A Model for Prediction of Rhegmatogenous Retinal Re-Detachment After Primary *Pars Plana* Vitrectomy

Um Modelo Preditor de Re-Descolamento de Retina Regmatogéneo Após Vitrectomia Via *Pars Plana* Primária

Bruno Barbosa Ribeiro [1], João Heitor Marques [2,1], Ana Sofia Martins [1], Daniela Pires [1], Gabriel Santos [1], João Miguel Coelho [1], Angelina Meireles [1,2]

[1] Serviço de Oftalmologia, Centro Hospitalar Universitário de Santo António - Unidade Local de Saúde Santo António, Porto, Portugal
[2] Instituto de Ciências Biomédicas Abel Salazar, Universidade do Porto, Porto, Portugal

Recebido/Received: 2024-10-12 | **Aceite/Accepted:** 2025-03-20 | **Published online/Publicado online:** 2025-06-04

DOI: https://doi.org/10.48560/rspo.38166

ABSTRACT

INTRODUCTION: Rhegmatogenous retinal detachment (RRD) is the most common form of retinal detachment and a frequent cause of vision loss. However, re-detachment is still a significant cause of morbidity. This study aims to identify risk factors and develop a prediction model for RD re-detachment after primary *pars plana* vitrectomy (PPV).

METHODS: Retrospective analysis of clinical data of RRD undergoing primary 23-gauge (G) PPV between January 2020 and December 2023 at the Surgical Retina Unit of a tertiary hospital. Demographic and surgical data were collected. The main outcome was surgical failure within six months of surgery. Patients submitted to prior retina surgery, other techniques than PPV or incomplete follow-up were excluded.

RESULTS: We identified 1483 vitreoretinal surgeries. Four-hundred and fifty cases were excluded due to diagnostic mislabeling (83), secondary surgery (309), or surgery other than PPV (58). Four-hundred and sixty-two cases were excluded due to insufficient data, follow-up losses or follow-up at different institutions. The final sample rendered 571 surgeries of 552 patients. Mean age was 68.9 ± 14.4 years, and 36.0% (198) of patients were female. The mean time from symptom onset to PPV was 6.22 ± 17.3 days. Regional analysis revealed delayed diagnosis for patients living further away when compared to the referral center district (12.3 ± 23.4 *vs* 4.8 ± 12.3 days, p=0.023, respectively). A primary anatomical failure occurred in 20.8%. On multivariate analysis, inferior breaks (OR [95%CI]: 2.41 [1.48-4.53], p=0.007), perfluoropropane gas tamponade (OR [95%CI]: 2.09 [1.34-3.27], p=0.001), axial length superior to 26.0 mm (OR [95%CI]: 3.53 [1.41-8.86], p=0.007), choroidal detachment (OR [95%CI]: 4.85 [1.37-17.1], p=0.014), total RD (OR [95%CI]: 2.03 [1.17-3.53], p=0.012) and subretinal fluid drainage through surgically induced retinotomy (OR [95%CI]: 2.37 [1.06-5.32], p=0.036) were associated with increased risk of failure. A prediction model revealed a risk for surgical failure of 16.7% if no risk factors were present (p<0.001) and 66.7% if more than one risk factors were present (p<0.001).

CONCLUSION: Our study provides novel information about the outcomes of RRD after primary 23G PPV. Identification of high-risk features may improve risk stratification and tailored patient counseling and selection.

KEYWORDS: Postoperative Complications; Retinal Detachment; Visual Acuity; Vitrectomy.

RESUMO

INTRODUÇÃO: O descolamento de retina (DR) regmatogéneo (DRR) é o tipo mais comum de DR e uma causa frequente de perda visual. O re-descolamento permanece uma causa importante de morbilidade. O objetivo deste trabalho consiste na identificação de fatores de risco e desenvolvimento de um modelo preditor de re-DR após vitrectomia *via pars plana* (VPP).

MÉTODOS: Análise retrospetiva de dados clínicos de DRR submetidos a VPP 23-gauge (G) entre Janeiro 2020 e Dezembro 2023 na Unidade de Retina Cirúrgica de um hospital terciário. Foram colhidos dados demográficos e cirúrgicos. O objetivo primário foi falência cirúrgica até 6 meses após a cirurgia. Foram excluídos pacientes submetidos a cirurgia vitreoretiniana prévia, outras técnicas que não PPV, ou seguimento incompleto.

RESULTADOS: Foram identificadas 1483 cirurgias vitreo-retinianas. Quatrocentos e cinquenta casos foram excluídos devido a má codificação (83), cirurgia secundária (309), ou outras técnicas cirúrgicas (58). Quatrocentos e sessenta e dois casos foram excluídos devido a dados insuficientes, perdas de seguimento, ou seguimento noutra instituição. A amostra final consistiu em 571 cirurgias de 552 pacientes. A idade média foi 68,9 ± 14,4 anos e 36,0% (198) dos pacientes foram mulheres. O tempo médio entre início de sintomas e PPV foi dias 6,22 ± 17,3 dias. A análise regional revelou um atraso diagnóstico em pacientes geograficamente distantes do centro de referência (12,3 ± 23,4 *vs* 4,8 ± 12,3 dias, p=0,023, respetivamente). A falência anatómica primária ocorreu em 20,8%. A análise multivariável revelou maior risco de falência cirúrgica na presença de rasgaduras retinianas inferiores (OR [95%CI]: 2,41 [1,48-4,53], p=0,007), tamponamento com perfluoropropano (OR [95%CI]: 2,09 [1,34-3,27], p=0,001), comprimento axial superior a 26,0 mm (OR [95%CI]: 3,53 [1,41-8,86], p=0,007), descolamento coroideu (OR [95%CI]: 4,85 [1,37-17,1], p=0,014), DR total (OR [95%CI]: 2,03 [1,17-3,53], p=0,012) e drenagem de fluido subretiniano através de retinotomia cirúrgica (OR [95%CI]: 2,37 [1,06-5,32], p=0,036). O modelo de predição revelou risco de falência cirúrgica de 16,7% na presença de nenhum fator de risco (p<0,001) e de 66,7% na presença de mais que um fator de risco (p<0,001).

CONCLUSÃO: Este estudo fornece informação relevante acerca do prognóstico de DRR após vitrectomia 23G primária. A identificação de características de alto-risco pode melhorar a estratificação de risco e personalizar o aconselhamento e seguimento destes pacientes.

PALAVRAS-CHAVE: Acuidade Visual; Complicações Pós-Operatórias; Descolamento da Retina; Vitrectomia.

INTRODUCTION

Rhegmatogenous retinal retachment (RRD) is the most common form of retinal detachment and an important cause of irreversible vision loss. It occurs when a full-thickness retinal break ensues, allowing fluid egress from the vitreous cavity into the subretinal space.[1]

Novel breakthroughs were made in the twentieth century, when Jules Gonin[2] revolutionized the field with the concept of retinal breaks. Visual prognosis markedly improved, firstly with extraocular surgery (Schepens, 1951)[3] and then with *pars plana* vitrectomy (PPV) by Charles and Machemer.[4,5]

Recent improvements in microsurgical instruments, the development of wide-angle visualization systems, the availability of intraocular gas tamponade, and the use of perfluorocarbon liquids have increased the popularity of PPV.[6] Currently, it is the most used surgical technique by many surgeons in the treatment of RRD.[7]

Although surgical success has increased in the last decades, several risk factors for surgical failure have been described.[8–12,12–14] These include total RD,[9,14,15] inferior breaks,[11,15] choroidal detachment,[14,16] and the use of cryotherapy.[15,17] However, some of these studies include both scleral buckling and PPV,[8,10,14] while others include re-operations.[14]

Given the heterogeneity of current evidence regarding surgical techniques and primary surgery, the purpose of this study was to identify risk factors for surgical failure after primary PPV for the treatment of RRD and to develop a risk model for surgical failure.

METHODS

STUDY DESIGN

We conducted a retrospective chart analysis of all consecutive adult patients submitted to primary 23-gauge (G) PPV for RRD with a recorded outcome between January 2020 and December 2023, at the Surgical Retina Unit of the

Ophthalmology Department of Santo António Local Health Unit, a tertiary Portuguese hospital.

The study was approved by our institutional review board and ethics committee - Departamento de Ensino Formação e Investigação - Unidade Local de Saúde Santo António, (2021.037(029-DEFI/030-CE) and conducted accordingly to the principles of the Declaration of Helsinki for the protection of human subjects in medical research.

PARTICIPANTS AND PROTOCOL

Demographic (including age, gender, and district codification by four-digit Portuguese postcode) data was collected. Preoperative (lens and foveal status, number of retinal breaks, location and type of largest break, number of superior and inferior clock hours detached, presence and grade of proliferative vitreoretinopathy [PVR]); intraoperative (use of laser photocoagulation and/or cryotherapy, type of tamponade used, sub-retinal fluid drainage route); postoperative evaluation (retinal status and time to surgical failure, best-corrected visual acuity [BCVA]), and development of surgical complications (cataract, ocular hypertension, cystoid macular edema, and endophthalmitis) were recorded.

For statistical purposes, "counting fingers" was classified as 0.01, "hand movement" as 0.005 and "light perception" as 0.0005.[18] BCVA was recorded in decimal scale and then converted to a logarithm of the minimum angle of resolution (logMAR) on an Excel spreadsheet.[19]

Patients submitted to prior retina surgery, other techniques than PPV, or incomplete follow-up were excluded. RD secondary to penetrating injury, vasoproliferative disorders, inflammatory eye disease, and pediatric RD were excluded.

OUTCOMES

Surgical failure was defined as surgeon recorded re-detachment, or a record of subsequent RD surgery within six months of primary surgery. For eyes with silicone oil tamponade, failure was defined if recorded re-detachment, or a record of subsequent RD surgery within six months after oil removal.

STATISTICAL ANALYSIS

The probability of failure was studied by multivariate logistic regression. All covariates were evaluated at a univariate level using $\chi 2$ tests. Any covariate with a $p<0.20$ progressed to multivariate modeling, where the full model was fitted, and backward selection was employed. A $p<0.05$ and the area under the receiver operating curve were used for final covariate selection.

Statistical analysis was performed using the SPSS software (SPSS statistics, version 26.0.0 for Mac OS, IBM, Somers, NY). The Kolmogorov-Smirnov test was used to assess normality. Comparison between independent continuous variables was evaluated using the Mann-Whitney U test and the T-Student test. Fisher's exact test was used for nominal scaled data. *P* values less than 0.05 were considered statistically significant.

RESULTS

From the period mentioned above, 1483 vitreoretinal surgeries were identified. Four-hundred and fifty cases were excluded due to diagnosis mislabeling (83), secondary surgery (309), or surgery other than PPV (58). Four-hundred and sixty-two cases were excluded due to insufficient

Table 1. Baseline demographic and ophthalmological data.

Covariate	Total
Demographic data	
Female, n (%)	198 (36.0)
Age, years (mean ± SD)	68.9 ± 14.4
Type of surgery, n(%)	
PPV	548 (96.0)
Combined phaco/PPV	23 (4.0)
Lens status	
Phakia	275 (49.2)
Pseudophakia	273 (48.8)
Aphakia	11 (2.0)
Fovea ON, n (%)	114 (20.3)
Choroidal detachment, n (%)	12 (2.2)
Single break, n (%)	275 (49.5)
Location of largest break	
9-3 o'clock	416 (85.4)
4 or 8 o'clock	17 (3.5)
5-7 o'clock	54 (11.1)
Superior clock hours detached	
<3 h	68 (17.8)
3 to 5 h	113 (29.5)
6 h	208 (52.8)
Inferior clock hours detached	
<3 h	148 (39.1)
3 to 5 h	76 (20.0)
6 h	155 (40.9)
Total RD, n (%)	87 (15.6)
Giant retinal tear, n (%)	11 (2.0)
PVR, n (%)	87 (14.6)
Laser photocoagulation used during surgery	326 (57.5)
Cryotherapy used during surgery	318 (56.1)
Laser photocoagulation and cryotherapy used during surgery	97 (17.1)
Intraoperative tamponade	
Sulphur hexafluoride gas	215 (38.1)
Perfluoropropane gas	226 (40.0)
Air	10 (1.8)
Silicone oil	114 (20.2)
Sub-retinal fluid drainage via surgically induced retinotomy	35 (6.3)
Comorbidities	
High myopia	68 (12.3)
Glaucoma	19 (3.4)
AMD	8 (1.5)
Postoperative complications	
Ocular hypertension	35 (6.6)
Hypotony	3 (0.6)
Cataract	115 (27.3)
Traumatic cataract	30 (5.6)
Cystoid macular edema	13 (4.8)

PVR, proliferative vitreoretinopathy; AMD, age-related macular degeneration; High myopia: subjective refraction spherical equivalent ≥ -6.0 diopters and/or axial length ≥ 26.0 mm;

data, follow-up losses or follow-up at different institutions. The final sample rendered 571 surgeries of 552 patients.

Mean age at surgery was 68.9 ± 14.4 years, and 198 (36.0%) patients were female. Two-hundred and eighty-four (50.8%) patients had undergone previous cataract surgery, and 11 (2.0%) were aphakic. Most patients presented with fovea off RD (67.2%) and underwent PPV alone (96.0%).

Most detachments (60.9%) presented with more than one detached inferior quadrant, and the largest tear was located between 9 and 3 o'clock in 416 (85.4%). Eighty-seven (15.6%) patients presented with total RD.

There were no significant baseline differences regarding preoperative BCVA (p=0.867), foveal status (p=0.985), or time to diagnosis (p=0.993). Eyes with primary failure had higher axial length (25.40 ± 2.37 *vs* 23.46 ± 0.61 mm, respectively, p<0.001). Full demographic and ophthalmological data are shown in Table 1.

Primary anatomical failure occurred in 20.8% (n=119) of surgeries. Table 2 shows univariate analysis for surgical failure.

Variables associated with increased risk of surgical failure were: age above 80 years old (OR [95%CI]: 1.54 [1.01-2.34], p=0.046); presence of choroidal detachment (OR [95%CI]: 3.86 [1.22-12.2], p=0.022); inferior breaks (OR [95%CI]: 2.72 [1.51-4.91], p<0.001); intraoperative cryotherapy (OR [95%CI]: 1.69 [1.07-2.67], p=0.026); total RD (OR [95%CI]: 1.90 [1.14-3.15], p=0.014); perfluoropropane tamponade (OR [95%CI]: 1.83 [1.21-2.75], p=0.004); and axial length superior to 26 mm (OR [95%CI]: 2.38 [1.02-5.59], p=0.046).

Tamponade with sulphur hexafluoride (OR [95%CI]: 0.44 [0.27-0.69], p<0.001) and intraoperative laser photocoagulation (OR [95%CI]: 0.57 [0.36-0.90], p=0.015) played a protective role regarding surgical success. Fig. 1 shows the

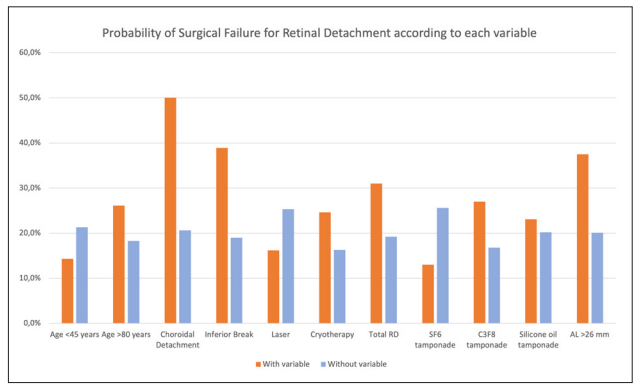

Figure 1. Probability of Surgical Failure for Retinal Detachment according to each variable.

Table 2. Frequencies of consultation reasons, records with visual acuity and with suggested diagnosis by the general practitioner.

	Failure, % (n)		OR [95% CI]	*p* value
	With variable	Without variable		
Age <45	14.3 (5)	21.3 (114)	0.62 [0.23-1.63]	0.329
Age >80	26.1 (48)	18.3 (71)	1.54 [1.01-2.34]	**0.043**
Countryside	22.7 (41)	20.0 (78)	0.85 [0.56-1.31]	0.468
Phakia	19.6 (54)	22.0 (65)	1.15 [0.77-1.73]	0.495
Pseudophakia	20.9 (57)	20.8 (62)	0.99 [0.67-1.49]	0.983
Fovea ON	21.1 (24)	20.8 (95)	0.98 [0.60-1.63]	0.950
Choroidal detachment	50.0 (6)	20.6 (110)	3.86 [1.22-12.2]	**0.022**
PVR	23.5 (24)	20.3 (95)	0.83 [0.50-1.38]	0.461
Single tear	22.5 (62)	19.3 (57)	1.22 [0.82-1.83]	0.334
>1 tear	20.1 (48)	21.4 (71)	0.92 [0.61-1.39]	0.706
>2 tears	23.9 (27)	20.1 (92)	0.80 [0.49-1.31]	0.373
Inferior break	38.9 (21)	19.0 (98)	2.72 [1.51-4.91]	**<0.001**
Giant tear	27.3 (3)	20.7 (116)	1.44 [0.38-5.50]	0.598
Retinotomy	31.4 (11)	20.1 (108)	1.79 [0.85-3.76]	0.127
Laser*	16.2 (39)	25.3 (58)	0.57 [0.36-0.90]	**0.015**
Cryotherapy*	24.6 (61)	16.3 (36)	1.69 [1.07-2.67]	**0.026**
>1 superior quadrant	20.9 (105)	20.6 (14)	0.98 [0.53-1.84]	0.956
>1 inferior quadrant	22.4 (95)	16.4 (24)	1.46 [0.89-2.40]	0.131
Total RD	31.0 (27)	19.2 (90)	1.90 [1.14-3.15]	**0.014**
Tamponade				
SF6	13.0 (28)	25.6 (91)	0.44 [0.27-0.69]	**<0.001**
C3F8	27.0 (61)	16.8 (58)	1.83 [1.21-2.75]	**0.004**
Silicone oil	23.1 (30)	20.2 (89)	1.45 [0.92-2.38]	0.109
AL >26 mm	37.5 (9)	20.1 (110)	2.38 [1.02-5.59]	**0.046**

OR, odds ratio; CI, confidence interval; PVR, proliferative vitreoretinopathy; RD, retinal detachment; SF6, sulfur hexafluoride; C3F8, perfluoropropane; values in bold indicate *p* value <0.05;

* univariate analysis was performed after the exclusion of patients who underwent simultaneous intraoperative laser photocoagulation and retinal cryopexy;

probability of surgical failure according to each covariable.

Table 3 shows a multivariate analysis for surgical failure. The final best fitting model included perfluoropropane gas tamponade (OR [95%CI]: 2.09 [1.34-3.27], *p*=0.001), inferior breaks (OR [95%CI]: 2.41 [1.28-4.53], *p*=0.007), axial length >26 mm (OR [95%CI]: 3.53 [1.41-8.86], *p*=0.007), presence of choroidal detachment (OR [95%CI]: 4.85 [1.17-17.1], *p*=0.014), total RD (OR [95%CI]: 2.03 [1.17-3.53], *p*=0.012), and subretinal fluid drainage through a surgically induced retinotomy (OR [95%CI]: 2.37 [1.06-5.32], *p*=0.036).

Table 3. Multivariate analysis.

	OR	95% CI	*p* value
Perfluoropropane (C3F8) gas tamponade	2.09	1.34-3.27	**0.001**
Inferior break	2.41	1.28-4.53	**0.007**
Axial length > 26 mm	3.53	1.41-8.86	**0.007**
Choroidal detachment	4.85	1.37-17.1	**0.014**
Total RD	2.03	1.17-3.53	**0.012**
Subretinal fluid drainage through surgically induced retinotomy	2.37	1.06-5.32	**0.036**

RD, retinal detachment; OR, odds ratio; CI, confidence interval; Multivariate analysis included variables with *p*<0.20 in the univariate analysis; Numbers in bold indicate *p* value <0.05;

The final model had an area under the curve (AUC) of 66.9% [95% CI 0.612-0.726] and the Pearson Chi-squared goodness of fit test produced a *p* value of 0.267. Fig. 2 depicts the receiver operating curve for the multivariate analysis.

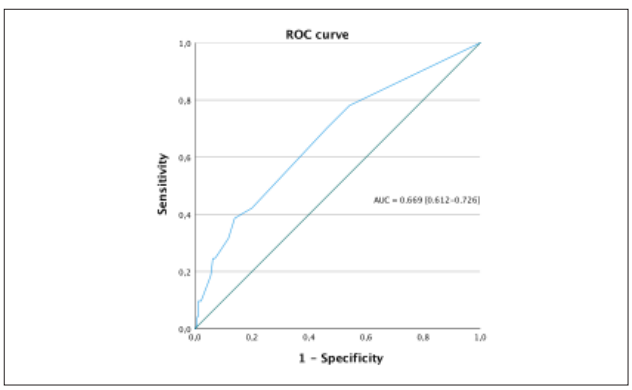

Figure 2. Receiver operating curve for the multivariate analysis.

Table 4 demonstrates the risk of surgical failure after risk stratification. From the covariates included in the final model, the presence of no risk factors yields a probability of success of 83.7%, which is reduced to 70.3% if one risk factor is present, and to 33.3% if more than one risk factors are present. Intraoperative risk factors (C3F8 tamponade and subretinal fluid drainage through a surgically induced retinotomy) can be seen as additional risk factors ("plus disease") and carry a worse prognosis.

Eyes with total RD exhibited longer time from symptoms to surgery (13.6 ± 30.9 *vs* 4.9 ± 13.1 days, respectively, *p*<0.001) and worse final BCVA (1.19 ± 0.72 *vs* 0.64 ± 0.72 logMAR, respectively, *p*<0.001). Fig. 3 demonstrates the relation between final visual acuity and total RD.

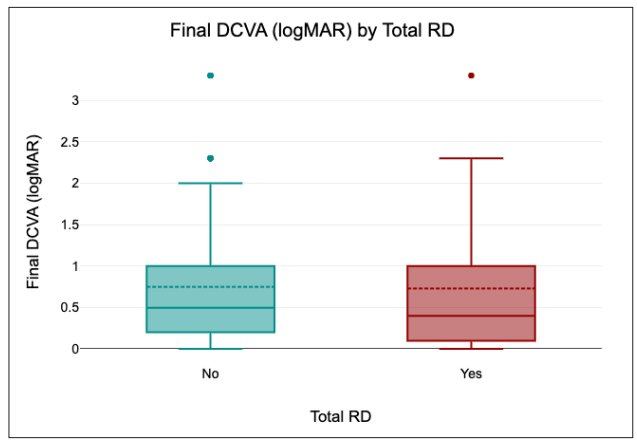

Figure 3. Box plot exhibiting the relation between final VA and presence of total RD.

Our analysis revealed worse final BCVA in the presence of choroidal detachment (1.84 ± 0.93 *vs* 0.73 ± 0.77 logMAR, respectively, *p*=0.001), perfluoropropane tamponade (0.80 ± 0.83 *vs* 0.66 ± 0.70 logMAR, respectively, *p*=0.043), silicone oil tamponade (1.41 ± 0.92 *vs* 0.55 ± 0.62 logMAR, respectively, *p*<0.001), age below 45 years (1.07 ± 0.97 *vs* 0.73 ± 0.76 logMAR, respectively, *p*=0.029) and above 80 years old (0.92 ± 0.83 *vs* 0.67 ± 0.75 logMAR, respectively, *p*<0.001), presence of PVR (1.03 ± 0.79 *vs* 0.69 ± 0.77 logMAR, respectively, *p*<0.001) and intraoperative laser photocoagulation (0.90 ± 0.82 *vs* 0.67 ± 0.75 logMAR, respectively, *p*=0.004).

Table 5 displays the regional stratification of surgical failure. District analysis revealed delayed diagnosis for patients living further from the referral center district (mean time from symptoms to diagnosis of 12.3 ± 23.4 *vs* 4.8 ± 12.3 days, respectively, *p*=0.023) and worse final BCVA (0.95 ± 0.78 *vs* 0.64 ± 0.80 logMAR, *p*=0.020, respectively). There was no significant delay in the surgical schedule (mean time from

Table 4. Multivariate analysis.

Score	Surgical success, n(%)	Surgical failure, n(%)	*p* value	*p* value (comparing with score 0)	"Plus"
Low-risk (n=418)	350 (83.7)	68 (16.3)	<0.001	-	38 (23.2), p=0.002 (n=164)
Medium-risk (n=138)	97 (70.3)	41 (29.7)	0.003	<0.001	22 (35.5), p=0.181 (n=62)
High risk (n=15)	5 (33.3)	10 (66.7)	<0.001	<0.001	-

Risk factors include inferior breaks, AL > 26 mm, choroidal detachment, total RD; Low-risk: no risk factors; Medium-risk: 1 risk factor; High-risk: >1 risk factors); "Plus" disease was considered if C3F8 tamponade OR retinotomy were applied;

Table 5. Surgical failure by district.

District	Failure, n (%)	*p* value	Final DCVA (logMAR)	*p* value	Time symptoms-surgery	*p* value	Time diagnosis-surgery	*p* value
Porto	34 (22.1)	-	0.64 ± 0.80	-	4.8 ± 12.3	-	3.3 ± 7.0	-
Braga	11 (14.3)	0.110[1]	0.55 ± 0.69	0.409[1]	8.3 ± 30.0	0.340[1]	1.77 ± 2.2	**0.014**[1]
Viana do Castelo	8 (19.0)	0.667[1]	0.58 ± 1.31	0.770[1]	8.3 ± 16.0	0.212[1]	1.95 ± 3.3	0.230[1]
Vila Real	26 (20.5)	0.745[1]	0.79 ± 0.76	0.145[1]	6.2 ± 14.3	0.406[1]	2.4 ± 6.1	0.221[1]
Bragança	**15 (27.8)**	0.398[1]	0.95 ± 0.78	**0.020**[1]	12.3 ± 23.4	**0.032**[1]	4.6 ± 9.1	0.266[1]
Açores	10 (13.5)	0.059[1]	0.93 ± 0.89	0.060[1]	3.3 ± 8.1	0.336[1]	2.1 ± 5.4	0.195[1]

p values are compared with reference district (Porto); 1-Independent Samples T-test; DCVA, distance corrected visual acuity; logMAR, logarithm of the minimum angle of resolution;

diagnosis to surgery day of 4.6 ± 9.1 *vs* 3.3 ± 7.0 days, *p*=0.266, respectively). Fig. 4 depicts regional variation regarding the time from onset of symptoms to RRD diagnosis.

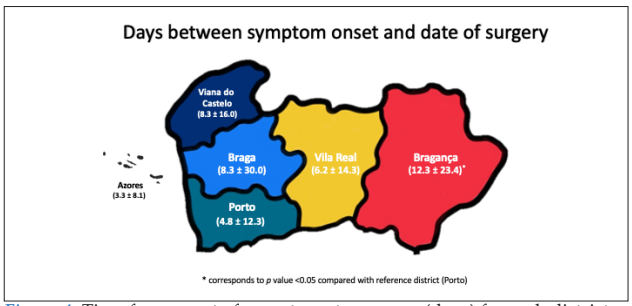

Figure 4. Time from onset of symptoms to surgery (days) for each district.

DISCUSSION

The main purpose of this study was to identify risk factors and develop a prediction model for re-detachment after primary *pars plana* vitrectomy (PPV) for rhegmatogenous RD.

A primary anatomical failure occurred in a fifth of patients. Most studies regarding rhegmatogenous re-detachment gather different populations and distinct criteria for surgical failure. The lack of a standardized definition may limit comparison. Despite this, our results were expected and in line with current evidence.[15,20,21]

We found that total RD, inferior location of largest retinal tears, higher (>26.0 mm) AL, presence of choroidal detachment at the time of diagnosis, subretinal fluid drainage through surgically induced retinotomy, and tamponade with C3F8 were independent risk factors for surgical failure.

In accordance with other studies,[9,11,13,15,22–24] our work proved that total RD conveys a worse visual prognosis, with almost twice the rate of surgical failure and worse final BCVA. The extent of RD can be seen as a marker of chronicity – in longstanding RD, the retina becomes shorted and rigid, rendering it more prone to re-detachment after surgery.[24] Apart from total RD, we cannot fully state that larger extent of RD is associated with a worse visual prognosis or higher risk of surgical failure, which is also in line with other authors.[15]

Some authors[17,25] have reported an association between numerous retinal breaks and an increased risk of failure – probably reflecting increased complexity. However, we did not find the number of retinal breaks to be associated with an increased risk of failure, in accordance with Yorston *et al*.[15] The location of the largest break, however, seems to be an independent risk factor for surgical failure – while less frequent, inferior breaks are associated with difficulty in head positioning and tamponade, increasing the risk for re-detachment, as previously noted.[11]

On the other hand, fluid drainage through a surgically induced retinotomy may reflect scenarios where a retinal break could not be found, rendering it more prone to surgical failure. Our model includes few of those cases, and thus may be underpowered to state that the absence of retinal tears conveys worse visual prognosis.

Axial myopia is a known risk factor for RRD, especially in younger people, either due to anterior-posterior traction or predisposing lesions.[26] Thus, it was not surprising to find that higher AL was associated with increased risk for surgical failure, probably reflecting higher complexity and requiring thorough management. On the other hand, comorbidities associated with high myopia (such as myopic tractional maculopathy) were not taken into account, which may limit conclusions.

Choroidal detachment at the time of diagnosis has long been described as a factor for worse prognosis after RRD.[14,16] It arises due to increased outflow through the retinal pigment epithelium and higher capillary pressure relative to interstitial pressure. Thus, it is a marker of long-standing and extensive RRD, carrying a worse visual prognosis.

Intraoperative tamponade with C3F8 was associated with higher failure rates. However, compared with SF6, it was more frequently used when the following characteristics were present: the largest break between 5 and 7 o'clock (14.6% *vs* 3.6%); inferior clock hours detached >3 h (75.2% *vs* 63.3%); PVR (14.0% *vs* 4.7%); total RD (13.0 *vs* 6.1%). Thus, C3F8 was used in more complex RD in which the surgeons refrained from silicone oil tamponade.

In our model, silicone oil tamponade was not associated with an increased risk of failure. However, failure rates can be affected by patients refusing oil removal. Given the worse prognosis, we typically reserve oil tamponade for situations in which it is irreplaceable or situations where it is medically indicated (e.g., in need of flying).

Previous reports from the scleral buckling versus primary vitrectomy in RRD (SPR) study have shown that

intraoperative cryopexy and lack of intraoperative laser photocoagulation can lead to poorer outcomes.[27,28] Intraoperative cryotherapy has been shown to increase the risk of PVR, particularly in horseshoe tears.[29] Our results align with the authors - after the exclusion of patients who underwent simultaneous intraoperative laser photocoagulation and cryopexy, univariate analysis revealed an increased risk of failure with cryopexy and a protective role for laser photocoagulation.

Several other studies have shown the presence of PVR grade C to be associated with increased risk for failure and worse visual prognosis.[9,11,14,22] This was not proved by our model, which probably reflects the low number of eyes fulfilling these criteria and difficulties in codification regarding this variable.

We could not find a significant increase in surgical failure regarding age stratification in the final model. Some authors have described lower success rates in younger[26] and older[15] patients. While the former may exhibit RD related to inherited disorders (e.g., Stickler's syndrome), the latter may find it difficult to comply with postoperative head positioning, rendering worse outcomes. We could only find an increased risk for younger patients in the univariate analysis. This may reflect the relatively low number of cases in the young and the elderly and does not necessarily mean there is no increased risk in these patients.

Since most risk factors can be assessed preoperatively, we developed a model for risk stratification based on our population to guide surgeons in risk stratification and improve outcomes. In our model, 73.2% of patients are at low risk (16.3%), 24.2% of patients at moderate risk (29.7%), and 2.6% of patients at high risk of failure (66.7%).

Recognizing additional factors (such as perfluoropropane tamponade and subretinal fluid drainage through a surgically induced retinotomy) may further aid in recognizing patients at increased risk of failure and need for reoperation. It may also help identify cases more suitable for trainee surgeons and those requiring multiple techniques (e.g., simultaneous scleral buckle and PPV).

Regional stratification revealed delayed diagnosis and, therefore, worse visual prognosis regarding patients living on the mainland further away from the referral center - probably reflecting more difficulties in healthcare access. These patients also exhibited a nonsignificant increased risk for failure. However, patients living in the Azores islands did not reveal delayed diagnosis or worse visual prognosis. In the future, this should highlight the need for patient education to enhance earlier diagnosis and improve patient outcomes. However, there was no regional difference regarding time from diagnosis to surgery date, which affirms the importance of dedicated retinal detachment programmes.

Our study has several strengths. We developed a large database of eyes submitted to primary 23G PPV for the treatment of rhegmatogenous retinal detachment in a real-world setting. Our methodology was robust, with a clear definition of anatomical success and exclusion of patients submitted to previous vitreoretinal surgery and those submitted primarily to other techniques (e.g., scleral buckle, pneumatic retinopexy). We also reaffirmed the importance of a dedicated retinal detachment surgical program regarding patient accessibility and care.

We also show some limitations. Its retrospective analysis has inherent limitations. Being a single-center study, it may be biased by surgeon preference and familiar surgical techniques. Since we gather patients from most regions, patient attendance is sometimes challenging, and follow-up may be shorter than ideal. Our model also exhibits a low number of patients fulfilling the criteria for high-risk for failure, which may underestimate its true validity.

We provided novel information regarding the outcomes of RRD after primary 23G PPV. Identification of high-risk features may improve risk stratification and tailored patient counseling and selection.

CONTRIBUTORSHIP STATEMENT / DECLARAÇÃO DE CONTRIBUIÇÃO

Todas os autores contribuiram substancialmente para a conceção, desenho do trabalho, aquisição, análise e interpretação dos dados para o trabalho; redação, revisão crítica e aprovação final da versão a ser publicada.

All the authors contributed substantially to the conception, design of the work, acquisition, analysis and interpretation of the data for the work; writing, critical revision and final approval of the version to be published.

RESPONSABILIDADES ÉTICAS

Conflitos de Interesse: Os autores declaram a inexistência de conflitos de interesse na realização do presente trabalho.

Fontes de Financiamento: Não existiram fontes externas de financiamento para a realização deste artigo.

Confidencialidade dos Dados: Os autores declaram ter seguido os protocolos da sua instituição acerca da publicação dos dados de doentes.

Proteção de Pessoas e Animais: Os autores declaram que os procedimentos seguidos estavam de acordo com os regulamentos estabelecidos pela Comissão de Ética responsável e de acordo com a Declaração de Helsínquia revista em 2024 e da Associação Médica Mundial.

Proveniência e Revisão por Pares: Não comissionado; revisão externa por pares.

ETHICAL DISCLOSURES

Conflicts of Interest: The authors have no conflicts of interest to declare.

Financing Support: This work has not received any contribution, grant or scholarship

Confidentiality of Data: The authors declare that they have followed the protocols of their work center on the publication of patient data.

Protection of Human and Animal Subjects: The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and those of the Code of Ethics of the World Medical Association (Declaration of Helsinki as revised in 2024).

Provenance and Peer Review: Not commissioned; externally peer-reviewed.

REFERENCES

1. Sultan ZN, Agorogiannis EI, Iannetta D, Steel D, Sandinha T. Rhegmatogenous retinal detachment: a review of current practice in diagnosis and management. BMJ Open Ophth. 2020;5:e000474. doi: 10.1136/bmjophth-2020-000474.
2. Marmor M, Gloor B. Controversy over the etiology and therapy of retinal detachment: the struggles of Jules Gonin. Surv Ophthalmol. 2013;58:184-95. doi: 10.1016/j.survophthal.2012.09.002.
3. Schepens C, Okamura I, Brockhurst R. The scleral buckling procedures. I. surgical techniques and management. AMA Arch Ophthalmol. 1957;58:797–811.
4. Charles S, Wood B. In: Vitreous microsurgery. 5th ed. Philadelphia: Lippincott: Williams & Wilkins; 2010.
5. Machemer R, Parel J, Buettner H. A new concept for vitreous surgery. I. instrumentation. Am J Ophthalmol. 1972;73:1–7.
6. Vaziri K, Schwartz S, Kishor K. Tamponade in the surgical management of retinal detachment. Clin Ophthalmol. 2016;10:471–6. doi: 10.2147/OPTH.S98529.
7. Hwang JC. Regional practice patterns for retinal detachment repair in the United States. Am J Ophthalmol. 2012;153:1125–8. doi: 10.1016/j.ajo.2011.11.034.
8. Thompson J, Snead M, Billington B, Barrie T, Thompson J, Sparrow J. National audit of the outcome of primary surgery for rhegmatogenous retinal detachment. II. Clinical outcomes. Eye. 2002;16:771–7.
9. Wickham L, Bunce C, Wong D, Charteris D. Retinal detachment repair by vitrectomy: simplified formulae to estimate the risk of failure. Br J Ophthalmol. 2011;95:1239–44. doi: 10.1136/bjo.2010.190314.
10. Mitry D, Awan M, Borooah S, Siddiqui M, Brogan K, Fleck B. Surgical outcome and risk stratification for primary retinal detachment repair: results from the Scottish Retinal Detachment study. Br J Ophthalmol. 2012;96:730–4. doi: 10.1136/bjophthalmol-2011-300581.
11. Williamson T, Lee E, Shunmugam M. Characteristics of rhegmatogenous retinal detachment and their relationship to success rates of surgery. Retina. 2014;34:1421–7. doi: 10.1097/IAE.0000000000000094.
12. Pastor J, Fernández I, Rodríguez de la Rúa E, Coco R, Sanabria-Ruiz Colmenares M, Sánchez-Chicharro D. Surgical outcomes for primary rhegmatogenous retinal detachments in phakic and pseudophakic patients: the Retina 1 Project- report 2. Br J Ophthalmol. 2008;92:378–82. doi: 10.1136/bjo.2007.129437.
13. Wickham L, Ho-Yen G, Bunce C, Wong D, Charteris D. Surgical failure following primary retinal detachment surgery by vitrectomy: risk factors and functional outcomes. Br J Ophthalmol. 2011;95:1234–8. doi: 10.1136/bjo.2010.190306.
14. Adelman R, Parnes A, Michalewska Z, Ducournau D. Clinical variables associated with failure of retinal detachment repair: the European vitreo-retinal society retinal detachment study report number 4. Ophthalmology. 2014;121:1715–9. doi: 10.1016/j.ophtha.2014.03.012.
15. Yorston D, Donachie PHJ, Laidlaw DA, Steel DH, Aylward GW, Williamson TH, et al. Stratifying the risk of re-detachment: variables associated with outcome of vitrectomy for rhegmatogenous retinal detachment in a large UK cohort study. Eye. 2023;37:1527-37. doi: 10.1038/s41433-023-02388-0.
16. Girard P, Karpouzas I. Pseudophakic retinal detachment: anatomic and visual results. Graefes Arch Clin Exp Ophthalmol. 1995;233:324–30.
17. Feltgen N, Heimann H, Hoerauf H, Walter P, Hilgers RD, Heussen N, et al. Scleral buckling versus primary vitrectomy in rhegmatogenous retinal detachment study (SPR study): Risk assessment of anatomical outcome. SPR study report no. 7. Acta Ophthalmol. 2013;91:282–7. doi: 10.1111/j.1755-3768.2011.02344.x.
18. Lange C, Feltgen N, Junker B, Schulze-Bonsel K, Bach M. Resolving the clinical acuity categories "hand motion" and "counting fingers" using the Freiburg Visual Acuity Test (FrACT). Graefes Arch Clin Exp Ophthalmol. 2009;247:137–42.
19. Holladay JT. Proper method for calculating average visual acuity. J Refract Surg. 1997;13:388–91.
20. Irigoyen C, Goikoetxea-Zubeldia A, Sanchez-Molina J, Amenabar Alonso A, Ruiz-Miguel M, Iglesias-Gaspar MT. Incidence and risk factors affecting the recurrence of primary retinal detachment in a tertiary hospital in Spain. J Clin Med. 2022;11:4551. doi: 10.3390/jcm11154551.
21. Momenaei B, Wakabayashi T, Kazan AS, Oh GJ, Kozarsky S, Vander JF, et al. Incidence and Outcomes of Recurrent Retinal Detachment after Cataract Surgery in Eyes with Prior Retinal Detachment Repair. Ophthalmol Retina. 2024;8:447-55. doi: 10.1016/j.oret.2023.11.005.
22. Yorston D, Donachie PHJ, Laidlaw DA, Steel DH, Sparrow JM, Aylward GW, et al. Factors affecting visual recovery after successful repair of macula-off retinal detachments: findings from a large prospective UK cohort study. Eye. 2021;35:1431. doi: 10.1038/s41433-020-1021-y.
23. Sung JY, Lee MW, Won YK, Lim HB, Kim JY. Clinical characteristics and prognosis of Total Rhegmatogenous retinal detachment: a matched case-control study. BMC Ophthalmol. 2020;20:286. doi: 10.1186/s12886-020-01560-4.
24. Yao Y, Jiang L, Wang ZJ, Zhang MN. Scleral buckling procedures for longstanding or chronic rhegmatogenous retinal detachment with subretinal proliferation. Ophthalmology. 2006;113:821-5. doi: 10.1016/j.ophtha.2005.12.011.
25. Afrashi F, Akkin C, Egrilmez S, Erakgun T, Mentes J. Anatomic outcome of scleral buckling surgery in primary rhegmatogenous retinal detachment. Int Ophthalmol. 2005;26:77–81.
26. Marques JH, Castro C, Malheiro L, Alves Correia N, Pessoa B, Melo Beirão J, et al. Dealing with rhegmatogenous retinal detachment in patients under 40 years old: a tertiary center results. Int Ophthalmol. 2021;41:475-82. doi: 10.1007/s10792-020-01597-w.
27. Heussen N, Feltgen N, Walter P, Hoerauf H, Hilgers RD, Heimann H, et al. Scleral buckling versus primary vitrectomy in rhegmatogenous retinal detachment study (SPR Study):

predictive factors for functional outcome. Study report no. 6. Graefes Arch Clin Exp Ophthalmol. 2011;249:1129–36.

28. Heussen N, Hilgers RD, Heimann H, Collins L, Grisanti S, SPR study group. Scleral buckling versus primary vitrectomy in rhegmatogenous retinal detachment study (SPR study): multiple-event analysis of risk factors for reoperations. SPR Study report no. 4. Acta Ophthalmol. 2011;89:622–8.
29. Bonnet M, Fleury J, Guenoun S, Yaniali A, Dumas C, Hajjar C. Cryopexy in primary rhegmatogenous retinal detachment: a risk factor for postoperative proliferative vitreoretinopathy? Graefes Arch Clin Exp Ophthalmol. 1996;23412:739–43.

Corresponding Author/
Autor Correspondente:

Bruno Barbosa Ribeiro
Serviço de Oftalmologia,
Centro Hospitalar Universitário de Santo António - Unidade Local de Saúde Santo António, Largo do Prof Abel Salazar,
4099-001 Porto, Portugal
E-mail: brunot.barbosaribeiro@gmail.com

ORCID: 0000-0002-8079-9101