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Factors associated with Retinal Displacement following Rhegmatogenous Retinal Detachment Repair: A prospective study

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Abstract

Objectives

To investigate the incidence and factors influencing retinal displacement as well as functional visual outcomes following rhegmatogenous retinal detachment (RRD) repair.

Methods

A prospective observational study which included patients ≥ 18 years old treated for primary, uncomplicated RRD at a tertiary vitreoretinal referral center between July 2023 and June 2024. Consecutive patients who underwent primary RRD repair were assessed with fundus autofluorescence and optical coherence tomography imaging within four months postoperatively.

Results

112 eyes were treated with vitrectomy and endotamponade (with/ without scleral buckle), 10 eyes had primary scleral buckle and one eye had pneumatic retinopexy. Retinal displacement was evident in 26 of 123 eyes (21.1%) post RRD repair. There was a significant correlation between macula displacement and lens status. Pseudophakic RRD was four times more likely than phakic RRD to have retinal displacement postoperatively. No significant correlation was observed between retinal displacement and RRD extent, preoperative macula status, surgical technique, and intraocular tamponade. Retinal displacement also did not affect postoperative visual outcome in our cohort, whereas preoperative macular status and intraocular gas tamponade did.

Conclusions

Retinal displacement is observed after RRD repair, particularly in pseudophakic eyes, but does not appear to have an impact on postoperative visual outcomes. Macular involvement and intraocular gas tamponade remain stronger predictors of visual distortion, highlighting the need for further studies to clarify the clinical relevance of displacement.

Introduction

Rhegmatogenous retinal detachment (RRD) is a common ocular emergency which constitute one of the major causes of acute visual loss. The annual international incidence of RRD was estimated to be 12.17 per 100,000 population and about one in 10,000 develop RRD each year.(1)

RRD patients require urgent referral to a vitreoretinal surgeon for prompt surgical repair, especially in cases where the macula is still attached. RRD is primarily treated with either scleral buckling (SB), pars

plana vitrectomy (PPV), pneumatic retinopexy, or combined PPV- encircling SB. With the advancement in treatment, primary reattachment rate following RRD repair have improved tremendously ranging from 73 to 92% (2, 3) However, despite successful reattachment and excellent visual acuity (VA) in most patients, up to a third of patients complain of visual distortions postoperatively. (4–6)

In current era of retinal detachment repair, the definition of treatment success has shifted significantly from simply achieving anatomic reattachment to now encompassing the restoration of the original structural integrity of reattachment. This is further aided by advancements in retinal imaging which allow observation of a variety of anatomic imaging biomarkers such as presence of hyperfluoresecent line adjacent and parallel to retinal vessels on fundus autofluorescence (FAF) after RRD repair. These hyperfluorescent lines, also known as 'retinal vessel printings" (RVP) or alternatively "retinal pigmented epithelium (RPE) ghost vessels" may reflect the augmented metabolic activity of previously hidden RPE now exposed to light following unintentional displacement of retinal vessels postoperatively. (6–9)

RVP has been identified as an important imaging biomarker for integrity of attachment after RRD repair. (5) A few studies have since suggested that retinal displacement could be responsible for suboptimal functional outcomes postoperatively, causing reduced visual acuity, diplopia or distorted vision. (6, 10, 11). The rate of retinal displacement has been reported to range from 35–72% after vitrectomy. (6, 7, 11–13) Various ocular and surgical factors have also been found to play a role in retinal displacement. (7, 11, 12, 14)

The aims of this study were to determine the incidence of retinal displacement, factors promoting its occurrence and association with visual distortion following RRD repair in a tertiary hospital in Peninsular Malaysia.

Materials and Methods

Patients

This prospective observational study included patients ≥ 18 years old treated for primary, uncomplicated RRD at Hospital Selayang, a tertiary vitreoretinal referral center between June 2023 and June 2024. All subjects were treated in accordance with the Declaration of Helsinki. This study was approved by the institutional Review Board of Hospital Selayang. Informed consent was obtained from all participants.

Exclusion criteria were presence of the following in study eye: history of previous retinal detachment, history of vitreoretinal surgery, preexisting macular condition, presence of proliferative vitreoretinopathy (PVR) grade C or greater, giant retinal tears, redetachment during follow-up, postoperative macular changes [e.g., overt macular epiretinal membranes (ERM), residual subretinal fluid (SRF), macula hole] and dense ocular opacity which preclude accurate evaluation of images.

Preoperative data collected include demographics [age, gender, medical history, myopic status defined as spherical equivalent refractive error (SE) of an eye ≤ -0.5 D when ocular accommodation is relaxed,

lens status and chronicity of RRD (acute RRD ≤ 2 weeks, chronic RRD > 2 weeks)]. Post operative data collected include retinal detachment features (location, quadrants involved, clock hours, location and number of retinal breaks, fovea status, presence of PVR) and intraoperative details (surgical technique, type of tamponades, heavy liquid use, presence of retinotomy).

Postoperative follow-ups were scheduled between one to four months, where patient underwent repeated ophthalmologic examinations and were evaluated with FAF and OCT imaging. During the visit, patients were asked if they experience distortion of straight lines when looking with just the operated eye, or a difference in image size between the two eyes. Visual acuities were tested using Snellen VA and converted to logMAR equivalent for the purpose of statistical analysis. Note that some of the eyes had intraocular tamponade in situ during VA check.

Surgical technique

Local anesthesia was given by retrobulbar or peribulbar route. For patients who underwent vitrectomy, 23G PPV was performed in all cases using a Constellation vitrectomy system (Alcon Labs, Fort Worth, TX, USA). A central and peripheral vitrectomy with scleral indentation was performed, and the vitreous base was shaved to relieve vitreous tractions on the retinal tears. Posterior retinotomy was performed in selected cases to facilitate drainage of SRF. After careful 360^{o} inspection of the periphery, fluid/air exchange was then performed to drain the remaining SRF. Perfluorocarbon liquid (PFCL) was used if endodrainage of SRF fail to achieve satisfactory flattening of the retina. Endolaser were performed around the retinal breaks and drainage retinotomy site. Finally, 16% perfluoropropane gas (C3F8) or silicone oil (SO) of various viscosity (1000–5700 centistokes) was used as the internal tamponade. The patients were placed in prone posture immediately after completion of surgery and over the next 24 hours, and subsequent posturing with the primary break at highest point for the next 1 week.

Imaging

FAF imaging was performed with Digital Retinal Camera CR-2 Plus AF (Canon Inc., Canon, Japan). OCT macula and some B-FAF images (excitation wavelength at 488 nm and barrier filter at 500 nm) were acquired using Spectralis HRA + OCT (Heidelberg Engineering, Heidelberg, Germany), which combines a confocal scanning laser ophthalmoscope with spectral-domain OCT.

Cross sectional macular images were captured to detect for post-operative changes that were likely to interfere with accurate evaluation of images e.g., overt macular ERM, residual SRF and macula hole. FAF image was used to assess for the presence of RVPs and their in relation to the adjacent retinal vessels. RVPs were defined as hyperautofluorescent lines running approximately parallel to retinal blood vessels and with a similar contour but separate from the blood vessel. The presence of RVPs was taken as evidence of retinal displacement only in the absence of confluent SRF on the corresponding OCT scan (to exclude potential artefact from a parallax effect).

Postoperatively, two independent graders (excluding authors and surgeons) who are retinal specialists assessed the presence of RVPs. When there was disagreement between the two graders, a third grader decided which grader's judgement should be accepted.

Statistical analysis

Categorical variables were will be reported as counts and percentages and compared using Chi-square test or Fisher's Exact test. Continuous variables will be reported as mean with standard deviation or median with interquartile range, and compared using independent sample T-test or Mann-Whitney U test.

Multiple logistic regression analysis was performed to determine whether there was a significant association among independent variables (ocular factors and surgical factors) and dependent variable (unintentional retinal displacement). Coefficients with 95% confidence intervals was reported. A P value of < 0.05 was considered significant.

Data was analyzed using SPSS (SPSS Inc., Chicago, IL).

Results

Demographics and clinical characteristics of the patient sample

A total of 241 patients were recruited during the study period of whom 116 patients were excluded due to media opacity or overt macular changes, and a further 6 patients were excluded due to incomplete follow up data. 119 patients (n = 123 eyes) remained in the study for further analysis. There were 74 males (62.2%) and 45 females (37.8%) with mean age of 49.83 ± 15.37 years.

At enrollment, 84 (68.3%) eyes were phakic and 39 (31.7%) eyes were pseudophakic. Three eyes were left aphakic postoperatively. Forty-six (37.4%) eyes were myopic of whom 22 (47.8%) were high myope (SE ≤ − 6.00 D). Sixty-nine (56.1%) eyes presented acutely within 2 weeks from symptoms onset (median = 7 days, range 1-1825 days). Mean presenting VA was 1.50 ± 1.08 logMar. There were 99 (80.5%) eyes with macula involving retinal detachment. Retinal detachment extended across superior-inferior quadrants in 74 (60.2%) eyes, confined to superior or inferior hemisphere in 21 (17.1%) and 28 (22.8%) eyes, respectively. Four (3.3%) eyes had RRD involving 1 quadrant, 61 (49.6%) eyes involving 2 quadrants, 16 (13.0%) eyes involving 3 quadrants and 39 (31.7%) involving 4 quadrants, approximately translated to a mean of 7.31 ± 3.07 clock hour involvement in study eyes. Retinal breaks were located in upper hemisphere in 69 (59.5%) eyes, in lower hemisphere in 31 (26.7%) and in both upper and lower hemispheres in 16 (13.8%) eyes. Retinal break is singular in 66 (57.9%) eyes.

There were 24 macula-on and 99 macula-off RRD eyes in current study. From the study, 10 eyes (8.1%, 2/10 macula-off RDs) were treated with cryo-buckle non-drain procedures, 54 eyes (43.9%, 44/54 macula-off RRDs) with vitrectomy and tamponade, 58 eyes (47.2%, 53/58 macula-off RRDs) combined encircling buckle, vitrectomy and tamponade and 1 eye (0.8%, macula on) with pneumatic retinopexy.

Among eyes which underwent vitrectomy (n = 112), 75 (67%) eyes received gas tamponade C3F8; whereas 37 (33%) eyes received SO tamponade. PFCL assisted SRF drainage was used in only 6/ 112 (5.4%) eyes. 27/ 112 eyes (24.1%) required additional posterior retinotomy to facilitate drainage of SRF. All numerical data (age, presenting logMAR VA, extent of retinal detachment) were normally distributed except for detachment duration and number of retinal breaks.

Macular displacement

After surgical repair, retinal displacement was observed in 26 of 123 eyes (21.1%) during the first postoperative follow-up at median of 47 days (range = 1-180 days). Variations in follow-up schedule exist as some patients were reviewed postoperatively at respective referring units for ease (Table 1).

Table 1
Demographics, ocular and RRD features, surgical factors and postoperative characteristics of the groups with and without retinal displacement after RRD repair (n = 123 eyes, simple logistic regression)

Demographics	**Retinal displacement absent, n (%)**	**Retinal displacement present, n (%)**	**p-value[a]**	**Odds Ratio (95% Confidence interval, CI)**	**p-value**
	(n = 97)	**(n = 26)**			
Age (years), mean ± SD	**47.68 ± 15.09**	**57.85 ± 13.93**	**0.001[b]**	**1.049 (1.016,1.084)**	**0.004**
Gender	58 (59.8)	18 (69.2)	0.379	1.000	0.381
Female	39 (40.2)	8 (30.8)		1.513 (0.599,3.821)	
Male					
Race	67 (69.1)	9 (34.6)	0.006[c]	1.000	0.014
Malay	19 (19.6)	9 (34.6)		3.526 (1.228,10.128)	0.019
Chinese	8 (8.2)	7 (26.9)		6.541 (1.904,22.288)	0.003
Indian	3 (3.1)	1 (3.8)		2.481 (0.232,26.485)	0.452
Others					
Ocular factors	66 (68.0)	21 (80.8)	0.205	1.793 (0.680,5.720)	0.211
Laterality	31 (32.0)	5 (19.2)			
OD					
OS					
Lens status	74 (76.3)	10 (38.5)	< 0.001	1.000	< 0.001
Phakic	23 (23.7)	16 (61.5)		5.148 (2.055,12.895)	
Pseudophakic					
Myopia status	39 (40.2)	7 (26.9)	0.214	1.000	0.218
Yes	58 (59.8)	19 (73.1)		1.825 (0.701, 43.752)	
No					
Presenting VA (logMAR), mean ± SD	1.48 ± 1.07	1.54 ± 1.12	0.805[b]	1.053 (0.703,1.576)	0.803
RRD characteristics	53 (66.3)	16 (66.7)	0.970	1.000	0.970
Detachment duration	27 (33.8)	8 (33.3)		0.981 (0.373,2.581)	

Demographics	**Retinal displacement absent, n (%)**	**Retinal displacement present, n (%)**	**p-value[a]**	**Odds Ratio (95% Confidence interval, CI)**	**p-value**
Age (years), mean ± SD	**(n = 97)**	**(n = 26)**			
	47.68 ± 15.09	**57.85 ± 13.93**	**0.001[b]**	**1.049 (1.016,1.084)**	**0.004**
Acute (≤ 2 weeks)					
Chronic (> 2 weeks)					
Detachment location	17 (17.5)	4 (15.4)	0.825	1.000	0.825
Superior	57 (58.8)	17 (65.4)		1.268 (0.376,4.278)	0.702
Superior-inferior	23 (23.7)	5 (19.2)		0.924 (0.215,3.965)	0.915
Inferior					
Detachment (clock hours), mean ± SD	7.18 ± 3.04	7.79 ± 3.20	0.195[a]	1.067 (0.921,1.236)	0.386
Detachment (quadrant)	54 (56.8)	11 (44.0)	0.252	1.000	0.254
≤ 2	41 (43.2)	14 (56.0)		1.676 (0.690,4.074)	
> 2					

Macula status	**21 (21.6)**	**3 (11.5)**	**0.248**	**1.000**	**0.256**
On	**76 (78.4)**	**23 (88.5)**		**2.118 (0.579,7.746)**	
Off					
Break's location	50 (54.3)	19 (79.2)	0.025[c]	Unable to compute	
Superior	16 (17.4)	5 (20.8)			
Inferior	26 (28.3)	0			
Superior inferior					
No. of breaks, median (IQR)	1 (7)	1 (2)	0.757[d]	0.754 (0.470,1.209)	0.241
PVR	78 (80.4)	21 (80.8)	0.967	1.000	0.967
No	19 (19.6)	5 (19.2)		1.023 (0.342,3.063)	
Yes					
Surgical factors	9 (9.3)	1 (3.8)	0.774[c]	1.000	0.617
Surgical technique	46 (47.4)	12 (46.2)		2.348 (0.270,20.388)	0.439
Primary SB	41 (42.3)	13 (50.0)			0.341
SB PPV	1 (1.0)	0 (0)		2.854 (0.330,24.698)	
PPV				Unable to compute[†]	
Pneumatic retinopexy					
Tamponade	58 (59.8)	18 (69.2)	0.563	1.000	0.579
Gas	30 (30.9)	7 (26.9)		0.752 (0.283,1.999)	0.345
SO	9 (9.3)	1 (3.8)		0.358 (0.042,3.021)	0.345
No tamponade					

[a]Chi-square tests were carried out unless specified

[b]Independent T test was performed

[c]Fisher's exact test was performed

[d]Mann-Whitney test was performed

[†] Pneumatic retinopexy excluded from analysis due to zero cell

Macula status **On** **Off**	**21 (21.6)** **76 (78.4)**	**3 (11.5)** **23 (88.5)**	**0.248**	**1.000** **2.118 (0.579,7.746)**	**0.256**
Retinotomy No Yes	68 (78.2) 19 (21.8)	17 (68.0) 8 (32.0)	0.295	1.000 1.684 (0.631,4.498)	0.298
Post operative characteristics Post op VA (logMAR), mean ± SD	0.90 ± 0.67	1.03 ± 0.71	0.381[b]	1.318 (0.712, 2.440)	0.379
Metamorphopsia No Yes	64 (68.1) 30 (31.9)	17 (65.4) 9 (34.6)	0.795	1.000 1.129 (0.451,2.826)	0.795
Aniseikonia No Yes	76 (80.9) 18 (19.1)	19 (73.1) 7 (26.9)	0.388	1.000 1.556 (0.568,4.260)	0.390
[a]Chi-square tests were carried out unless specified					
[b]Independent T test was performed					
[c]Fisher's exact test was performed					
[d]Mann-Whitney test was performed					
[†] Pneumatic retinopexy excluded from analysis due to zero cell					

The group with and without retinal displacement were comparable in terms of gender, myopic status, preoperative VA and duration of detachment. Location and extent of RRD, location and number of retinal breaks, fovea status and PVR status did not affect the rate of retinal displacement. Surgical factors also did not affect the rate of retinal displacement in current study. Although not statistically significant (P = 0.774), retinal displacement was less frequent in eyes that underwent SB (1/10 eyes, 10.0%) than PPV (13/54 eyes, 24.1%) or combined SB/PPV (12/58 eyes, 20.7%). There was also lower incidence of retinal displacement in SO filled eye (7/37 eyes, 18.9%) as compared to gas filled eye (18/76 eyes, 23.7%), P = 0.563. Gas tamponade resulted in more downward than upward displacement. SO filled eye did not report a directional preference of retinal displacement (Table 1).

From simple logistic regression, older age and pseudophakia were found to have higher incidence of retinal displacement (Table 1). Multiple logistic regression showed that pseudophakia was the only

significant factor of retinal displacement (odds ratio, 4.667; P = 0.002) (Table 2). Subgroup analysis of RRD features by lens status revealed traits of pseudophakic RRD: older age (P < 0.001), more extensive detachment involving > 2 quadrants (P = 0.013), frequent foveal involvement (P = 0.085), and retinal breaks commonly located in the superior hemisphere (P = 0.351) (Table 5).

Table 2
Factors associated with retinal displacement (multiple logistic regression)

Variable	b	Adjusted odds ratio (95% CI)	p-value
Pseudophakia (Ref: phakic)	1.540	4.667 (1.775, 12.267)	0.002
Multiple stepwise logistic regression was performed with adjustment of age, myopic status, lens status, RRD extent (quadrants), macula status, number of retinal breaks, intraocular tamponade and surgical technique.			
Model fit was examined using the Hosmer-Lemeshow test (p = 0.298), classification table (78.4%) and area under receiver operating characteristic curve (74.7%).			
CI, confidence interval			

Table 3
Factors associated with post operative metamorphopsia (multiple logistic regression)

Variable	b	Adjusted odds ratio (95% CI)	p-value
macula detachment (Ref: no macula detachment)	1.775	5.255 (1.012, 27.298)	0.048
Gas tamponade (Ref: SO)	1.567	4.012 (1.454, 11.071)	0.007
Multiple stepwise logistic regression was performed with adjustment of pre and post operative VA, macula status, RRD extents (quadrant), intraocular tamponade, surgical technique and duration of follow up.			
Model fit was examined using the Hosmer-Lemeshow test (p = 0.232), classification table (68.4%) and area under receiver operating characteristic curve (75.5%)			
CI, confidence interval; SO, silicon oil; VA, visual acuity			

Table 4
Factors associated with post operative aniseikonia (multiple logistic regression)

Variable	b	Adjusted odds ratio (95% CI)	p-value
Gas tamponade (Ref: SO)	1.409	4.093 (1.093, 15.334)	0.036
Multiple stepwise logistic regression was performed with adjustment of age, detachment duration, pre operative VA, RRD extent (quadrant), macula status, intraocular tamponade and follow up duration.			
Model fit was examined using the Hosmer-Lemeshow test (p = 0.142), classification table (78.0%) and area under receiver operating characteristic curve (75.4%)			
CI, confidence interval; SO, silicon oil			

Table 5
RRD features and retinal displacement between pseudophakic and phakic eyes (n = 123 eyes).

Age, median (IQR)	**Pseudophakic retinal detachment, n (%)**	**Phakic retinal detachment, n (%)**	**P-value[a]**
	(n = 39)	**(n = 84)**	
	65 (11)	**42.5 (20)**	**< 0.001[b]**
Detachment (quadrant)	15 (38.5)	50 (61.7)	0.017
≤ 2	24 (61.5)	31 (38.3)	
> 2			
Macula status	4 (10.3)	20 (23.8)	0.078
On	35 (89.7)	64 (76.2)	
Off			
Break's location	18 (50.0)	51 (63.7)	0.288
Superior	13 (36.1)	18 (22.5)	
Inferior	5 (13.9)	11 (13.8)	
Superior inferior			
Number of breaks	21 (53.8)	45 (53.6)	0.977
Singular	18 (46.2)	39 (46.4)	
Multiple			
PVR	9 (23.1)	15 (17.9)	0.497
Yes	30 (76.9)	669 (82.1)	
No			
Tamponade	24 (61.5)	52 (61.9)	0.238
Gas	14 (35.9)	9 (10.7)	
SO	1 (2.6)	23 (27.4)	
No tamponade			
Retinal displacement	16 (41.0)	10 (11.9)	< 0.001

[a]Chi-square tests were carried out unless specified

[b] Mann-Whitney test was performed

Age, median (IQR)	Pseudophakic retinal detachment, n (%) (n = 39)	Phakic retinal detachment, n (%) (n = 84)	P-value[a]
	65 (11)	**42.5 (20)**	**< 0.001[b]**
Yes	23 (59.0)	74 (88.1)	
No			
[a]Chi-square tests were carried out unless specified			
[b] Mann-Whitney test was performed			

Visual outcome

We observe an improvement in overall logMAR VA from 1.51 ± 1.08 preoperatively to 0.92 ± 0.68 postoperatively at follow up. Eyes with retinal displacement showed less VA improvement (logMAR 1.54to 1.03) than those without (logMAR 1.48 to 0.9). However, the difference was not statistically significant (P = 0.381) (Table 1).

In our study, metamorphopsia was reported in 39 eyes (31.7%) postoperatively. Among eyes with RVPs, 34.6% (9/26) demonstrated metamorphopsia. No correlation was found between postoperative metamorphopsia and retinal displacement (P = 0.795) (Table 1). Multiple logistic regression analysis identified preoperative macular detachment (P = 0.048, OR = 5.255, 95% CI = 1.012–7.298) and the use of intraocular gas tamponade (P = 0.007, OR = 4.012, 95% CI = 1.454–11.071) significant predictors of postoperative metamorphopsia.

Aniseikonia was observed in 25 eyes (20.3%) postoperatively, with all patients reporting micropsia. There was no significant association between aniseikonia and retinal displacement (P = 0.388), although 26.9% (7/26) of eyes with RVPs exhibited aniseikonia (Table 1). Stepwise multivariate regression analysis demonstrated that intraocular tamponade type was the sole significant predictor. Gas tamponade was associated with a fourfold higher likelihood of postoperative aniseikonia compared with silicone oil. (P = 0.036, OR = 4.093, 95% CI = 1.093–15.334).

Discussion

There has been a recent interest and an increasing body of evidence exploring photoreceptor realignment following retinal reattachment surgery. The prevalence of retinal displacement ranges between 35% and 72% for PPV. (15) The theoretical concept of photoreceptor realignment following retinal reattachment was raised almost fifty years ago but was not actively investigated until recently with the advent of multimodal imaging. Shiragami et al. first identified hyperfluorescent lines on FAF imaging following retinal detachment surgery in 2010. These hyperfluorescent lines is termed “retinal

vessel printings” or “RPE ghost vessels”. Shiragami postulated that these hyperfluorescent lines were caused by increased metabolic activity in previously concealed RPE cells which were exposed to light postoperatively. (7) On the other hand, Dell’Omo et al. theorized that the inherent difference in fluorescent spectral properties and fluorophores between concealed and unconcealed RPE cells has given rise to retinal vessel printings even years after surgery. (6) Those lines were thought to represent unintentional retinal displacement after RRD repair and have been used to assess the integrity of retinal reattachment. High integrity retinal reattachment is defined as the absence of RVP on FAF imaging postoperatively and vice versa, which presumably indicates an alignment of photoreceptors closer to their original position relative to the RPE cells.

Different surgical methods for repairing RRD may lead to varying rates of retinal displacement. (16) Brosh et al. proposed that retinal displacement occurs more frequently and is more severe following PPV as compared to pneumatic retinopexy.(10) SB is not as frequently associated with retinal displacement and has been demonstrated in some studies to be superior to PPV in that regard. (17, 18) Rohowetz et al. demonstrated in a small retrospective series that retinal displacement is an infrequent complication of SB surgery for macula-involving RRD, occurring in only 1 of 12 eyes studied.(19) Bansal et al. demonstrated in their prospective study that SB without external SRF drainage is less associated with retinal displacement compared to SB with external drainage or SB-PPV. (17) Our study produced corresponding results where SB (none had external drainage) resulted in retinal displacement less frequently as compared with PPV and SB-PPV. This is because PPV uses forced internal drainage during surgery. With air-fluid exchange in PPV, there is also a near 100% gas fill which exerts a large buoyant force on a larger area of a relatively mobile retina. Therefore, PPV causes more iatrogenic movement of SRF, in contrast to pneumatic retinopexy and SB which allow for a more natural reabsorption of SRF by the RPE, thus reducing the risk of retinal displacement. (15) Although our study demonstrated a relatively lower rate of retinal displacement in eyes that underwent primary SB, the findings cannot be generalized owing to the limited sample size in this cohort.

Retinal displacement is consistently influenced by the type of tamponade used. Studies by Pandya et al. and Codenotti et al. reported that SO tamponade is associated with a lower incidence of displacement as compared to gas (5, 12) In the current study, we observed a higher incidence of displacement in eyes treated with gas (C3F8) than with SO. These differences can be explained by the distinct physical properties of the tamponades. SO has higher specific gravity, lower interfacial tension and reduced buoyancy relative to gas, facilitating natural egression of SRF and reducing the likelihood of retinal slippage. (7) In contrast, gas bubbles exert forces approximately 30 times greater than SO, stretching the retina against RPE, and leading to reattachment misaligned with its original position. (6) Unlike prior reports, our study did not demonstrate directional preference related to tamponade type. (5, 6, 12) Downward dislocation occurred more frequently with both gas and silicone oil tamponades. Their lower density relative to water predisposes the retina to inferior displacement.

Unlike previous studies, we found a significant association between lens status and retinal displacement, whereby the pseudophakic RRD group was four times more likely than phakic RRD group

to have retinal displacement following RRD repair. To the best of our knowledge, this association has not been reported in other studies. (6, 10, 11) Literature review suggests that pseudophakic RRD is more prevalent in older age groups, typically involves a greater extent of retinal detachment, more frequent foveal involvement, multiple breaks (often located anteriorly and inferiorly), and higher incidence of PVR C. (20) A subgroup analysis of pseudophakic eyes with retinal displacement in our study revealed features consistent with pseudophakic RRD. These characteristics have also been recognized as risk factors for primary anatomical failure in RRD repair, leading us to believe that these may have contributed to the higher incidence of retinal displacement in pseudophakic compared to phakic eyes (41.0% vs. 12.3%, $P < 0.001$) in our cohort.

Consistent with previous observations, our findings indicate that the use of PFCL and adjuvant posterior retinotomies does not significantly reduce the incidence of displacement. Intraoperative OCT demonstrates that complete drainage of subretinal fluid is not achieved despite PFCL use or posterior retinotomies, suggesting that residual subretinal fluid at the conclusion of surgery does not play a decisive role in either promoting or preventing displacement.

In our cohort, eyes with clinical or OCT evidence of macular abnormalities were excluded, suggesting that visual distortion after retinal detachment surgery in otherwise normal maculae may be attributable to retinal displacement. However, our study showed that postoperative visual outcome did not have a positive association with the presence of RVPs on FAF, correspond with previous reports. (6, 7, 13) Prior studies further indicate that macular microstructural changes, beyond translocation or displacement, are likely the primary contributors to postoperative distortion. (21, 22) Thus, whether macular displacement alone is sufficient to explain visual complaints remains debatable.

Previous studies have shown that eyes with a larger extent of retinal detachment are more likely to develop postoperative metamorphopsia and aniseikonia, and our findings were similar, with half of the patients reporting visual distortion having RRD involving more than two quadrants.(21, 23, 24) Interestingly, the current study showed that a more extensive RRD did not correspond to a higher frequency of retinal shift, suggesting that the increased incidence of visual distortion observed could be attributable to other factors related to extent of RRD, such as macular microstructural changes.

Consistent with prior reports, macula-involving RRD was associated with higher odds of postoperative distortion, likely due to separation of the macula from the RPE and disruption of photoreceptor–RPE metabolic function.(22, 23, 25, 26) While we excluded eyes with overt OCT anomalies, microstructural macular changes not assessed in our study may also underlie postoperative distortion. (21–23) Finally, intraocular gas tamponade emerged as a significant predictor of both metamorphopsia and aniseikonia, likely through retinal stretching or compression of photoreceptors, with the high interfacial tension of gas accentuating this effect against the RPE and inducing postoperative image distortion.

The identification of retinal displacement is largely influenced by the imaging methods used. Variability exists among studies in terms of FAF imaging techniques and retinal field sizes. Casswell et al. proposed that differences in excitation wavelengths between imaging modalities—specifically, the longer

wavelength (530–580 nm) used by fundus cameras compared to the 488 nm wavelength employed in confocal scanning laser ophthalmoscopy (cSLO)—may impact the detection of retinal displacement by stimulating fundal fluorophores differently. (14) Despite these differences, both imaging methods yield comparable results, albeit with only moderate agreement. In our study, we improved our detection rates by employing both fundus camera and cSLO imaging. However, recent concerns have been raised regarding the sensitivity of FAF imaging in detecting retinal displacement, particularly in cases where RVPs are subtle or the RPE mosaic is sparse. (27) This has highlighted the need for alternative imaging techniques. Brosh et al. explored a novel homography technique applied to infrared (IR) imaging and demonstrated its exceptional ability to accurately align retinal vessels in normal eyes, with high sensitivity and specificity in detecting true retinal displacement. (28) However, this method requires the availability of pre-detachment IR images, which may limit its applicability to certain medical centres and patient populations.

Limitation

The strengths of current study include prospective, cross-sectional design, excluded cases that are likely to increase the chances of displacement and affect visual outcomes, which could interfere with the accuracy of results (preexisting maculopathy, PVR grade C or worse, residual SRF, overt ERM and media opacity). The primary outcome, the presence or absence of RVPs, was assessed by two independent graders to avoid potential bias and caused falsely high or low reported rate of retinal displacement. We acknowledge the limitations of current study which include inadequate sample size, therefore affecting the power of the study, short follow-up period and lack of preoperative imaging for comparison postoperatively. The presence of visual distortion can also be assessed using more objective methods, i.e. Amsler grids or M-CHARTS (Inami & Co Ltd) for metamorphopsia; Awaya New Aniseikonia Test (Handaya, Tokyo, Japan) for aniseikonia.

Future longitudinal studies with adequate sampling and specific considerations for evaluation of pseudophakic RRD, more precise quantification of the presence or absence of retinal displacement, the degree, angle, and direction of displacement, and assessment of fovea microstructural changes can be carried out to further prognosticate retinal displacement.

Conclusion

Retinal displacement was observed in a proportion of eyes following primary RRD repair, particularly in pseudophakic cases. However, its presence did not influence postoperative visual outcomes in our cohort, whereas preoperative macular status and intraocular gas tamponade were significant predictors of visual distortion. These findings suggest that retinal displacement does not appear to have an impact on postoperative visual outcome compared with other clinical factors, and further studies are warranted to clarify its true clinical relevance.

Declarations

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Conflict of Interest

No conflicting relationship exists for any author.

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Author Contribution Statement

Dr Hui Wen was responsible for designing study, conducting the literature search, writing research proposal, collecting, extracting and analyzing data, interpreting results, updating reference lists and writing report. Dr Justin was responsible for reviewing study design, screening potentially eligible studies, review research proposal, data collection and writing report. Miss Fei Yee was responsible for study design, conducted regression analyses, interpreting results, creating 'Summary of findings' tables and writing the report. Dr Beatrice contributed to data collection and extraction and review the report. Dr Haireen and Dr Zabri designed study, reviewed research proposal and report.

References

1. Ge JY, Teo ZL, Chee ML, Tham YC, Rim TH, Cheng CY, et al. International incidence and temporal trends for rhegmatogenous retinal detachment: A systematic review and meta-analysis. Surv Ophthalmol. 2024;69(3):330–6.
2. Walter P, Hellmich M, Baumgarten S, Schiller P, Limburg E, Agostini H, et al. Vitrectomy with and without encircling band for pseudophakic retinal detachment: VIPER Study Report No 2-main results. Br J Ophthalmol. 2017;101(6):712–8.
3. Joseph DP, Ryan EH, Ryan CM, Forbes NJK, Wagley S, Yonekawa Y, et al. Primary Retinal Detachment Outcomes Study: Pseudophakic Retinal Detachment Outcomes: Primary Retinal Detachment Outcomes Study Report Number 3. Ophthalmology. 2020;127(11):1507–14.
4. Schawkat M, Valmaggia C, Lang C, Scholl HP, Guber J. Multimodal imaging for detecting metamorphopsia after successful retinal detachment repair. Graefes Arch Clin Exp Ophthalmol. 2020;258(1):57–61.
5. Pandya VB, Ho IV, Hunyor AP. Does unintentional macular translocation after retinal detachment repair influence visual outcome? Clin Exp Ophthalmol. 2012;40(1):88–92.

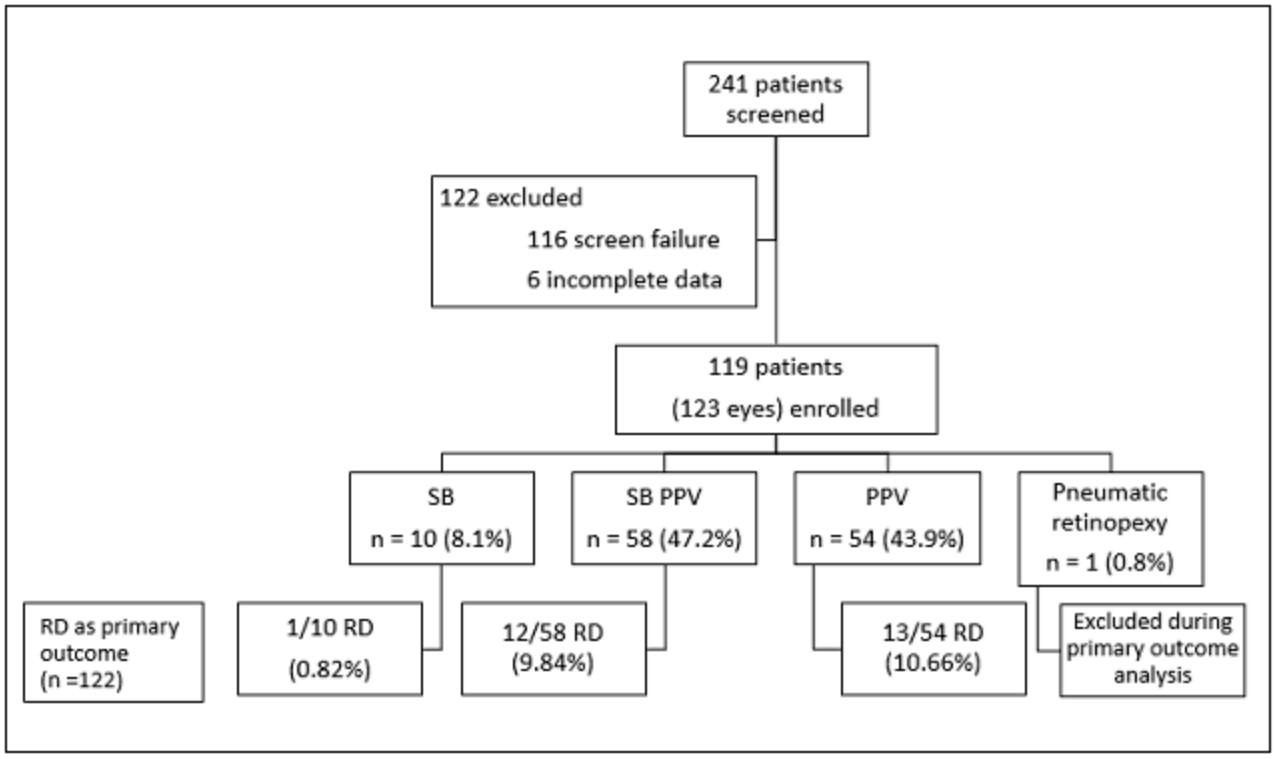
6. dell'Omo R, Scupola A, Viggiano D, Sammarco MG, De Turris S, Romano MR, et al. Incidence and Factors Influencing Retinal Displacement in Eyes Treated for Rhegmatogenous Retinal Detachment With Vitrectomy and Gas or Silicone Oil. Invest Ophthalmol Vis Sci. 2017;58(6):BIO191-BIO9.
7. Shiragami C, Shiraga F, Yamaji H, Fukuda K, Takagishi M, Morita M, et al. Unintentional displacement of the retina after standard vitrectomy for rhegmatogenous retinal detachment. Ophthalmology. 2010;117(1):86–92 e1.
8. Muni RH, Lee WW, Bansal A, Ramachandran A, Hillier RJ. A paradigm shift in retinal detachment repair: The concept of integrity. Prog Retin Eye Res. 2022;91:101079.
9. Brosh K, Roditi E, Muni RH. Retinal Vessel Printings on Fundus Autofluorescence Imaging Represent Retinal Displacement: Proof of Prior Hypothesis. Am J Ophthalmol. 2022;238:e3-e4.
10. Brosh K, Francisconi CLM, Qian J, Sabatino F, Juncal VR, Hillier RJ, et al. Retinal Displacement Following Pneumatic Retinopexy vs Pars Plana Vitrectomy for Rhegmatogenous Retinal Detachment. JAMA Ophthalmol. 2020;138(6):652–9.
11. Lee E, Williamson TH, Hysi P, Shunmugam M, Dogramaci M, Wong R, et al. Macular displacement following rhegmatogenous retinal detachment repair. Br J Ophthalmol. 2013;97(10):1297–302.
12. Codenotti M, Fogliato G, Iuliano L, Querques G, Maestranzi G, Prati M, et al. Influence of intraocular tamponade on unintentional retinal displacement after vitrectomy for rhegmatogenous retinal detachment. Retina. 2013;33(2):349–55.
13. Cobos E, Rubio MJ, Arias L, Caminal JM, Garcia-Bru P, Catala J, et al. Incidence and Relation with Anatomical and Functional Variables of Postoperative Macular Displacement in Rhegmatogenous Retinal Detachment. Retina. 2016;36(5):957–61.
14. Casswell EJ, Yorston D, Lee E, Heeren TFC, Harris N, Zvobgo TM, et al. Effect of Face-Down Positioning vs Support-the-Break Positioning After Macula-Involving Retinal Detachment Repair: The PostRD Randomized Clinical Trial. JAMA Ophthalmol. 2020;138(6):634–42.
15. Houle O, You E, Hebert M, Jin S, Qi SR, Dirani A. Retinal Displacement: Providing New Insights for Retinal Detachment Surgery. J Ophthalmol. 2021;2021:9999797.
16. Cruz-Pimentel M, Huang CY, Wu L. Scleral Buckling: A Look at the Past, Present and Future in View of Recent Findings on the Importance of Photoreceptor Re-Alignment Following Retinal Re-Attachment. Clin Ophthalmol. 2022;16:1971–84.
17. Bansal A, Naidu SC, Marafon SB, Kohler JM, In S, Mahendrakar PA, et al. Retinal Displacement after Scleral Buckle versus Combined Buckle and Vitrectomy for Rhegmatogenous Retinal Detachment: ALIGN Scleral Buckle versus Pars Plana Vitrectomy with Scleral Buckle. Ophthalmol Retina. 2023;7(9):788–93.
18. Heimann H, Hellmich M, Bornfeld N, Bartz-Schmidt KU, Hilgers RD, Foerster MH. Scleral buckling versus primary vitrectomy in rhegmatogenous retinal detachment (SPR Study): design issues and implications. SPR Study report no. 1. Graefes Arch Clin Exp Ophthalmol. 2001;239(8):567–74.
19. Rohowetz LJ, Shaheen AR, Russell JF, Ashkenazy N, Iyer PG, Sridhar J, et al. EVALUATION OF RETINAL DISPLACEMENT FOLLOWING PRIMARY SCLERAL BUCKLING FOR MACULA-INVOLVING

RHEGMATOGENOUS RETINAL DETACHMENT. RETINA. 2022;42(8):1498–502.

20. Ferrara M, Mehta A, Qureshi H, Avery P, Yorston D, Laidlaw DA, et al. Phenotype and Outcomes of Phakic Versus Pseudophakic Primary Rhegmatogenous Retinal Detachments: Cataract or Cataract Surgery Related? American Journal of Ophthalmology. 2021;222:318–27.
21. Murakami T, Okamoto F, Sugiura Y, Okamoto Y, Hiraoka T, Oshika T. Changes in aniseikonia and influencing-factors following successful macula-off retinal detachment surgery. Sci Rep. 2019;9(1):11588.
22. Zhou C, Lin Q, Chen F. Prevalence and predictors of metamorphopsia after successful rhegmatogenous retinal detachment surgery: a cross-sectional, comparative study. Br J Ophthalmol. 2017;101(6):725–9.
23. Kumar V, Naik A, Kumawat D, Sundar D, Chawla R, Chandra P, et al. Multimodal imaging of eyes with metamorphopsia after vitrectomy for rhegmatogenous retinal detachment. Indian J Ophthalmol. 2021;69(10):2757–65.
24. Okamoto F, Sugiura Y, Okamoto Y, Hiraoka T, Oshika T. Metamorphopsia and optical coherence tomography findings after rhegmatogenous retinal detachment surgery. Am J Ophthalmol. 2014;157(1):214–20 e1.
25. Pastor G, Salleron J, Zessler A, Stoebener S, Angioi-Duprez K, Berrod JP, et al. Prevalence and Risk Factors for Metamorphopsia after Successful Retinal Detachment Surgery. Ophthalmologica. 2024:1.
26. Borowicz D, Nowomiejska K, Nowakowska D, Brzozowska A, Toro MD, Avitabile T, et al. Functional and morphological results of treatment of macula-on and macula-off rhegmatogenous retinal detachment with pars plana vitrectomy and sulfur hexafluoride gas tamponade. BMC Ophthalmol. 2019;19(1):118.
27. Roditi E, Bansal A, Potter MJ, Totah H, Strassman I, Magal I, et al. Fundus Autofluorescence Underestimates Retinal Displacement. Ophthalmol Retina. 2023;7(4):368–71.
28. Brosh K, Roditi E, Bansal A, Martins Melo I, Potter MJ, Muni RH. Optical coherence tomography homography for detection of retinal displacement: a validation study. Graefes Arch Clin Exp Ophthalmol. 2024;262(12):3797–804.

Figures

Figure 1 Flow chart of patients recruitment to the study



RD, retinal displacement

Figure 1

See image above for figure legend

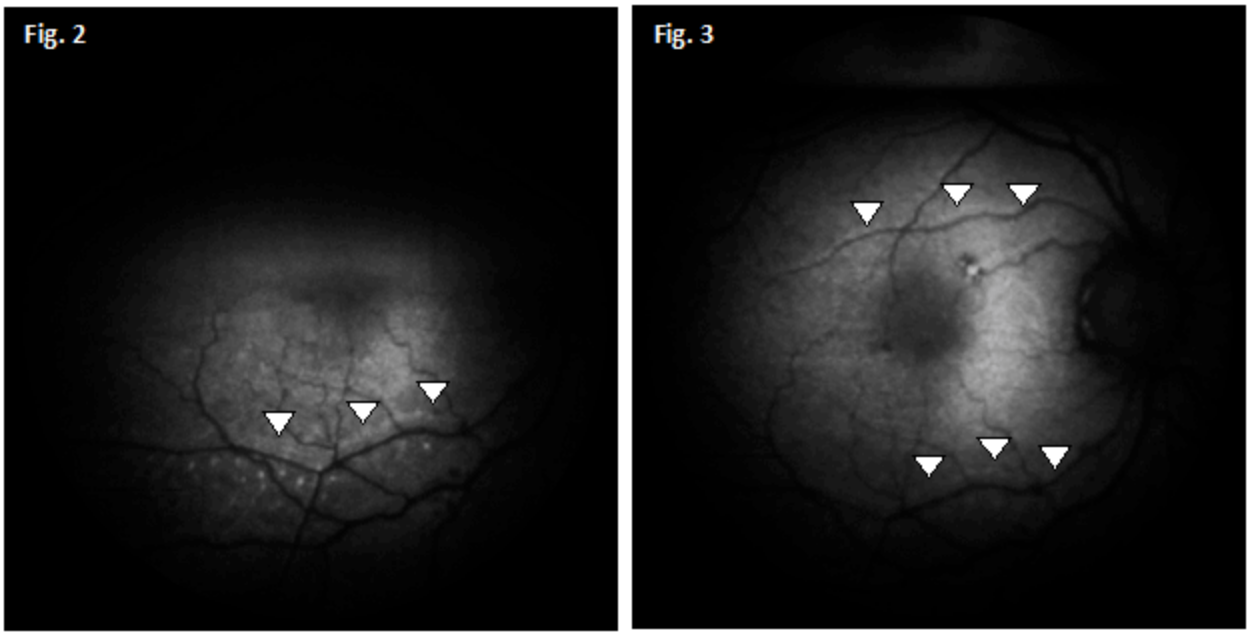


Figure 2 and 3: Downward displacement of the retina observed on B-FAF images after repair of RRD with combined encircling buckle, vitrectomy and gas tamponade. **Figure 2:** B-FAF images three weeks after RRD repair. **Figure 3:** B-FAF images 5 weeks after RRD repair show RVPs (white arrows) superiorly to the corresponding retinal vessels, indicating a downward displacement of the retina.

Figure 2

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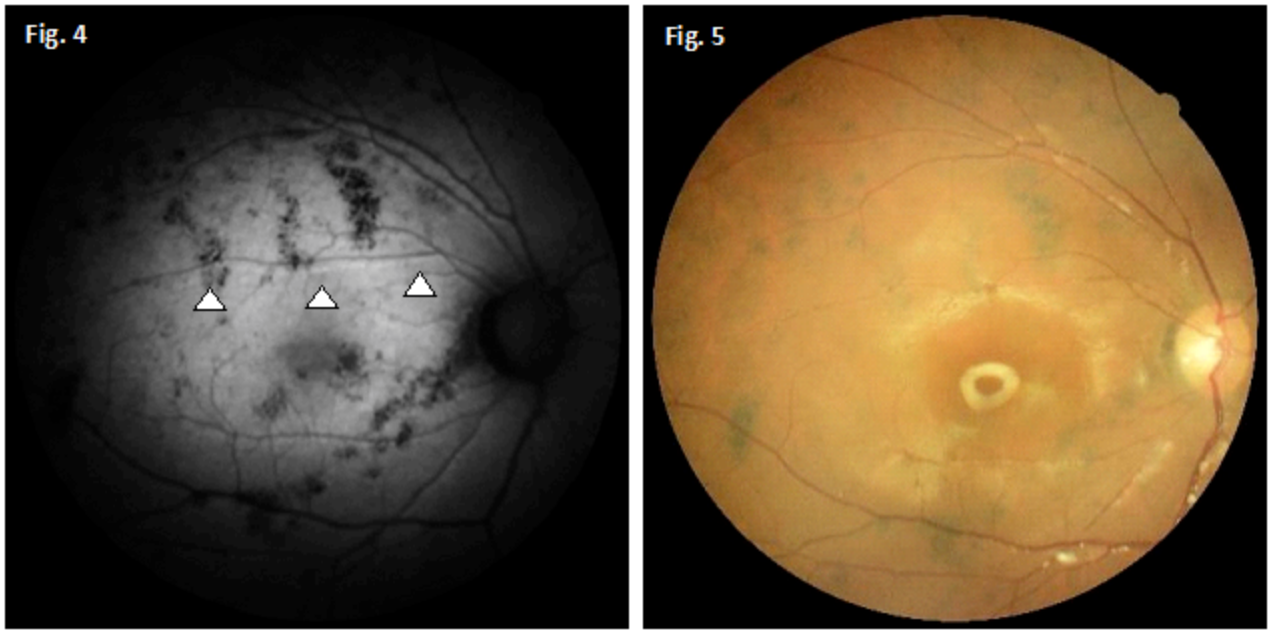


Figure 4 and 5: Upward displacement of the retina observed on B-FAF images after repair of RRD with combined encircling buckle, vitrectomy and SO 1000cs tamponade. B-FAF image and coloured fundus photo 3.5 months after RRD repair show RVPs (white arrows) superiorly to the corresponding retinal vessels, indicating a downward displacement of the retina.

Figure 3

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