Surgical variables included operative technique, type of tamponade agent, endolaser photocoagulation pattern (localized laser treatment around retinal breaks versus completed 360-degree laser retinopexy), and the performance of retinectomy, retinotomy, or membrane peeling. All surgical procedures were performed by seven vitreoretinal surgeons. The duration of silicone oil (SO) tamponade was recorded in days. Re-RD was classified as early recurrence if it occurred within the first 6 postoperative weeks and as late recurrence if it occurred more than 6 weeks postoperatively [7].

Best-corrected visual acuity (BCVA) was assessed using Snellen charts preoperatively and at all postoperative visits, with values converted to logarithm of the minimum angle of resolution (logMAR) units for statistical analysis. Visual acuity measurements of counting fingers, hand motion, light perception, and no light perception were converted to logMAR equivalents according to the method described by Schulze-Bonsel et al. [22].

Final retinal status at the last follow-up visit was categorized as attached, attached under SO tamponade, or detached. Cystoid macular edema (CME) was assessed using postoperative spectral-domain OCT (SD-OCT; Heidelberg Engineering GmbH). CME was defined as the presence of multiple intraretinal cystoid hyporeflective spaces of variable size and shape, predominantly involving the inner nuclear and outer plexiform layers, associated with retinal thickening and loss of the normal foveal contour [23–25].

Surgical procedure

The choice of surgical approach was left to the discretion of the operating surgeon and was based on both preoperative clinical assessment and intraoperative findings. PPV was generally preferred in pseudophakic eyes and in more complex cases of RRD, including those with multiple or posterior retinal breaks, giant retinal tears, total retinal detachment, significant media opacity, vitreous hemorrhage, macular hole-associated RRD, or PVR grade B or C. SB surgery was primarily performed in younger phakic patients with less complex RRD, particularly in eyes with single or clustered peripheral retinal breaks involving the anterior or equatorial retina. Combined PPV and SB procedures were typically reserved for more advanced cases, especially those with PVR grade C associated with retinal foreshortening and inferior retinal pathology [26–28].

Vitrectomy

A standardized chandelier-assisted 23-gauge three-port PPV was performed under sub-Tenon anesthesia using 10 mL of ropivacaine [29]. In phakic patients older than 50 years, combined phacoemulsification with implantation of an aspheric intraocular lens was routinely carried out. Following core vitrectomy, triamcinolone acetonide (Tricanort 40 Injection, 40 mg/mL; American Remedies) was injected to visualize posterior vitreous detachment. Retinal stabilization was achieved using perfluorodecalin (Alchimia HPF10; Moria, Italy) or perfluoro-n-octane (Alchimia HPF8; Moria, Italy), and vitreous base shaving was performed under scleral indentation using a metal depressor. After fluid-air exchange, subretinal fluid was drained through the retinal breaks to achieve retinal reattachment. Endolaser photocoagulation was applied around all retinal breaks; in cases with multiple, large, or undetectable breaks, 360° circumferential laser retinopexy was performed.

The choice of intraocular tamponade was based on intraoperative findings and surgeon preference and included 20% sulfur hexafluoride gas (SF_6 20%; Micro-Gas SF6 Mixed, Micromed Srl, Rome, Italy) or silicone oil (SO), including Densiron Xtra (Fluoron; Geuder, Germany), Siluron 5000 (Fluoron; Geuder, Germany), or Oxane 1300 (Bausch & Lomb; Toulouse, France). SO tamponade was preferentially used in eyes with multiple retinal breaks involving different quadrants or in the presence of PVR. Sclerotomies were routinely closed with 8 – 0 Vicryl sutures. At the conclusion of surgery, a subconjunctival injection of 2 mg dexamethasone and 1 mg gentamicin was administered. Postoperative positioning was tailored according to the location of the retinal breaks. Patients were prescribed a fixed combination of topical corticosteroids and antibiotics for one month postoperatively.

In cases of re-RD, particularly in the presence of epiretinal PVR, membrane staining with brilliant blue (Membrane Blue Dual; DORC, Zuidland, The Netherlands) was followed by membrane peeling, with routine peeling of

Table 1 Univariate analysis of demographic, clinical and ocular variables associated with RRD Recurrence

Variable, *n* (%)	Recurrence group (*n* = 44 eyes)	Reattachment group (*n* = 165 eyes)	*p* value
Sex			0.588
Male	32 (72.7)	113 (68.5)	
Female	12 (27.3)	52 (31.5)	
Age, mean ± SD	62.8 ± 12.9	61 ± 13.2	0.430
Hypertension	25 (56.8)	52 (31.5)	**0.002**
Smoking	5 (11.4)	9 (5.5)	0.173
Dyslipidemia	12 (27.3)	32 (19.4)	0.257
Diabetes	6 (13.6)	17 (10.3)	0.531
Preoperative glaucoma	9 (20.5)	11 (6.7)	**0.009**
Previous surgery	16 (36.4)	57 (34.5)	0.822
Lens status			0.576
Phakic	30 (68.2)	105 (63.6)	
Pseudophakic	14 (31.8)	60 (36.4)	
High myopia	21 (47.7)	37 (22.4)	**0.008**

Table 2 Univariate analysis of anatomical features at presentation associated with RRD Recurrence

Variable, *n* (%)	Recurrence group (*n* = 44 eyes)	Reattachment group (*n* = 165 eyes)	*p* value
Laterality			0.411
Right eye	26 (59.1)	86 (52.1)	
Left eye	18 (40.9)	79 (47.9)	
Type of RRD			0.747
Superior-based RRD	25 (56.8)	101 (61.2)	
Inferior-based RRD	14 (31.8)	49 (29.7)	
Sub-total RRD	2 (4.5)	11 (6.7)	
Total RRD	3 (6.8)	4 (2.4)	
Quadrants of RRD, mean ± SD	1.90 ± 0.86	1.63 ± 0.69	**0.033**
Number of tears			0.788
Single	19 (43.2)	75 (45.5)	
Multiple	25 (56.8)	90 (54.5)	
Location of largest tear			0.666
Superotemporal	21 (47.7)	93 (56.4)	
Superonasal	7 (15.9)	25 (15.2)	
Inferotemporal	12 (27.3)	33 (20.0)	
Inferonasal	4 (9.1)	14 (8.5)	
Giant tear	3 (6.8)	13 (7.9)	0.814
PVR	14 (31.8)	16 (9.7)	**< 0.001**
Macular status			0.469
On	15 (34.1)	70 (42.4)	
Off	29 (65.9)	95 (57.6)	
Vitreous hemorrhage	4 (9.1)	15 (9.1)	1.000
Macular hole	2 (4.5)	3 (1.8)	0.309

the inner limiting membrane at the posterior pole. Subretinal dendritic PVR membranes were removed through retinectomy by flipping the retina from the outside in and using end-grasping or serrated forceps. In cases of re-RD secondary to anterior PVR, either peripheral retinectomy [30] or placement of a silicone encircling band was performed.

Episcleral approach

After sub-Tenon anesthesia with 10 mL of ropivacaine and completion of a 360° conjunctival peritomy, the four rectus muscles were isolated. A silicone band (4 mm x 1.25 mm) was positioned 12 mm posterior to the limbus in emmetropic eyes and 12.5 mm posterior to the limbus in myopic eyes. Cryoretinopexy was then performed to seal the retinal breaks, and external drainage of subretinal fluid was carried out when indicated.

Statistical analysis

The collected data were entered into a spreadsheet and analysed using IBM SPSS Statistics for Windows, version 29 (Armonk, NY, USA). Nominal variables were expressed as frequencies and percentages, while continuous variables were presented as means ± standard deviations (SD) or medians, as appropriate. Data normality was assessed using the Kolmogorov-Smirnov test. Comparisons of baseline characteristics between cases with and without recurrence were performed using independent Student's t-tests, Mann-Whitney rank-sum tests, Fisher's exact tests, or χ^2 tests, as appropriate. Binary logistic regression analyses were used to identify potential risk factors associated with recurrence. Multivariable logistic regression models were applied to determine independent risk factors for re-RD while controlling for potential confounding variables; separate domain-specific models were initially constructed using variables significant in univariate analyses, followed by a final model including variables that remained significant in these intermediate analyses, excluding surgeon due to the limited number of recurrence events relative to the number of surgeons. Results were reported as odds ratios (OR) with 95% confidence intervals (CI), and a p-value < 0.05 was considered statistically significant.

Results

Study population and baseline characteristics

A total of 209 eyes from 209 patients were included in the present study, with a mean age of 61.4 ± 13 years (range, 20-87). Detailed baseline demographic and clinical characteristics of the study population are shown in Tables 1 and 2. The mean interval between symptom onset and surgery was 6.7 ± 10.3 days (median, 3; range, 0-61 days). Initial repair consisted of PPV in 162 (77.5%) eyes, SB in 26 (12.4%) eyes, and combined PPV with SB in 21 (10.1%) eyes (Table 3). In eyes undergoing PPV, silicone oil (SO) was the most commonly used retinal tamponade, being employed in 102 eyes (63%), with a mean duration of

Table 3 Univariate analysis of intraoperative characteristics considered during primary RD surgery and associated with RRD recurrence

Variable, *n* (%)	Recurrence group (*n* = 44 eyes)	Reattachment group (*n* = 165 eyes)	*p* value
Surgical technique			0.337
PPV	30 (68.2)	132 (80)	
SB	10 (22.7)	16 (9.7)	
PPV + SB	4 (9.1)	17 (10.3)	
Phacoemulsification			0.660
No	26 (59.1)	102 (61.8)	
yes	18 (40.9)	63 (38.2)	
Tamponade in PPV			0.813
SF6 20%	11/30 (36.7)	49/132 (37.1)	
Oil	19/30 (63.3)	83/132 (62.9)	
Tamponade in PPV + SB			0.768
SF6 20%	1/4 (25)	7/17 (41.2)	
Oil	3/4 (75)	10/17 (58.8)	
Pattern of endo-laser			0.932
Focal	39 (88.6)	147 (89.1)	
360°	5 (11.4)	18 (10.9)	
Surgeon			**0.002**

tamponade of 150 ± 49 days (median, 148; range, 43-310 days), whereas 60 eyes (37%) received gas tamponade.

Incidence of recurrence

The total rate of primary recurrence after surgery observed in our cohort was 21.1% (*n* = 44 eyes). Among these, 14 (31.8%) patients experienced re-RD while the retina was still supported by SO. The mean interval between initial RRD surgery and recurrence was 2.7 ± 4.2 months (range, 0.5-19.3 months). 23 (52.3%) eyes experienced early recurrence in the first 6 weeks after performing surgery; while 21 (47.7%) eyes developed late recurrence. Early recurrences occurred after a mean interval of 27 ± 0.9 days, whereas late recurrences developed after a mean interval of 183 ± 146.2 days. All eyes had a minimum follow-up of 12 months, with a mean follow-up duration of 18.7 ± 12.3 months.

Risk factors for recurrence

Regarding demographic, clinical and ocular characteristics, univariate analysis revealed statistically significant associations with RRD recurrence for the following variables: hypertension ($p = 0.002$), presence of preoperative glaucoma ($p = 0.009$), and high myopia ($p = 0.008$) (Table 1). In contrast, no significant associations with re-RD were found for sex, age, smoking status, dyslipidemia, diabetes, previous surgery, or lens status. Therefore, these variables were excluded from multivariate analysis.

A multivariate logistic regression analysis was performed to evaluate the association between recurrence rate and demographic, clinical and ocular characteristics. The analysis revealed that high myopia (OR: 5.916; 95% CI, 2.069-16.915; $p < 0.001$), systemic hypertension (OR: 3.031; 95% CI, 1.088-8.445; $p = 0.034$), and preoperative glaucoma (OR: 4.021; 95% CI, 1.098-14.724; $p = 0.036$) were significant predictors of re-RD in our cohort. The overall model was statistically significant ($p = 0.003$), with a Nagelkerke determination coefficient of $R^2 = 0.254$.

Table 4 Multivariate logistic regression analysis of risk factors for RRD recurrence

Variable	OR (95% CI)	*p*-value
High myopia	4.25 (1.730-11.515)	0.002
Hypertension	2.72 (1.105–6.755)	0.031
Glaucoma	4.08 (1.455–16.522)	0.014
PVR	4.68 (1.683–13.642)	0.006

Regarding the anatomical features of RRD at presentation, univariate analysis showed a statistically significant association between RRD recurrence and the number of quadrants involved ($p = 0.033$) as well as the presence of PVR (grade B or higher) ($p < 0.001$) (Table 2).

Conversely, re-RD showed no significant association with laterality, RRD location, number of retinal tears, quadrant of the main tear, presence of giant retinal tears, macular status, vitreous hemorrhage, or presence of a macular hole. However, multivariable logistic regression analysis revealed that only the presence of PVR (OR, 3.494; 95% CI, 1.484-8.225; $p = 0.004$) was a significant predictor of re-RD.

Although the recurrence group had a longer mean interval from symptom onset to surgery (8.39 ± 11 days) than the reattachment group (6.28 ± 10 days), this difference was not statistically significant.

Regarding intraoperative factors, the distribution of recurrence differed significantly among surgeons ($p = 0.002$) (Table 3). Other intraoperative variables, including surgical technique, type of endotamponade and pattern of laser retinopexy, showed no significant association with re-RD.

The variables identified as significant predictors in the previous multivariable analyses were subsequently included in a final multivariable logistic regression model. Due to the limited number of recurrence events, the surgeon variable was excluded from the final model. The final multivariable model assessing factors associated with recurrence risk, including the presence of PVR, high myopia, pre-existing glaucoma, and systemic hypertension, was statistically significant ($p < 0.001$) and demonstrated moderate explanatory power (Nagelkerke $R^2 = 0.292$). The detailed findings of the multivariate logistic regression analysis are shown in Table 4.

Among the variables included in the multivariable model, PVR was associated with the highest risk of postoperative recurrence, conferring an almost fivefold

increase in the likelihood of re-RD (OR: 4.68). High myopia was also strongly associated with recurrence, increasing the risk more than fourfold (OR: 4.25), while pre-existing glaucoma was associated with a similar increase in risk (OR: 4.08). Systemic hypertension was independently associated with recurrence, increasing the likelihood by nearly threefold (OR: 2.72).

Functional outcomes

Preoperative BCVA was comparable between the recurrence and reattachment groups (0.97 ± 0.89 vs. 1.11 ± 0.98 logMAR; U = 3623.000; $p = 0.765$), whereas at final follow-up, visual acuity was significantly worse in the recurrence group (0.83 ± 0.78 vs. 0.34 ± 0.47 logMAR; U = 4511.000; $p < 0.001$). Patients with preoperative PVR had significantly worse baseline BCVA than those without PVR (1.34 ± 0.96 vs. 0.94 ± 0.89 logMAR; $p = 0.018$) and continued to exhibit poorer visual outcomes at final follow-up (0.99 ± 0.83 vs. 0.36 ± 0.49 logMAR; $p < 0.001$).

Patients who developed postoperative PVR ($n = 42$; 26 eyes in the recurrence group and 16 eyes in the reattachment group) did not differ in baseline BCVA from eyes that did not develop postoperative PVR ($n = 167$) (1.27 ± 0.99 vs. 0.93 ± 0.88 logMAR; $p = 0.095$). However, eyes with postoperative PVR showed significantly worse BCVA at final follow-up compared with those without postoperative PVR (0.89 ± 0.76 vs. 0.34 ± 0.48 logMAR; $p < 0.001$).

Anatomical outcomes

Overall, retinal reattachment was achieved in 205 (98.1%) eyes at final follow-up. Final anatomical outcomes differed significantly between groups, with retinal attachment observed in 40 of 44 eyes (90.9%) in the recurrence group versus 165 of 165 eyes (100%) in the reattachment group ($\chi^2 = 15.293$, $p < 0.001$). When considering the detailed anatomical status at final follow-up, 30 (68.2%) eyes in the recurrence group were attached, 10 (22.7%) were attached under SO, and 4 (9.1%) remained detached under SO, compared with 162 (98.2%), 3 (1.8%), and 0 (0%), respectively, in the reattachment group ($\chi^2 = 42.819$, $p < 0.001$).

Overall, CME was present in 50 (23.9%) of eyes. Eyes in the recurrence group demonstrated a higher rate of CME ($n = 17$, 38.6%) than those in the reattachment group ($n = 33$, 20.0%) ($\chi^2 = 6.629$, $p = 0.010$).

Characteristics of the recurrence group

Among the eyes that experienced recurrence, 33 (75%) eyes had a single re-RD, 10 (22.7%) experienced a second redetachment, and 1 (2.3%) had three recurrences. Eyes with multiple recurrences demonstrated worse visual acuity at final follow-up compared with those experiencing a single recurrence (1.00 ± 0.73 vs. 0.76 ± 0.79 logMAR), although this difference did not reach statistical significance (U = 219.000, $p = 0.172$). CME was significantly associated with the number of recurrences ($\chi^2 = 3.866$, $p = 0.049$), occurring more frequently in eyes with multiple recurrences ($n = 11$; 7 eyes with CME, 63.6%) than in those with a single recurrence ($n = 33$; 10 eyes with CME, 30.3%).

Discussion

The primary objectives of this retrospective real-world study were to determine the incidence of re-RD in our cohort and to identify ocular and systemic predictors associated with re-RD. Previous studies have reported rates of re-RD ranging from 21% to 29% [3–7]. In our research, the incidence of re-RD was 21.1%, which is consistent with the rates previously described in the literature. Most recurrences clustered in the early postoperative period, consistent with previous studies [7, 12, 31].

This study demonstrates that the main factors associated with re-RD include PVR, high myopia, pre-existing glaucoma, and systemic hypertension. The final multivariable model showed moderate explanatory power (Nagelkerke $R^2 = 0.292$). Among these, PVR emerged as the strongest independent predictor of re-RD, in agreement with previous reports and further supporting its central role in the pathogenesis of re-RD through the reopening of existing retinal breaks and the formation of new ones [8, 10–12, 32, 33].

Pathological myopia was also independently associated with re-RD, consistent with previous studies [4, 7, 34–36]. In highly myopic eyes, particularly in the presence of posterior staphyloma, complete induction of posterior vitreous detachment during surgery may be technically challenging because of stronger vitreoretinal adhesions and posterior displacement of the vitreous base [37]. Furthermore, vitreoschisis may act as a scaffold for cellular proliferation, thereby facilitating PVR development and increasing the risk of re-RD.

Interestingly, to our knowledge, this is the first study to identify pre-existing glaucoma as a risk factor for re-RD. A possible explanation for this association lies in the chronic inflammatory and neurovascular alterations that characterize glaucoma. These changes have been linked to endothelial dysfunction, microglial activation, and persistent inflammatory signalling, all of which may contribute to a pro-fibrotic intraocular environment. In particular, glaucoma has been associated with increased oxidative stress, activation of nuclear factor κB (NF-κB), and upregulation of several growth factors, cytokines, and chemokines, including transforming growth factor-α and -β (TGF-α, TGF-β), tumor necrosis factor-α (TNF-α), and interleukins 1, 1β, 6, and 8. In addition, dysregulation of extracellular matrix components such

as interstitial collagen, laminin, fibronectin, and matrix metalloproteinases (MMPs) have also been described [38]. Collectively, these mechanisms may increase susceptibility to PVR and, consequently, to re-RD. Further investigations are needed to better elucidate the pathophysiological pathways underlying this association.

Another noteworthy finding was the association between systemic hypertension and re-RD, which is in line with observations reported by Oncel et al. and Gao et al. [16, 39]. This relationship may also be mediated by oxidative stress and chronic inflammatory pathways. Excessive production of reactive oxygen species, endothelial dysfunction, and microvascular damage may collectively promote retinal fibrosis and PVR formation, ultimately predisposing patients to re-RD [16, 39–41].

In our study, a greater baseline extent of RRD was associated with an increased risk of re-RD on univariate analysis, likely reflecting greater surgical complexity and a higher propensity for PVR development. However, this association was not confirmed in the multivariate analysis, where the number of detached quadrants was no longer independently associated with recurrence risk, in contrast to the findings reported by Felfeli et al. [14].

Previous studies have also identified longer RRD duration as a potential risk factor for recurrence, presumably because chronic RRD may promote PVR formation [42]. Although patients in the recurrence group in our cohort showed a trend toward a longer interval between symptom onset and surgery, this association did not reach statistical significance. These findings suggest that time to surgery alone may not represent a decisive determinant of recurrence risk.

In contrast to the study by Cicinelli et al., which identified 360-degree prophylactic laser retinopexy as a protective factor against re-RD, our study did not demonstrate a significant association [13]. This result supports a lesion-directed surgical strategy and highlights the importance of avoiding overtreatment, consistent with other reports in the literature [6, 43, 44].

Similarly, SB and PPV achieved comparable anatomical outcomes in our cohort, challenging the historical perception of SB inferiority and underscoring the importance of appropriate case selection [7, 45, 46].

Finally, several factors previously reported as potential predictors of recurrence, including age, sex, smoking status, lens status, number, location, and size of retinal breaks, RRD location, macular involvement, and type of tamponade, were not independently associated with re-RD in our analysis [4, 5, 8, 13, 47].

Regarding functional outcomes, re-RD was associated with significantly poorer visual outcomes, likely reflecting cumulative retinal structural damage, prolonged macular detachment, and a higher prevalence of PVR in these cases [12, 22, 48]. In addition, the presence of grade B or C PVR at presentation was associated with a worse visual prognosis, consistent with the findings of Yorston et al. [49].

Final anatomical success was achieved in 98.1% of cases, placing our results within the upper range of outcomes previously reported in the literature [6]. Nevertheless, persistent RRD was observed in 9% of recurrent cases, consistent with prior series and underscoring the complexity of managing re-RD [12]. Long-term SO tamponade was selectively maintained in 22.7% of recurrent eyes with limited visual potential, a proportion lower than that reported in some earlier studies [48]. Furthermore, CME occurred more frequently in recurrent cases, in agreement with previous reports [13, 23–25].

In our cohort, eyes with multiple recurrences tended to have poorer visual acuity outcomes, consistent with the findings reported by Enders et al. and Stenz et al. [48, 50].

This study has several limitations. Its retrospective design may be subject to selection bias and unmeasured confounding. The single-center setting may limit the generalizability of the findings. In addition, the limited sample size and number of recurrence events may have reduced the robustness of multivariable analyses, resulting in relatively wide confidence intervals for some estimates, and precluded reliable assessment of surgeon-specific effects, factors associated with early versus late recurrence, and predictors of multiple recurrences. Additionally, potential selection bias in the allocation of cases to different surgeons may have influenced surgical outcomes. Furthermore, functional outcomes beyond visual acuity, such as metamorphopsia, were not assessed. Future prospective, multicenter studies with standardized protocols and comprehensive functional evaluations are warranted to validate and extend these findings.

Conclusion

In conclusion, re-RD remains a relevant clinical challenge, affecting approximately one-fifth of patients. Our findings confirm PVR and pathological myopia as major risk factors for recurrence and suggest that glaucoma and systemic hypertension may represent additional potential risk factors associated with an increased risk of re-RD. As most recurrences occurred early, intensified early postoperative surveillance may be beneficial, while prolonged follow-up should also be maintained given the possibility of late recurrences. Given that many of the identified risk factors are not directly modifiable, improved risk stratification may support individualized surgical planning, facilitate patient counseling and prognostic assessment, improve patient education regarding symptoms suggestive of recurrence, and optimize postoperative surveillance. Further studies are warranted to confirm the role of glaucoma and systemic hypertension in re-RD and to

clarify the mechanisms through which these conditions may contribute to disease recurrence.

Abbreviations

RRD	Rhegmatogenous retinal detachment
PVR	Proliferative vitreoretinopathy
CME	Cystoid macular edema
re-RD	Recurrent retinal detachment
PPV	Pars Plana vitrectomy
SB	Scleral buckling
OCT	Optical coherence tomography
SO	Silicone oil
BCVA	Best-corrected visual acuity
SD	standard deviation
OR	Odds ratio
CI	Confidence intervals

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Author contributions
Conception and design: CV, MM; acquisition of the data: CV, MP, PMT, GGA, CEG, FP; analysis and interpretation of the data: CV, PF, MM; drafting of the manuscript: CV; critical review of the manuscript: all the authors; final approval of the manuscript: all the authors.

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Data availability
The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The study was approved by the Ethics Committee of Area Vasta Emilia Centro (CE-AVEC), the Ethics Committee responsible for Arcispedale Sant'Anna Azienda Ospedaliero-Universitaria di Ferrara (Teaching Hospital of Ferrara), Italy (approval code: 559/2025/Oss/AOUFe). The study was conducted in accordance with the principles of the Declaration of Helsinki, and written informed consent was obtained from all participants in accordance with the requirements of CE-AVEC.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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