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ORIGINAL RESEARCH

Recurrent Rhegmatogenous Retinal Detachment: Characteristics, Risk Factors, and Outcomes

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Purpose: Rhegmatogenous retinal detachment (RRD) is a severe retinal disorder that can lead to vision impairment and potentially blindness. After RRD repair surgery, every vitreoretinal surgeon aims to understand the characteristics of the RRD and to achieve permanent flattening without any recurrence. This study aimed to identify factors predisposing patients to recurrent RRD.

Patients and Methods: This retrospective study was conducted at King Abdullah University Hospital and included all patients who underwent pars plana vitrectomy for RRD repair between January 2015 and December 2023. All demographic, clinical, operative, and outcome data were extracted. The primary outcome was to assess the risk factors affecting the recurrence of RRD. The secondary outcome included factors affecting the final status (flat or detached) of the retina. Using proper statistical methods, the results were generated.

Results: The study comprised 348 patients with primary RRD, of whom 44.5% had a previous ocular surgical history. The rate of recurrent RRD was 28.2%. At the last follow-up, 12.6% of the whole patients had persistent retinal detachment without anatomical successful reattachment. Superior-based RRD was the most common type, affecting 145 of 290 patients, and macular involvement in the RRD was observed in 80% of the cases. Recurrent RRD was higher in younger ages, longer duration of symptoms, extensive total type of RRD, involvement of inferior quadrants, detached macula, presence of proliferative vitreoretinopathy, and insufficient prophylactic laser retinopexy ($p < 0.05$). On multivariate logistic analysis, extensive total RRD, presentation duration, and insufficient prophylactic laser retinopexy were considered as a significant independent factor.

Conclusion: Duration of symptoms, involvement of more quadrants, and insufficient laser retinopexy could influence RRD recurrence. These results may coincide with previous literature but provide insights into the newly investigated population. Increasing the awareness of RRD symptoms, identifying high-risk patients, and ensuring prompt surgical intervention may reduce RRD-related complications and decrease the rate of recurrence.

Keywords: rhegmatogenous retinal detachment, recurrent retinal detachment, prophylactic retinopexy, pars plana vitrectomy, proliferative vitreoretinopathy, retinal tamponade

Introduction

Rhegmatogenous retinal detachment (RRD) is a serious retinal disorder that threatens vision and can lead to blindness, despite improved and successful treatment. Before the twentieth century, RRD often led to complete vision loss in the affected eye and, if it occurred bilaterally, could result in complete blindness. This severely impacted individuals' ability to work and maintain independence and contributed to significant social, psychological, and economic burden on both patients and healthcare systems.[1,2] Except in trauma cases, most risk factors that predispose to RRD affect both eyes. These include high pathological myopia, the presence of high-risk retinal breaks, a family history of RRD, peripheral lattice degeneration, ocular surgery (mainly complicated surgery), and age-related symptomatic posterior vitreous

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detachment.[1,3] With modern advancements in RRD repair, the reported anatomic success following a single RRD surgery repair can be achieved in approximately 90% of patients.[4–6] However, despite advances in surgical techniques, approximately 10% of patients may develop recurrent RRD, requiring additional surgeries.[7] Risk factors for recurrent RRD include initial characteristics of the RRD, primary surgical technique, ocular trauma, number of breaks, lens status (mainly aphakia), myopia, inflammation, retinal and choroidal atrophy, vitreous and retinal hemorrhage, vitreous loss, and a failure to identify all retinal breaks.[8–11]

Rachal and Burton investigated the role of improper surgical techniques and other factors that prevent the adequate closure of all the retinal tears, identifying the following factors to be related to recurrent RRD: proliferative vitreoretinopathy (PVR), preretinal membranes, undetected retinal tears, inadequate scleral buckle, new retinal tears, inadequate chorioretinal reaction, iatrogenic retinal tears, loss of buckle height, and macular holes. Inadequate closure of existent retinal breaks accounted for 77% of primary surgical failures.[12–19] Despite efforts for early diagnosis, and treatment, the prognosis and success rate for RRD repair surgery could be variable among patients. Therefore, it is crucial to identify individuals who are at preoperatively high risk of recurrence of RRD after RRD repair surgery.

This study investigated the demographic, clinical, and anatomical characteristics of patients with RRD in a tertiary hospital in Jordan. Furthermore, this study aimed to assess the factors that predispose patients to recurrent RRD, as well as those contributing to permanent retinal detachment.

Materials and Methods

Patients and Data

This study was conducted at King Abdullah University Hospital (KAUH) between January 2015 and December 2023, obtained ethical approval from the Institutional Review Board at Jordan University of Science and Technology (IRB # 2022/148/56), and was conducted in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki and its later amendment. We retrospectively included all patients who underwent pars plana vitrectomy (PPV) for RRD repair. Patient data, including general demographic characteristics and medical history, were extracted from KAUH's electronic database. Additionally, information on detailed past ocular surgical history, as well as the presence of glaucoma and lens status before PPV surgery, was collected. Operative characteristics of RRD and its associated tears, along with other pathological retinal findings, were also documented. Furthermore, we documented details of the operative techniques used, including the type of tamponade, pattern of the endo-laser, and execution of retinectomy. Visual outcomes of the affected eye were measured. Finally, the number of RRD recurrences and the final status of the retina were studied and investigated.

The inclusion criteria were patients who underwent PPV for primary RRD and followed up at least 6 months after surgery. Most of the patients were followed for more than 1 year. Only few of the patients were followed between 6 months and 1 year duration. The exclusion criteria included: 1) Patients who underwent PPV for other types of retinal detachment (tractional retinal detachment and exudative retinal detachment), epiretinal membranes, idiopathic macular holes, dislocated nuclear material, or dislocated intraocular lenses (IOL) following complicated cataract surgery. 2) Patients with previous RRD. 3) Those with macular degeneration, retinal vein occlusion, proliferative diabetic retinopathy, uveitis syndromes, or retinal dystrophies. 4) Patients with giant retinal tears, retinal dialysis, choroidal detachment, and retinoschisis-related RRD. 5) RRD repaired with scleral buckle. 6) Patients with surgical failure for anatomical alignment following RRD surgery. 7) Patients with insufficient data or with early loss of follow up.

The primary outcome was to identify the incidence of recurrent RRD in the same eye and to investigate the factors associated with the recurrence. Secondary (recurrent) RRD was defined as an anatomical failure following successful primary RRD surgery (if RRD was persistent due to initial surgical failure, it was excluded). Secondary outcomes included factors affecting the final retinal status.

Demographic data included sex, age at first RRD presentation, and the laterality of the affected eye. Comprehensive medical histories were obtained and comprised histories of diabetes mellitus, hypertension, asthma, seizure disorders, and Marfan syndrome. A detailed record of previous ocular surgeries was also obtained, including any procedures before RRD onset. These surgeries were categorized into adult cataract extraction, congenital cataract extraction, PPV

performed for other causes unrelated to RRD, trauma surgery, refractive surgery (including corneal procedures, phakic-IOL implantation, and keratoplasty), and glaucoma surgery. The type of ocular surgery was included in order to identify which previous surgical operations may contribute to recurrent RRD. Adult cataract surgery was also categorized into simple, uncomplicated operations and complicated operations with posterior capsule rupture (with or without vitreous loss). Presentation duration was defined as the duration from the first symptoms noticed by the patient to the day of presentation and was measured in days. The mean duration of symptoms was 35.3 ± 8.2 days.

According to the surgical records and ophthalmic examination at admission, the extent of RRD, types, locations, and numbers of retinal tears were recorded in addition to other pathological retinal findings. The retina was divided into four quadrants centered on the fovea: superotemporal, superonasal, inferotemporal, and inferonasal. RRD was classified first according to the initial site of detachment (at presentation) regardless of the number of detached quadrants. RRD was classified into superior-based, inferior-based, total RRD (at presentation), and posterior pole detachment. Furthermore, the number of involved quadrants by the RRD was calculated and comprised one, two, three and four quadrants. Notably, the involvement of all four quadrants does not mean total RRD. Each quadrant's involvement was also investigated and reported, individually. Macular status was also reported and divided into macula-on (macula was still attached at the time of operation) and macula-off (macula detached at the time of operation). In cases of partial macular detachment, the macula was considered "on" if the fovea was attached, and "off" if the fovea was detached. In these cases, optical coherence tomography (OCT) was utilized and analyzed to confirm the attachment of the fovea.

Break locations were classified first as superotemporal, superonasal, inferotemporal, inferonasal, and posterior pole breaks. If a break was located on the horizontal line that connected the fovea, the break was classified as superior. In cases with multiple breaks, the location of the most important tear with more likelihood to initiate RRD was reported. The number of breaks was calculated and divided into single, double, triple, and multiple (four or more) tears. The types of breaks involved in the analysis were horseshoe tears or operculated tears.

Additional retinal pathologies were reported and investigated, including lattice degeneration, macular holes, non-diabetic vitreous hemorrhage, proliferative vitreoretinopathy (PVR; grade B or more).The clinical documentation of previous posterior vitreous detachment (PVD) was assessed.

The type of tamponade utilized during the PPV was recorded, including silicone oil (SO), octafluoropropane (C_3F_8) gas, and sulfur hexafluoride (SF_6) gas. The duration of SO tamponade was measured in weeks. Endo-laser treatment given during the PPV was classified into laser given around the retinal breaks only or laser given around the breaks and 360 degrees (completed). Furthermore, retinectomy performed during the operation was reported. Lens status before the operation was also documented (phakic, pseudophakic, or aphakic). Moreover, the development of postoperative glaucoma was reported. Cases of transient postoperative intraocular pressure (IOP) elevation were not considered as glaucoma cases. To be considered as postoperative glaucoma, persistent IOP elevation requiring treatment (either medical or surgical) or the presence of optic nerve damage and/or visual field defect should be presented.

Visual outcomes were measured for all eyes at 1 month, 3 months, and either at 1 year postoperatively or at the last follow-up visit for patients who did not continue follow-up to 1 year. The recurrence of RRD in the same eye was assessed and measured, with recurrence defined as "two or more RRD in the same eye." Recurrence timing was categorized into recurrence developed after removal of SO, recurrence developed while the retina was kept under SO, and recurrence developed after injecting the vitreous cavity with gas during the first PPV. The duration between the first and second RRD was measured in weeks. Moreover, the type of tamponade utilized in the revision surgery for recurrent RRD was studied and divided into SO, SF_6 gas, and C_3F_8 gas, and the retina was kept detached without further revision surgery. The decision to leave the retina detached without further management was either patient-directed or if the retina was detached in a closed-funnel pattern with severe ischemic changes. The retinal status at the last follow-up visit was either flat or detached.

Perioperative Settings

Best-corrected visual acuity (BCVA) was measured using a Snellen visual acuity chart. The visual acuity was measured in decimal and converted to LogMAR visual acuity. For patients with visual acuity of counting fingers, hand motion, light perception, or "no light perception", measurements were converted according to Schulze-Bonsel et al's method.[20]

Spectral domain-OCT (Retinascan RS-3000; NIDEK, Gamagori, Japan) was utilized to study the foveal status in cases of partially detached macula. In cases of media opacity, B scan-ultrasonography (NIDEK, Gamagori, Japan) was used to assess the retinal status.

All surgeries were performed under general or retrobulbar anesthesia by three consultant vitreoretinal surgeons who followed the same principle procedural institutional guidelines with the same machinery instrumentations. A 23-gauge vitrectomy system (Combined Wide-Field Elite Pack, Bausch and Lomb) was utilized for all procedures. A core vitrectomy was performed using the vitreous cutter followed by the induction of posterior vitreous detachment, if not already present. Peripheral vitreous shaving with scleral depression was performed in all cases.

Retinal reattachment with perfluorocarbon liquid, endo-laser photocoagulation (around the breaks and 360° peripheral retina), air- perfluorocarbon exchange, and internal tamponade was performed in all cases. PVR, if present, was carefully peeled using intraocular forceps. The vitreous tamponades utilized for RRD treatment were SO (Huile Silicone Purifie Csi, FCI, France), SF_6 gas (GOT SF6 multi, Alchimia, Ponte S. Nicolo, Italy), and C_3F_8 gas (GOT C3F8 multi, Alchimia, Ponte S. Nicolo, Italy). The decision of the tamponades was individualized case-by-case.

The postoperative regimen included topical 0.3% moxifloxacin eye drops administered six times daily for 1 week and 1% topical prednisolone acetate eye drops administered at the same frequency, which were usually tapered off over 4 weeks. During the follow-up period, antiglaucoma eye drops such as beta-blockers or carbonic anhydrase inhibitors, were prescribed when the IOP was > 22 mmHg.

Regarding the recurrence of RRD, revision surgery was performed for most patients and included the removal of SO if the recurrence developed under the SO. If required, retinectomy was performed using the cutter, followed by meticulous endo-diathermy using the unipolar cautery. A supplementary laser treatment extending beyond the level of the equator was also performed. Following this, the eye was filled with either another SO or gas.

Statistical Analyses

The collected data was entered into a spreadsheet and analyzed using the IBM SPSS statistical package for Windows v.29 (Armonk, New York, USA). Nominal variables were expressed as the frequency (percentage) and continuous variables as the mean ± standard error of the mean (SEM). Data normality was tested using the Kolmogorov–Smirnov test. The statistical significance between the study groups was determined by using the Chi-square test for categorical variables and the Student's *t*-test for continuous variables. A statistically significant result was considered if $p \leq 0.05$. Binary logistic regression analysis was employed to assess the independent factors affecting the recurrence of RRD and the final status of the retina.

Results

Patient Characteristics and Outcomes

During the study period, about 1108 cases of retinal detachment were identified. From those, 686 were excluded as being operated for tractional or exudative retinal detachment. From the 422 cases of RRD, 74 cases were excluded due to surgical failure, scleral buckle repair, the presence of giant tears or retinal dialysis, or due to early loss of follow up. At the end, the study comprised 348 patients with primary RRD. Table 1 presents the general demographics and clinical characteristics of these patients. The mean age of the patients was 46.3 ± 1.0 years, with most of them being male individuals (73.3%). Eye laterality was almost similar for both sides. More than half of the patients (55.5%) had no previous ocular surgeries. However, 31% (108 patients) had undergone cataract surgery (96 adult and 12 congenital). Among the adult cataract surgery patients (out of 96 patients), 25 had complicated cataract surgery.

Most patients (252/348, 72.4%) received SO as a retinal tamponade with a mean duration of implantation of 39.9 ± 2.9 weeks. The remaining patients received either SF_6 (13.8%) or C_3F_8 (13.8%) gas. Unfortunately, 98 patients (28.2%) experienced recurrence in the same eye, with over half of those patients (54/98, 55.1%) developing a second RRD while the retina was kept under the SO. Figure 1 summarizes the characteristics of recurrent RRD cases. The final outcome showed that 304 patients (87.4%) had a flat retina. The preoperative BCVA was 1.537 LogMAR units, a

−0.3374 ± 0.05 LogMAR unit change in the BCVA at the last follow-up visit for the whole sample was observed (indicating an improvement of the BCVA of about 16 Snellen letters) About one third of the patients developed postoperative glaucoma.

Table 1 General Characteristics and Factors Affecting the Recurrence of RRD Within the Same Eye

Variables	Number (percentage) or Mean ± SEM			
	Overall (N= 348)	Only one RRD (N = 250)	Two or More RRD (N = 98)	p-value
Sex				0.54
Male	255 (73.3)	180 (71.4)	72 (28.6)	
Female	93 (26.7)	67 (72.8)	25 (27.2)	
Age (years)	46.3 ± 1.0	48.3 ± 1.1	41.8 ± 2.2	0.004
Presentation duration (days)	35.3 ± 8.2	20.2 ± 3.1	75.1 ± 20.0	0.004
Laterality				0.44
Right eye	177 (50.9)	123 (71.1)	50 (28.9)	
Left eye	171 (49.1)	124 (72.5)	47 (27.5)	
Ocular parameters				
Axial length (mm)	24.99 ± 0.14	25.06 ± 0.2	24.82 ± 0.3	0.44
Spherical equivalent (diopter)	−2.43 ± 0.82	−2.78 ± 1.0	−0.81 ± 0.3	0.36
Medical history				
Diabetes mellitus	61 (17.5)	41 (67.2)	20 (32.8)	0.23
Hypertension	92 (26.4)	69 (75.8)	22 (24.2)	0.26
Seizure syndromes	6 (1.7)	2 (33.3)	4 (66.7)	0.05
Marfan syndrome	4 (1.1)	2 (50.0)	2 (50.0)	0.32
Asthma	8 (2.3)	4 (50.0)	4 (50.0)	0.45
Past ocular operations				0.04
No operations	193 (55.5)	145 (76.3)	45 (23.7)	
Adult cataract surgery	96 (27.6)	67 (69.8)	29 (30.2)	
Congenital cataract surgery	12 (3.4)	8 (72.7)	3 (27.3)	
Trauma surgery	25 (7.2)	13 (52.0)	12 (48.0)	
Pars plana vitrectomy	13 (3.7)	6 (46.2)	7 (53.8)	
Refractive surgery	7 (2.0)	6 (85.7)	1 (14.3)	
Glaucoma surgery	2 (0.6)	2 (100.0)	0 (0.0)	
Complicated adult cataract surgery				0.26
Yes	25 (26.0)	16 (64.0)	9 (36.0)	
No	71 (74.0)	231 (72.4)	88 (27.6)	

(*Continued*)

Table 1 (Continued).

Variables	Number (percentage) or Mean ± SEM			
	Overall (N= 348)	**Only one RRD (N = 250)**	**Two or More RRD (N = 98)**	**p-value**
Reported history of previous symptomatic PVD	17 (4.9)	31 (63.3)	18 (36.7)	0.10
Lens status at the presentation of RRD:				0.27
Phakic	215 (61.7)	161 (74.9)	54 (25.1)	
Pseudophakic	118 (34.0)	79 (66.9)	39 (33.1)	
Aphakic	15 (4.3)	10 (66.7)	5 (33.3)	
Presence of preoperative glaucoma	29 (8.8)	21 (72.4)	8 (27.6)	0.56
Presence of postoperative glaucoma	105 (30.2)	74 (70.5)	31 (29.5)	0.41
Type of RRD at presentation (out of 290)				0.001
Superior-based RRD	145 (50.0)	120 (83.3)	24 (16.7)	
Inferior-based RRD	75 (25.9)	57 (76.0)	18 (24.0)	
Total RRD	69 (23.8)	33 (47.8)	36 (52.2)	
Posterior pole detachment	1 (0.3)	1 (100.0)	0 (0.0)	
Number of involved quadrants (out of 276)				0.0001
One quadrant	16 (5.8)	13 (81.3)	3 (18.8)	
Two quadrants	134 (48.6)	107 (80.5)	26 (19.5)	
Three quadrants	47 (17.0)	38 (80.9)	(19.1)	
Four quadrants	79 (28.6)	41 (51.9)	38 (48.1)	
Involvement of each quadrant separately (out of 231)				
Superior-temporal quadrant	189 (81.8)	133 (70.4)	56 (29.6)	0.11
Superior-nasal quadrant	140 (60.6)	95 (68.3)	44 (31.7)	0.07
Inferior-temporal quadrant	181 (80.8)	126 (69.6)	55 (30.4)	0.02
Inferior-nasal quadrant	135 (58.4)	86 (63.7)	49 (36.3)	0.001
Macular status (out of 296)				0.001
Macula on (intact)	57 (19.3)	51 (89.5)	6 (10.5)	
Macula off (detached)	239 (80.7)	161 (67.6)	77 (32.4)	
Number of tears (out of 299)				0.37
No tears found	23 (7.7)	16 (69.6)	7 (30.4)	
One tear	163 (54.5)	117 (71.8)	46 (28.2)	
Two tears	50 (16.7)	39 (81.3)	9 (18.7)	
Three tears	23 (7.7)	18 (78.3)	5 (21.7)	
Multiple tears	40 (13.4)	34 (85.0)	6 (15.0)	

(*Continued*)

Table 1 (Continued).

Variables	Number (percentage) or Mean ± SEM			
	Overall (N= 348)	**Only one RRD (N = 250)**	**Two or More RRD (N = 98)**	**p-value**
Location of the main tear according to quadrants (out of 258)				0.26
Superior-temporal quadrant	143 (55.4)	113 (79.6)	29 (20.4)	
Superior-nasal quadrant	42 (16.3)	34 (82.9)	7 (17.1)	
Inferior-temporal quadrant	37 (14.3)	25 (67.6)	12 (32.4)	
Inferior-nasal quadrant	31 (12.0)	21 (67.7)	10 (32.3)	
Macular hole	5 (1.9)	3 (60.0)	2 (40.0)	
The presence of other retinal pathologies*				
Lattice degeneration	98 (28.2)	72 (73.5)	26 (26.5)	0.40
Macular hole	13 (3.7)	9 (69.2)	4 (30.8)	0.52
VH	23 (6.6)	15 (65.2)	8 (34.8)	0.31
PVR	109 (31.3)	63 (57.8)	46 (42.2)	0.0001
Type of tamponade used in the RRD repair surgery				0.25
Silicone oil	252 (72.4)	117 (70.2)	75 (29.8)	
SF_6 gas	48 (13.8)	39 (81.3)	9 (18.8)	
C_3F_8 gas	48 (13.8)	34 (70.8)	14 (29.2)	
Pattern of endo-laser used during RRD repair surgery				0.004
Around tears only	72 (20.7)	42 (58.3)	30 (41.7)	
Completed	276 (79.3)	208 (75.4)	68 (24.6)	
Duration of SO tamponading, if SO was used (weeks)	39.9 ± 2.9	43.2 ± 3.9	32.0 ± 3.1	0.10
Performing retinectomy during the RRD repair surgery	25 (7.2)	12 (48.0)	13 (52.0)	0.006
Visual outcomes				
Preoperative BCVA (LogMAR)	1.537 ± 0.04	1.450 ± 0.05	1.761 ± 0.04	0.002
Change in BCVA at 1 month postoperatively (LogMAR)	−0.3317 ± 0.05	−0.3397 ± 0.04	−0.3109 ± 0.05	0.78
Change in BCVA at 3 months postoperatively (LogMAR)	−0.3722 ± 0.05	−0.4269 ± 0.04	−0.2493 ± 0.04	0.12
Change in BCVA at 1 year postoperatively (LogMAR)	−0.3090 ± 0.07	−0.3775 ± 0.006	−0.1617 ± 0.07	0.07
Change in BCVA at last follow-up (LogMAR)	−0.3374 ± 0.05	−0.4560 ± 0.05	−0.0262 ± 0.05	0.0001

Note: *The sample size for these variables is indicated in Table 2.
Abbreviations: BCVA, best corrected visual acuity; NS, not significant; PVD, posterior vitreous detachment; PVR, proliferative vitreoretinopathy; RRD, rhegmatogenous retinal detachment; SEM, standard error; VH, vitreous hemorrhage.

Ophthalmologic Preoperative Characteristics

Table 1 presents the anatomical and operative features of RRD at presentation. Half of the patients (145/290) presented with superior-based RRD. Additionally, nearly half of the patients with recorded quadrant involvement (134/276) had two quadrants affected (Table 1). The order of quadrants involvement was superior-temporal (81.8%), inferior-temporal

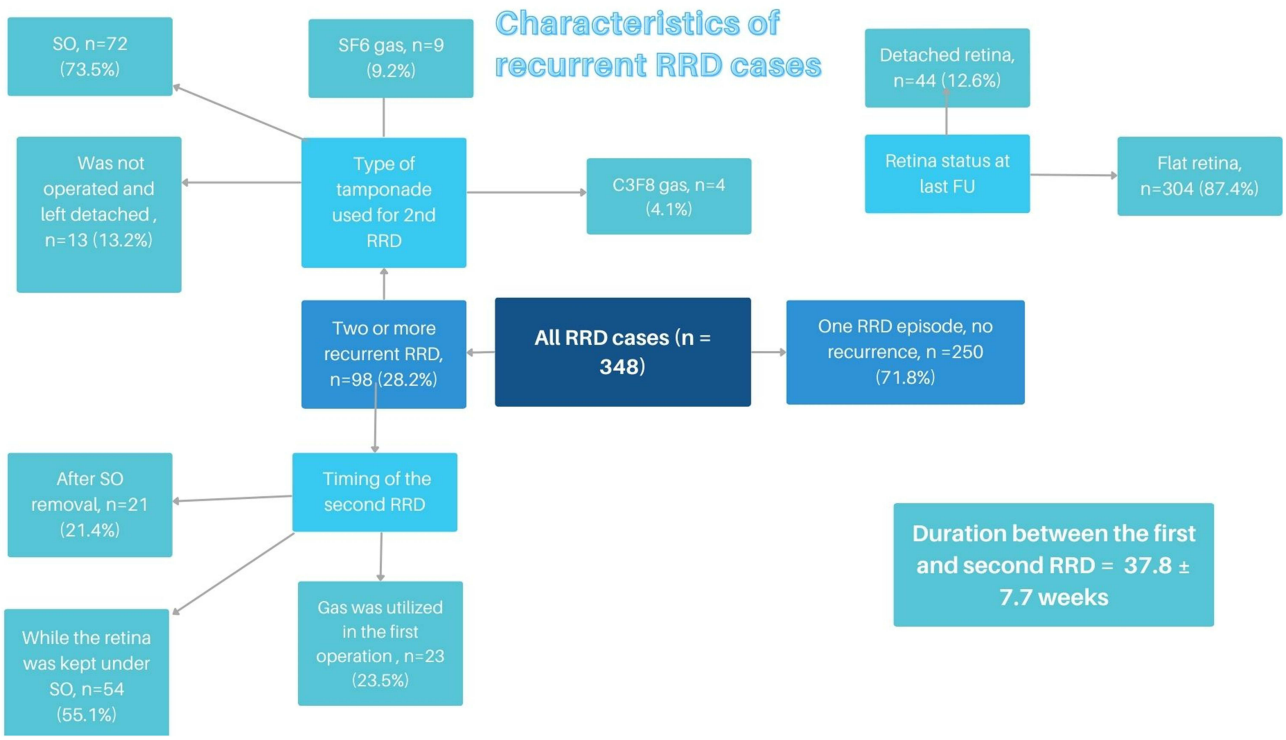

Figure 1 Chart for the characteristics of recurrent RRD cases.

(80.8%), superior-nasal (60.6%), and inferior-nasal (58.4%). Of 296 patients with recorded macular status, 239 (80.7%) had a detached macula. Regarding the number of tears, over half of the patients with the recorded number of tears (163/299, 54.5%) had only one tear. The most common location for the main tear was in the superior-temporal quadrant (55.4%). Finally, almost all patients presented with other retinal pathologies (340/348, 97.7%), with the most common being PVR (31.3%), and lattice degeneration (28.2%).

Factors Affecting RRD Recurrence in the Same Eye

Table 1 summarizes the factors that might be associated with the RRD recurrence in the same eye. No statistical differences were observed regarding sex, laterality, ocular parameters, type of tamponade used, and number and location of tears between single-episode and recurrent RRD patients. It was revealed that the recurrent RRD had a younger mean age ($p < 0.01$). Patients with recurrent RRD had a significantly higher mean of presentation duration (75.1 ± 20.0 days) than those without recurrence (20.2 ± 3.1 days; $p < 0.01$). Interestingly, a higher percentage of patients with recurrent RRD had been exposed to previous trauma surgeries (48.0%) and PPV (53.8%) than those without recurrent RRD ($p < 0.05$). Additionally, the type of RRD at presentation was significantly associated with the recurrence of RRD ($p < 0.01$). Approximately 52% of patients who had recurrent RRD presented with a total RRD type.

A highly significant relation was observed between the RRD recurrence and number of quadrants involved ($p < 0.001$) (Table 1). Patients with involvement of four quadrants in the first RRD were more likely to have a recurrent episode of RRD. However, when we considered the involvement of each quadrant separately, there were significant relation between recurrence and the involvement of the inferior-nasal and inferior-temporal quadrants. Furthermore, a higher percentage of patients (92.9%) with recurrent RRD had the macula detached than those without recurrent RRD (75.9%; $p < 0.01$). A significantly higher percentage of patients (46.9%) with recurrent RRD had PVR as a retinal pathology than those without recurrence (25.2%; $p < 0.001$). The pattern of endo-laser used during the first RRD repair surgery was significantly associated with the recurrence of RRD ($p < 0.01$). A higher percentage of patients with recurrent RRD (30.6%) had endo-laser only around tears than those without recurrence (16.8%). Lastly, performing

retinectomy during the RRD repair surgery was also significantly associated with RRD recurrence ($p < 0.01$). Among patients with RRD, 13.3% (13/98) underwent retinectomy, compared to only 4.8% (12/250) without recurrent RRD.

After binary logistic regression analysis, it was found that total RRD at presentation, insufficient endo-laser, the presence of PVR, and duration of presentation were the independent risk factors associated with recurrent RRD.

Regarding the visual outcome, patients without recurrent RRD achieved better improvement in BCVA at 1-year follow up than patients with recurrent RRD. Change in BCVA at 1-year follow up for patients without recurrent RRD was −0.3775 ± 0.006 LogMAR (indicating improvement of about 19 Snellen letters), while the change for recurrent RRD patients was −0.1617 ± 0.07 LogMAR (indicating improvement of 8 Snellen letters).

Factors Affecting the Retina Status at the Last Follow Up

Table 2 summarizes the factors affecting the retina status (flat vs detached) in the same. No statistical differences were observed regarding sex, laterality, ocular parameters, past ocular operations, and type of tamponade used between patients with flat and detached retinas. However, patients with detached retinas had a younger mean age than those

Table 2 Factors Affecting the Status of the Retina at the last Follow-Up

Variables	**Number (Percentage) or Mean ± SEM**		
	Flat (N= 304)	**Detached (N= 44)**	**p-value**
Sex			
Male	225 (88.2)	30 (11.8)	0.30
Female	79 (84.9)	14 (15.1)	
Age (years)	47.2 ± 1.0	39.9 ± 3.4	0.017
Presentation duration (days)	22.7 ± 4.6	137.9 ± 61.4	0.0001
Laterality			0.25
Right eye	152 (85.9)	25 (14.1)	
Left eye	152 (88.9)	19 (11.1)	
Ocular parameters			
Axial length (mm)	25.06 ± 0.1	24.37 ± 0.5	0.40
Spherical equivalent (diopter)	−2.51 ± 0.9	−1.12 ± 0.4	0.26
Medical history			
Diabetes mellitus	51 (83.6)	10 (16.4)	0.22
Hypertension	84 (91.3)	8 (8.7)	0.12
Seizure syndromes	3 (50.0)	3 (50.0)	0.005
Marfan syndrome	3 (75.0)	1 (25.0)	0.41
Asthma	8 (100.0)	0 (0.0)	0.36
Past ocular operations			0.67
No operations	167 (86.5)	26 (13.5)	
Adult cataract surgery	87 (90.6)	9 (9.4)	
Congenital cataract surgery	10 (83.3)	2 (16.7)	

(*Continued*)

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Table 2 (Continued).

Variables	Number (Percentage) or Mean ± SEM		
	Flat (N= 304)	**Detached (N= 44)**	**p-value**
Trauma surgery	21 (84.0)	4 (16.0)	
Pars plana vitrectomy	10 (76.9)	3 (23.1)	
Refractive surgery	7 (100.0)	0 (0.0)	
Glaucoma surgery	2 (100.0)	0 (0.0)	
Complicated adult cataract surgery	21 (84.0)	4 (16.0)	0.24
Type of RRD at presentation (out of 290)			0.002
Superior-based RRD	134 (92.4)	11 (7.6)	
Inferior-based RRD	66 (88.0)	9 (12.0)	
Total RRD	51 (73.9)	18 (26.1)	
Posterior pole detachment	1 (100.0)	0 (0.0)	
Number of involved quadrants (out of 276)			0.003
One quadrant	16 (100.0)	0 (0.0)	
Two quadrants	123 (91.8)	11 (8.2)	
Three quadrants	42 (89.4)	5 (10.6)	
Four quadrants	60 (75.9)	19 (24.1)	
Involvement of each quadrant separately (out of 231)			
Superior-temporal quadrant	164 (86.8)	25 (13.2)	0.33
Superior-nasal quadrant	117 (83.6)	23 (16.4)	0.02
Inferior-temporal quadrant	155 (85.6)	26 (14.4)	0.15
Inferior-nasal quadrant	110 (81.5)	25 (18.5)	0.001
Macular status (out of 296)			0.022
Macula on (intact)	55 (96.5)	2 (3.5)	
Macula off (detached)	204 (85.4)	35 (14.6)	
Number of tears (out of 299)			0.041
No tears found	18 (78.3)	5 (21.7)	
One tear	139 (85.3)	24 (14.7)	
Two tears	47 (94.0)	3 (6.0)	
Three tears	22 (95.7)	1 (4.3)	
Multiple tears	39 (97.5)	1 (2.5)	

(*Continued*)

Table 2 (Continued).

Variables	Number (Percentage) or Mean ± SEM		
	Flat (N= 304)	**Detached (N= 44)**	**p-value**
Location of the main tear according to quadrants (out of 258)			0.09
Superior-temporal quadrant	131 (91.6)	12 (8.4)	
Superior-nasal quadrant	40 (95.2)	2 (4.8)	
Inferior-temporal quadrant	29 (78.4)	8 (21.6)	
Inferior-nasal quadrant	28 (90.3)	3 (9.7)	
Macular hole	5 (100.0)	0 (0.0)	
The presence of other retinal pathologies*			
Lattice degeneration	87 (88.8)	11 (11.2)	0.40
Macular hole	12 (92.3)	1 (7.7)	0.49
VH	22 (95.7)	1 (4.3)	0.18
PVR	90 (82.6)	19 (17.4)	0.053
Type of tamponade used in the RRD repair surgery			0.15
Silicone oil	216 (85.7)	36 (14.3)	
SF_6 gas	46 (95.8)	2 (4.2)	
C_3F_8 gas	42 (87.5)	6 (12.5)	
Duration of SO tamponading, if SO was used (weeks)	41.3 ± 3.3	29.8 ± 4.2	0.16
The recurrence of RRD after the first surgery			0.0001
No (only one RRD was developed)	250 (100.0)	0 (0.0)	
Two or more RRDs	54 (55.1)	44 (44.9)	
Pattern of endo-laser used during RRD repair surgery			0.0001
Around tears only	53 (73.6)	19 (26.4)	
Completed	251 (90.9)	25 (9.1)	
Performing retinectomy during the RRD repair surgery	17 (68.0)	8 (32.0)	0.003

Note: *The sample size for these variables is indicated in Table 2.
Abbreviations: BCVA, best corrected visual acuity; NS, not significant; PVD, posterior vitreous detachment; PVR, proliferative vitreoretinopathy; RRD, rhegmatogenous retinal detachment; SEM, standard error; VH, vitreous hemorrhage.

with flat retinas ($p < 0.05$). Patients with detached retinas had a longer mean duration of presentation (137.9 ± 61.4 days) than those with flat retinas (22.7 ± 4.6 days; $p < 0.0001$). Additionally, a higher percentage of patients with detached retinas (6.8%) had cognitive impairments than those with flat retinas (1.0%).

The type of RRD at presentation was significantly associated with retinal status ($p < 0.01$). A higher percentage of patients with detached retinas (47.4%) had a total RRD type than the percentage of those with flat retinas (20.2%). A significant relation was observed between the retina status and number of quadrants involved ($p < 0.01$). Patients who had the involvement of four quadrants in the first RRD were more likely to have detached retinas. However, when we considered the involvement of each quadrant separately, there were significant associations between retina status and the involvement of

the superior-nasal and inferior-nasal quadrants (Table 2). Furthermore, a higher percentage of patients with detached retinas (94.6%) had the macula also detached compared to the percentage of those with flat retinas (78.8%; $p < 0.05$).

There was a highly significant association was identified between RRD recurrence and retinal status ($p < 0.001$). A higher percentage of patients with detached retinas (43.2%) had endo-laser only around tears than the percentage of those with flat retinas who had endo-laser around the tear (17.4%) ($p < 0.001$). Among patients with detached retinas, 18.2% (8/44) underwent retinectomy, compared to only 5.6% (17/304) of patients with flat retinas ($p < 0.01$).

Binary logistic regression analysis was performed and revealed that insufficient endo-laser was the independent risk factor affecting the final status of the retina.

Discussion

This study, conducted on a Jordanian population with RRD, assessed the factors affecting the recurrence of RRD (during and after SO tamponade), as well as factors affecting the retinal status at the last follow-up. To the best of our knowledge, this is the first reported study to be conducted in Jordan. Findings revealed that three-quarters of the patients were male individuals, with approximately half having a history of prior ocular surgery. The superior RRD, along with the superior-temporal breaks, were most commonly encountered. The rate of recurrent RRD was 28.2%. The recurrence of RRD was higher with younger age, longer symptom duration, prior ocular trauma, PPV, total RRD or four-quadrant detachment, involvement of inferior quadrants, macular detachment, and the presence of PVR. Furthermore, performing a complete 360-degree prophylactic laser was related to a protective effect against recurrent RRD. Regarding the retinal status at the last follow-up, young patients, longer presentation duration, total RRD, detached macula, the absence of tears during the PPV, the involvement of inferior-nasal quadrant, recurrent RRD, and inadequate prophylactic laser were related to a higher risk of detached retina at the final follow-up.

RRD is the separation of the neurosensory retina from the underlying retinal pigment epithelium. The attachment forces between these layers are inherently weak, and once overwhelmed, the detachment can occur rapidly.[14,21] Universally, high myopia and horseshoe retinal tears are recognized as significant risk factors contributing to the incidence of RRD.[22–24] In a study conducted by Moussa et al, significant risk factors associated with RRD included a younger age group, high myopia, male sex, and the presence of horseshoe tears.[24] The characteristics and location of the RRD are dictated by the type and location of the underlying retinal breaks.[25,26]

Regarding the role of previous ocular surgery and trauma, Sung et al found that patients with pseudophakic eyes and a history of ocular trauma significantly increased the risk of total RRD than partial RRD.[27] Cataract surgery can cause posterior vitreous detachment, and blunt trauma can impose traction on the vitreous, increasing the risk for RRD.[28] Cardillo et al found that ocular injuries were associated with PVR.[29] A previous report focused on phacoemulsification, the primary method of cataract extraction, estimated the 10-year risk of pseudophakic RRD to range between 0.36% and 2.9%.[30] A recent study reported the incidence and risk factors of RRD after modern cataract surgery and found that the 1-year incidence of RRD after cataract surgery was 0.21%.[31] The risk of pseudophakic RRD is considered to be higher in the first 6–24 months after cataract surgery.[9] Some factors, such as posterior capsule rupture or the operation being performed by a trainee surgeon, have been shown to shorten the median time from surgery to pseudophakic RRD. In terms of prior PPV, Momenaei et al demonstrated that recurrent RRD can develop following any RRD repair, regardless of the initial method, although risk appeared the lowest in patients with combined PPV and scleral buckle, though this was not statistically significant.[4] In our study, the previous ocular history of PPV was associated with a higher risk of recurrent RRD. One hypothesis that may explain the risk of recurrent RRD after PPV is that the remaining peripheral vitreous might contract due to postoperative inflammation, resulting in new peripheral breaks. This inflammation may also be an instigator for PVR development.[32]

PVR is currently regarded as one of the most significant factors in recurrent RRD and surgical failure, with success rates reduced to between 45% and 85% in cases involving PVR.[33–36] Williamson et al reported that the presence of PVR lowers surgical success rates by 22%. Their study also identified inferonasal or posterior breaks and four-quadrant RRD as risk factors for recurrence in patients with PVR.[37] However, these findings contrast with those of Irigoyen et al, who found no significant association between PVR and recurrent RRD.[9] In our study, PVR was significantly associated with recurrent RRD and PVR was found in 46.9% of recurrent RRD cases. Regarding the involvement of the inferior

quadrants, Irigoyen et al found that RRD recurrence was significantly associated with inferior sector involvement, with recurrent RRD being observed in over a third (34.3%) of these cases.[9] These results were similar to our analyses, where the involvement of inferior-nasal and inferior-temporal was associated with a higher risk of recurrent RRD.

Irigoyen et al also found a significant association between sex and recurrent RRD.[9] In their study, 63.5% of patients were male individuals. The recurrence rate in male patients was 33.1% versus 21.6% in female patients.[9] Similarly, Callaway et al found that women were less likely than men to undergo operation for recurrent RRD.[38] A large study was conducted by Radeck et al on 5791 eyes with RRD and found that a total of 300 patients (5%) had bilateral RRD.[1] According to their study, 220 (of the bilateral cases) patients were male individuals (73%), and the mean age at initial RRD was 55 years.[1] However, males were not shown to have a statistically higher rate of recurrent RRD. The observed gender discrepancy may be attributed to men's larger axial lengths and variations in vitreous base size.[39,40] Moreover, men are prone to more trauma, such as head contusions and ocular injury.[41] The enrollment of trauma patients in our study may contribute to a higher male percentage than other studies. In this study, the mean age for patients with recurrent RRD was younger. However, in binary logistic analysis, age was an independent factor. Age, as a risk factor, is controversial. While most previous articles reported that old age is a risk factor for recurrent RRD, other papers reported different results. Jia LY et al reported that middle-aged patients (40–59) are risk factor for recurrent RRD.[8] Furthermore, Irigoyen et al reported that patients younger than <50 years are more likely to develop recurrent RRD than patients from 50 to 80 years.[9] Regarding our study, the involvement of trauma patients and congenital cataract patients may contribute to the younger age of the patients.

The long presentation period before diagnosis reported by many of our patients requires a critical examination. The mean duration of presentation in recurrent RRD group was 75.1 days in comparison to 20.2 days for patients with one RRD. Longer reported duration increases the rate of macula-off RRD, PVR rate, a large area of involvement, and a poorer functional outcome,[9] warranting the need for increased awareness of the symptoms of RRD in the population. Prophylactic laser retinopexy of high-risk lesions to prevent the development of RRD may have a crucial role.[3,42–44] Avitabile et al reported in their study a reduction in the rate of bilateral RRD from 13.4% to 1.2% after prophylactic photocoagulation, cryotherapy, or scleral buckle in 305 phakic fellow eyes with predisposing retinal lesions.[45] Morris et al investigated the outcomes of observation, focal retinopexy, and 360-degree retinopexy on 269 pseudophakic fellow eyes.[2] They revealed that 33 of 175 untreated fellow eyes (19%) developed RRD, while five of 22 focally treated fellow eyes (23%) experienced RRD. In contrast, only one of 72 fellow eyes (1.4%) receiving 360-degree prophylaxis developed RRD during an average follow-up period of 5 years.[2] In this study cohort, eyes that underwent completed 360-degree laser during PPV had lower rates of recurrent RRD. However, even with laser treatment securing high-risk lesions, RRD may still occur.[3,19,46,47] Retinal breaks leading to subsequent RRD in treated fellow eyes can also develop near (anterior or posterior) areas of prophylactic treatment in approximately 20% of the cases.[19,48] Therefore, safety and efficacy of prophylactic treatment remain controversial.

Limitations

This study had some limitations. First, it was retrospective in nature, which may compromise the reliability of the data compared to those of a prospective study. Additionally, multiple ophthalmologists attended to the patients, potentially introducing variability in clinical examinations and case note recordings, which could affect data quality. Furthermore, not all the essential information was available for analysis, and many patients had incomplete data. However, there were no systematic differences between patients with and without missing data that could affect the end results. Moreover, data regarding postoperative complications such as macular edema or uveitis was included. In addition, a longer follow-up period, such as one year, would provide more robust data. Finally, this study was based on a 23-gauge vitrectomy system and the more advanced systems (such as 25-gauge or 27-gauge) were not considered.

Conclusion

A definitive study regarding the risk factors for recurrent RRD and the optimal surgical technique for primary RRD has yet to be conducted. This study revealed that recurrent RRD may be more prevalent among those with longer symptom durations, extensive total RRD, the presence of PVR, and insufficient prophylactic laser treatment.Enhancing awareness of RRD symptoms, identifying patients at risk for the development of RRD, and ensuring timely surgical intervention

may reduce the complications related to RRD and enhance the success rates. Larger, international, and multi-center studies are needed to establish the main risk factors and optimal surgical methods for these cases.

Abbreviations

RRD, Rhegmatogenous Retinal Detachment; PVR, Proliferative Vitreoretinopathy; PVD, Posterior Vitreous Detachment; PPV, Pars Plana Vitrectomy; IOL, Intraocular Lens; BCVA, Best-Corrected Visual Acuity; LogMAR, Logarithm of the Minimum Angle of Resolution; IOP, Intraocular Pressure; OCT, Optical Coherence Tomography; SEM, Standard Error of the Mean; CPM, Cuts Per Minute; SF_6, Sulfur Hexafluoride; C_3F_8, Octafluoropropane; SO, Silicone Oil.

Data Sharing Statement

The datasets generated and analyzed during this study are available from the corresponding authors upon reasonable request.

Ethical Approval

This study was conducted in accordance with the 1964 Declaration of Helsinki and its later amendments. Ethical approval was obtained from the Institutional Review Board (IRB) at Jordan University of Science and Technology and King Abdullah University Hospital, Irbid, Jordan (2022/148/56). The authors confirm that patients' privacy was maintained, and the data were anonymized and kept confidential. The IRB waived the need for consent due to the study's retrospective nature.

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Disclosure

The authors report no conflicts of interest in this work.

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