

Visual Acuity Inadequately Reflects Vision-Related Quality of Life in Patients After Macula-Off Retinal Detachment Surgery

Heijan Ng,¹ Koenraad A. Vermeer,¹ Jan C. van Meurs,² and Ellen C. La Heij²

¹Rotterdam Ophthalmic Institute, Rotterdam, the Netherlands

²The Rotterdam Eye Hospital, Vitreoretinal Surgery, Rotterdam, the Netherlands

Correspondence: Heijan Ng, Rotterdam Ophthalmic Institute, Schiedamse Vest 160d, 3011 BH Rotterdam, The Netherlands; h.ng@oogziekenhuis.nl.

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PURPOSE. To determine the impact of postoperative visual function on the vision-related quality of life (VRQoL) in patients after anatomically successful surgery for macula-off rhegmatogenous retinal detachment (RRD) and to propose a classification to grade the extent of macular detachment using preoperative optical coherence tomography (OCT) scans.

METHODS. This prospective study evaluated 48 patients. At 12 months after surgery, visual function assessments were as follows: metamorphopsia (M-CHARTS), aniseikonia (New Aniseikonia Test), best corrected visual acuity (BCVA) (Early Treatment Diabetic Retinopathy Study [ETDRS]), low contrast BCVA (10% ETDRS), color vision (Hardy Rand Rittler), and stereopsis (Titmus Fly). VRQoL was assessed by the National Eye Institute Visual Functioning Questionnaire-25 (NEIVFQ-25). Associations between visual function parameters and NEIVFQ-25 scores were evaluated. Preoperative OCT-scans were classified into six stages according to the extent of macular detachment based on an ETDRS-grid: incomplete perifoveal detachment (1), incomplete parafoveal detachment (2), incomplete foveal detachment (3), complete foveal detachment (4), complete parafoveal detachment (5), and complete perifoveal detachment (6).

RESULTS. General vision and driving were the lowest scoring categories. General vision had the strongest correlation with low contrast BCVA ($r = -0.41$, $P = 0.002$), while driving had the strongest correlation with stereopsis ($r = -0.39$, $P = 0.008$). All macular detachments were graded stage 3 or beyond. Patients with stage 3 macular detachments had the highest visual function values compared to the other stages. The highest percentage of patients with metamorphopsia, aniseikonia and BCVA > 0.1 logMAR was found in stages 5 and 6.

CONCLUSIONS. Macula-off RRD particularly affects general vision and driving. The extent of macular detachment is a potential predictor for visual function and can be graded using the proposed classification.

Keywords: metamorphopsia, aniseikonia, macula, quality of life, rehabilitation

Macula-off rhegmatogenous retinal detachment (RRD) is a retinal disease that can lead to blindness if left untreated. Although more than 90% of the surgeries result in reattachment,^{1,2} many patients suffer from visual function loss after surgery, which includes reduced visual acuity, contrast sensitivity, color vision and stereopsis, and presence of metamorphopsia and aniseikonia.³⁻⁸ The combination of high anatomic success rates and disappointing visual function outcomes warrants further evaluation of the impact of macula-off RRD on the quality of life after surgery.^{9,10}

Visual function is conventionally assessed by visual acuity measurement and is considered to be an important determinant of quality of life: even mild visual impairment in one eye negatively affects quality of life.¹¹ However, visual acuity alone may not fully reflect visual rehabilitation because macula-off RRD also affects other visual functions. Identifying associations between postoperative visual function and

quality of life can contribute to a better understanding of how macula-off RRD affects a patient's well-being. Particularly postoperative metamorphopsia and aniseikonia would be of additional value considering the high prevalence of 64% to 89%^{4,7,8,12} and 58% to 61%,^{6,13} respectively.

Although macula-off RRD is associated with poor visual function, Brenton et al.¹⁴ have reported that foveal splitting RRD may have a relatively good visual prognosis, which suggests that macula-off RRD does not necessarily result in poor visual function. On the basis of these findings, we hypothesize that the extent of macular detachment could be a potential predictor for visual function. A classification of macular detachments could be of additional value to make studies more comparable, particularly one based on preoperative optical coherence tomography (OCT) because this method is more reliable than clinical examination in determining the macular status.¹⁵ Therefore we propose a clas-

sification to grade the extent of macular detachment using preoperative OCT.

The purpose of this study was to determine the impact of postoperative visual function (metamorphopsia, aniseikonia, visual acuity, low contrast acuity, color vision, and stereopsis) on the vision-related quality of life in patients after anatomically successful surgery for macula-off RRD. In addition, we propose a classification to grade the extent of macular detachment using preoperative OCT.

MATERIALS AND METHODS

Study Design

This prospective observational study was conducted in The Rotterdam Eye Hospital (Rotterdam, the Netherlands) between April 2017 and September 2019 and was approved by the Medical Ethical Committee of the Erasmus Medical Centre (Rotterdam, the Netherlands). The research followed the tenets of the Declaration of Helsinki.

Study Population

Patients who were 18 years and older and presented at the hospital with a primary unilateral macula-off RRD and healthy fellow eye were qualified to participate in the study. A healthy fellow eye was obligatory for comparative (e.g., color vision and metamorphopsia) and binocular assessments (aniseikonia, stereopsis).

Preoperative exclusion criteria were as follows: proliferative vitreoretinopathy grade C or more,¹⁶ macular hole, giant tear, any vision compromising comorbidities in either study or fellow eye (e.g., diabetic retinopathy or uveitis) with the exception of cataract.

Postoperative exclusion criteria were as follows: re-detachment, macular hole, silicone oil tamponade, additional vitreoretinal surgery, persistent subfoveal fluid, cystoid macular edema, and epiretinal membrane stage 2 or more.¹⁷

One investigator (H.N.) approached eligible patients after surgery was scheduled. Patients were interviewed by one investigator (H.N.) to recall the onset of visual symptoms that included light flashes, floaters, visual field defects and central vision loss. Duration of macular detachment (DMD) was defined as the time between onset of central vision loss and retinal repair surgery. Patients were excluded when DMD exceeded 10 days or if DMD could not be determined. Each patient provided written informed consent before enrollment in the study.

Surgical Procedures

All surgeries were performed by one of five experienced vitreoretinal surgeons. The performed surgical technique was either pars plana vitrectomy or scleral buckling.

Standard 23-gauge vitrectomy was performed with vitreous traction release around breaks, subretinal fluid drainage, and endolaser photocoagulation. Phacoemulsification was performed according to the surgeon's preference. Scleral buckling consisted of drainage and indentation by a local radial or circular explant (with or without encircling band). Retinopexy was either perioperative cryocoagulation or postoperative laser. All patients received gas tamponade (SF6 or C3F8) and were instructed to posture six hours a day

for one week, in a manner to reduce the risk of a residual retinal fold in the macula.

Preoperative Assessments

All patients underwent ophthalmic examination that included best corrected visual acuity (BCVA) measurement using projector optotypes (Snellen), expressed in decimal, and fundus examination after dilatation with 0.5% tropicamide. Preoperative data collection included gender, age, study eye, preoperative BCVA, quadrants of detachment, duration of macular detachment, and preoperative lens status.

Preoperative OCT Assessment and Classification of Macular Detachment

OCT volume scans were obtained from both the study and fellow eye using a Spectralis OCT2 (Heidelberg Engineering, Heidelberg, Germany) after pupil dilatation with 0.5% tropicamide. The scans were evaluated using Heidelberg Eye Explorer system software. In SLO images of the study eyes, the umbo was identified based on the B scans and an ETDRS grid was overlaid centered on the umbo (Fig. 1). All images were classified into six stages according to the extent of macular detachment (Fig. 2). We adapted the classification proposed by Klaas et al. (non-published data by J. Klaas, "Prognostic Value of SD-OCT in Patients With Macular Involving Rhegmatogenous Retinal Detachment—A Modified Classification of the Macular Status," presented at EURETINA Congress, September 22, 2018).

Postoperative Visual Function Assessments

All assessments were performed 12 months after surgery by a single investigator (H.N.). BCVA and low contrast BCVA were measured at 4 m using conventional ETDRS and 10% ETDRS charts and expressed as logarithm of the minimal angle of resolution (logMAR).

The following assessments were all performed at 30 cm with refraction corrected for this distance.

The magnitude of metamorphopsia was measured with the M-CHARTS (Inami Co, Tokyo, Japan). The test was presented in horizontal and vertical direction to determine metamorphopsia scores for horizontal lines (M_H) and vertical lines (M_V). Metamorphopsia was defined as absent if both M_H and M_V scores were 0. Scores above 2.4° were considered as 2.4° for statistical analysis.¹²

Aniseikonia was assessed by the New Aniseikonia Test (Handaya, Tokyo, Japan). The test was presented in horizontal and vertical direction to determine horizontal aniseikonia (A_H) and vertical aniseikonia (A_V). Macropsia was defined as aniseikonia of at least +2% and micropsia was defined as aniseikonia of -2% or worse. Aniseikonia was defined as absent if both A_H and A_V were between -1% and 1%.¹⁸

For color vision assessment we used the Hardy Rand Rittler test (fourth edition, Richmond Products). The test score was equal to the number of correctly identified figures. Pseudoisochromatic plates are developed to assess the color confusion axes of congenital color vision disorders. Because acquired color vision disorders generally do not follow these confusion axes, assigning a score based on the number of correctly identified figures seems more appropriate in this study.¹⁹

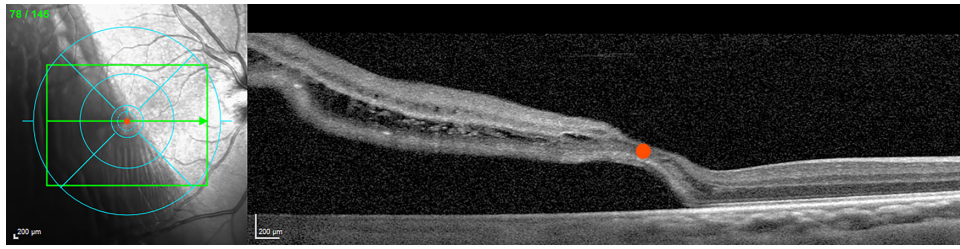


FIGURE 1. Example of a B scan and the corresponding SLO image. The *red dot* in the B scan represents the umbo and corresponds to the *red dot* in the SLO image. The ETDRS grid is centered on the umbo. This is a stage 3 macular detachment in which the fovea is incompletely detached.

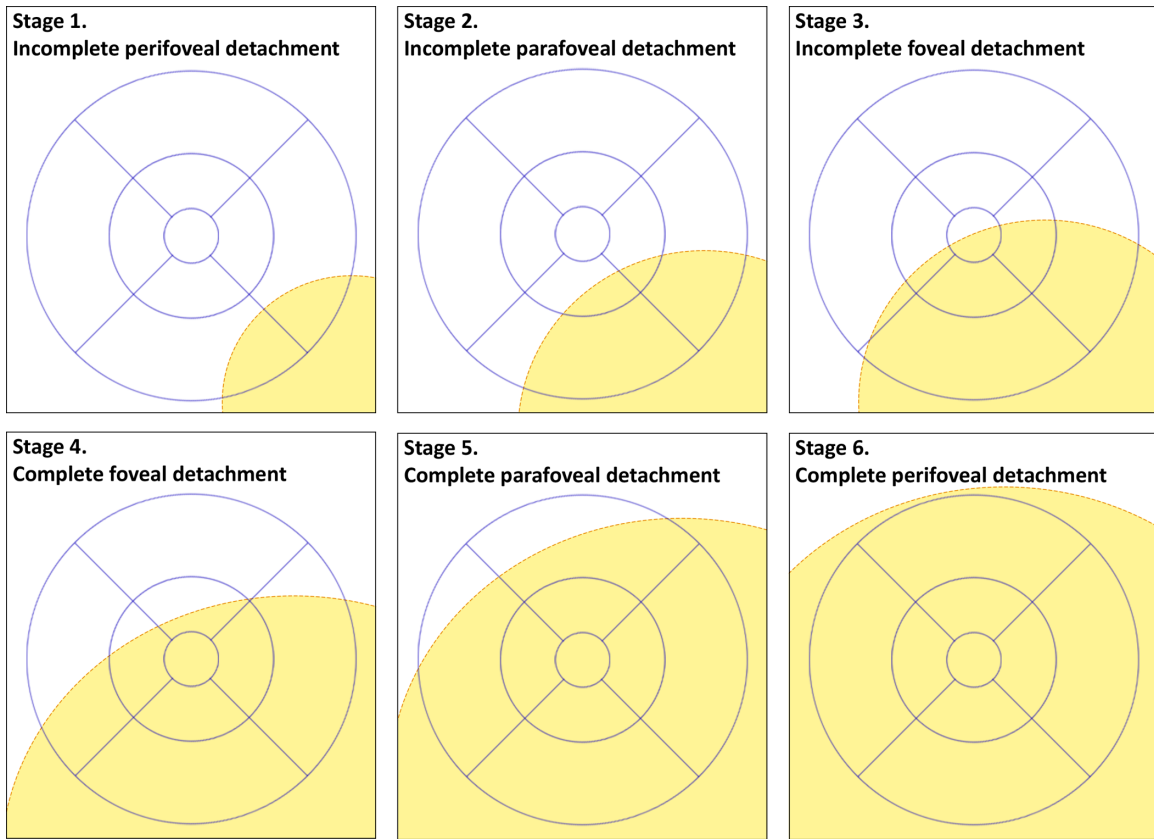


FIGURE 2. Classification of macular detachment which consists of six stages according to the extent of macular detachment based on an ETDRS grid. The *yellow area* represents the retinal detachment.

Stereopsis was examined using Titmus Fly Test. Absence of gross stereopsis was regarded as 6000 seconds of arc for statistical analysis.²⁰

Postoperative Vision-Related Quality of Life

At 12 months after surgery, patients were asked to self-administer the National Eye Institute Visual Functioning Questionnaire-25 (NEIVFQ-25) including optional items. The values were recoded and averaged to generate scores for the following 12 sub-scales: general health, general vision, ocular pain, near activities, distance activities, social functioning, mental health, role difficulties, dependency, driving, color vision and peripheral vision. The overall compos-

ite score was calculated by averaging all sub-scale scores, excluding general health.²¹

Statistical Analysis

Categorical variables were presented as frequencies and percentages. Continuous variables were expressed as mean \pm standard deviation in case of normal distributed data, or as median (interquartile range) otherwise.

Significant differences between pre- and postoperative measurements were determined with the paired Student's *t*-test in case of normal distribution and the Wilcoxon signed-rank test for nonnormal distribution. The same tests were used to assess differences between study and fellow eye.

The correlation between visual function parameters and NEIVFQ-25 scores was evaluated by bivariate analysis using Spearman's rank correlation coefficient.

Preoperative visual acuity values were converted from decimal to logMAR equivalents. Counting fingers and hand movements were considered as 1.6 logMAR and 1.9 logMAR, respectively, for statistical analysis.²² A *P* value below 0.05 was considered statistically significant. We corrected for multiple testing using the Bonferroni correction to adjust the threshold for statistical significance. This applies to the correlation between visual function parameters and NEIVFQ-25 scores (104 correlations, the threshold for statistical significance was adjusted to $0.05/104 = 0.0005$).

Statistical analyses were performed using SPSS statistics version 24.0.

RESULTS

We approached 143 patients of which 80 were included initially. Reasons for not including 63 patients were: unwillingness to participate (*n* = 31, 49%), DMD of more than 10 days (*n* = 28, 45%) and no reliable determination of DMD (*n* = 4, 6%). All included patients gave a written consent to participate.

Of the 80 primarily included patients, 27 were excluded during the study. Reasons for exclusion of these 27 patients were as follows: redetachment (*n* = 8), cystoid macular edema (*n* = 5), preoperative macular hole (*n* = 3), silicone oil tamponade (*n* = 2), persistent subfoveal fluid postoperative (*n* = 2), epiretinal membrane stage 2 (*n* = 1), uveitis (*n* = 1), giant tear (*n* = 1), vitreomacular traction (*n* = 1), vitreous hemorrhage (*n* = 1), vitreoretinal surgery for epiretinal membrane (*n* = 1), and retinal detachment in the fellow eye (*n* = 1).

At 12 months after surgery, 53 patients underwent visual function examination, of which 50 completed all assessments whereas two patients were unable to complete the New Aniseikonia Test due to tilted vision in the study eye. All 53 patients were asked to complete the NEIVFQ-25 questionnaire of which five patients were unwilling to participate, which resulted in 48 patients for analysis.

Patient Characteristics

Patients were predominantly male (71%) with a mean age of 60 years (Table 1). Most patients underwent vitrectomy (*n* = 44 [92%]), of which 12 patients (27%) had vitrectomy combined with phacoemulsification. Fourteen patients (29%) had phacoemulsification during one-year follow-up, which resulted in 38 (79%) pseudophakic and 10 (21%) phakic study eyes at 12 months after surgery.

Visual Function 12 Months After Surgery

In study eyes, BCVA increased from 1.3 (0.8–1.9) logMAR preoperatively to 0.09 (0.0–0.2) after surgery (*P* < 0.001) (Tables 1 and 2). BCVA gain was 1.2 (0.6–1.6) logMAR. Both BCVA and low contrast BCVA were significantly better in fellow eyes (*P* < 0.001 for both), as was color vision (*P* = 0.02) (Table 2). Metamorphopsia was present in 42 patients (88%), with horizontal and vertical scores of 0.7° (0.4°–0.9°) and 0.7° (0.3°–1.0°). No significant difference was found between horizontal and vertical scores (*P* = 1.0).

TABLE 1. Baseline Demographic Data

Characteristics	
Total patients	48
Gender, n (%)	
Male	34 (71)
Age (years), mean ± SD	60 ± 9
Study eye, n (%)	
OD	23 (48)
Preoperative BCVA (logMAR), median (IQR)	1.3 (0.8–1.9)
Quadrants of detachment, n (%)	
1	11 (23)
2	20 (42)
3	14 (29)
4	3 (6)
Duration of macular detachment (days), median (IQR)	5 (4–7)
Preoperative lens status, n (%)	
Phakic	36 (75)
Pseudophakic	12 (25)
Surgery technique, n (%)	
Scleral buckling	4 (8)
Vitrectomy	44 (92)
Combined with phacoemulsification	12 (27)

SD, standard deviation; IQR, interquartile range.

logMAR: logarithm of the minimal angle of resolution.

Metamorphopsia was not present in fellow eyes. Aniseikonia was perceived as micropsia in the majority of the patients.

Vision-Related Quality of Life 12 Months Postoperatively

Dependency, peripheral vision, role difficulties and color vision were the four highest scoring categories for vision-related quality of life, whereas general vision was given the lowest score, followed by general health, driving, social functioning, and near activities (Fig. 3).

Correlation Between Visual Function and Vision-Related Quality of Life

Of the eight visual function parameters, low contrast BCVA showed the strongest correlation with four vision-related quality of life categories ($|r| \geq 0.4$) (Table 3). Stereopsis showed the same association but with less vision-related quality of life categories. These correlations were all negative; however, no correlation reached statistical significance after Bonferroni correction.

Classification of Macular Detachment and Visual Function

Preoperative OCT was obtained for 30 patients (63%) and could not be obtained for 18 patients. Reasons for not obtaining preoperative OCT were bullous RRD that prevented macular visualization (*n* = 11), insufficient quality of OCT (*n* = 5), and immediate surgery (*n* = 2). All macular detachments were graded stage 3 or beyond (Table 4). Patients with stage 3 macular detachments had the highest visual function values compared with the other stages, except for stereopsis. For the presence of metamorphopsia, aniseikonia and BCVA > 0.1 logMAR, the highest percentage of such patients was found in stages 5 and 6 (Fig. 4).

TABLE 2. Visual Function 12 Months After Surgery in Study Eye and Fellow Eye

Visual Function	Study Eye	Fellow Eye	P Value
BCVA (logMAR), median (IQR)	0.09 (0.0–0.2)	−0.06 (−0.1 to 0.02)	<0.001
Low contrast BCVA (logMAR), median (IQR)	0.4 (0.2–0.5)	0.2 (0.1–0.2)	<0.001
Metamorphopsia			
M _H score (°), median (IQR)	0.7 (0.4–0.9)	0.0 (0.0–0.0)	<0.001
M _V score (°), median (IQR)	0.7 (0.4–1.0)	0.0 (0.0–0.0)	<0.001
Present, n (%)	42 (88)	0 (0)	<0.001
Color vision (n), median (IQR)	34 (33–34)	34 (34–35)	0.02
Aniseikonia*			
A _H score (%), median (IQR)	0 (−3 to 0)		
A _V score (%), median (IQR)	−1 (−4–0)		
No aniseikonia, n (%)	20 (42)		
Micropsia, n (%)	22 (46)		
Macropsia, n (%)	4 (8)		
Failed measurement†	2 (4)		
Stereopsis (seconds of arc)*, median (IQR)	200 (110–400)		

IQR, interquartile range.

* Binocular test.

† Due to tilted vision in study eye. BCVA: best corrected visual acuity, MH: metamorphopsia horizontal, MV: metamorphopsia vertical, AH: aniseikonia horizontal, AV: aniseikonia vertical, logMAR: logarithm of the minimal angle of resolution, IQR: interquartile range.

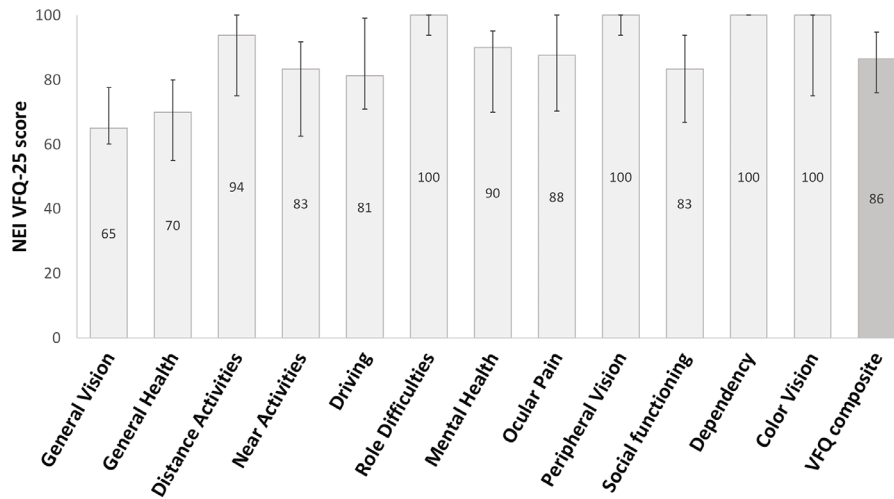


FIGURE 3. Twelve-month postoperative NEIVFQ-25 scores, ordered from low to high (n = 48). Scores are presented as median. Error bars show interquartile range. NEIVFQ-25: National Eye Institute Visual Functioning Questionnaire-25.

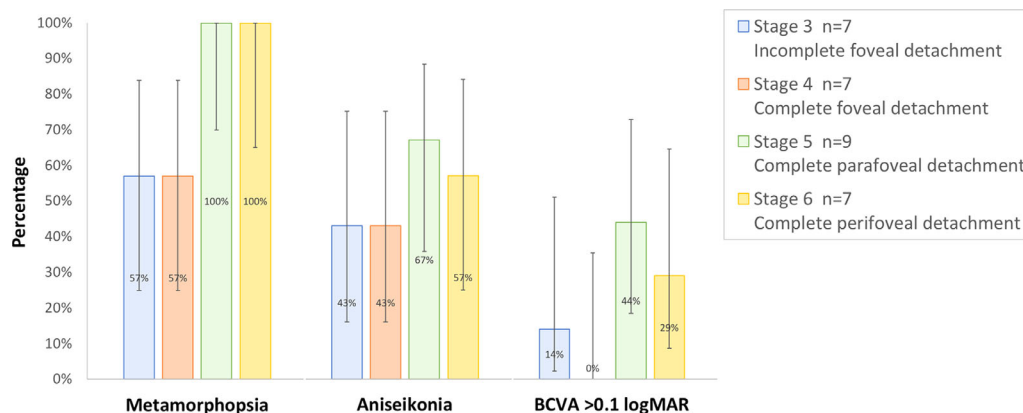


FIGURE 4. Percentage of patients with metamorphopsia, aniseikonia and BCVA >0.1 logMAR for each stage. Error bars show 95% confidence intervals. BCVA: best corrected visual acuity, logMAR: logarithm of the minimal angle of resolution.

TABLE 3. Twelve-Month Postoperative Correlation Between Visual Function and NEIVFQ-25 Scores*

NEI VFQ-25 Sub-Scales	Visual Function																											
	Low Contrast BCVA				M _V				M _H				A _V				A _H				Color Vision				Stereopsis			
	P	r	P	r	P	r	P	r	P	r	P	r	P	r	P	r	P	r	P	r	P	r	P	r	P	r	P	r
Composite score	0.02	-0.30	0.002	-0.40	0.01	-0.32	0.009	-0.34	0.3	0.06	0.5	-0.004	0.04	0.25	0.004	-0.004	0.04	0.25	0.004	0.04	0.25	0.004	0.04	0.25	0.004	-0.40		
General health	0.4	-0.05	0.1	-0.18	0.2	0.14	0.4	-0.05	0.4	0.03	0.4	0.02	0.07	0.22	0.1	0.02	0.07	0.22	0.1	0.02	0.07	0.22	0.1	0.02	0.07	-0.19		
General vision	0.02	-0.29	0.002	-0.41	0.04	-0.24	0.08	-0.21	0.4	-0.03	0.5	-0.01	0.08	0.21	0.09	-0.01	0.08	0.21	0.09	-0.01	0.08	0.21	0.09	-0.01	0.08	-0.20		
Ocular pain	0.4	0.02	0.4	0.02	0.08	-0.20	-0.01	0.02	0.5	-0.30	0.2	-0.12	0.2	0.14	0.002	-0.12	0.2	0.14	0.002	-0.12	0.2	0.14	0.002	-0.12	0.2	-0.42		
Near activities	0.09	-0.20	0.05	-0.25	0.04	-0.26	0.009	-0.35	0.02	0.30	0.1	0.19	0.05	0.24	0.01	0.19	0.05	0.24	0.01	0.19	0.05	0.24	0.01	0.19	0.05	-0.35		
Distance activities	0.7	-0.22	0.02	-0.31	0.005	-0.37	0.004	-0.38	0.3	0.10	0.4	0.02	0.1	0.15	0.02	0.02	0.1	0.15	0.02	0.02	0.1	0.15	0.02	0.02	0.1	-0.31		
Social functioning	0.06	-0.23	0.004	-0.38	0.09	-0.19	0.1	-0.18	0.4	0.03	0.5	0.02	0.09	0.20	0.04	0.02	0.09	0.20	0.04	0.02	0.09	0.20	0.04	0.02	0.09	-0.27		
Mental Health	0.02	-0.31	0.002	-0.41	0.01	-0.33	0.007	-0.36	0.4	0.05	0.5	0.01	0.03	0.28	0.04	0.01	0.03	0.28	0.04	0.01	0.03	0.28	0.04	0.01	0.03	-0.27		
Role difficulties	0.02	-0.30	0.001	-0.45	0.008	-0.35	0.004	-0.38	0.3	-0.07	0.3	-0.07	0.04	0.25	0.01	-0.07	0.04	0.25	0.01	-0.07	0.04	0.25	0.01	-0.07	0.04	-0.33		
Dependency	0.2	-0.12	0.2	-0.13	0.01	-0.33	0.01	-0.33	0.5	0.02	0.4	-0.03	0.03	0.27	0.003	-0.03	0.03	0.27	0.003	-0.03	0.03	0.27	0.003	-0.03	0.03	-0.41		
Driving	0.2	-0.14	0.04	-0.28	0.3	-0.09	0.2	-0.13	0.4	0.05	0.2	0.11	0.3	0.10	0.008	0.11	0.3	0.10	0.008	0.11	0.3	0.10	0.008	0.11	0.3	-0.39		
Color vision	0.04	-0.25	0.02	-0.30	0.3	-0.08	0.4	-0.03	0.4	-0.03	0.3	-0.07	0.2	0.14	0.07	-0.07	0.2	0.14	0.07	-0.07	0.2	0.14	0.07	-0.07	0.2	-0.23		
Peripheral vision	0.06	-0.23	0.09	-0.20	0.05	-0.24	0.02	-0.30	0.2	0.13	0.3	-0.06	0.3	0.09	0.05	-0.06	0.3	0.09	0.05	-0.06	0.3	0.09	0.05	-0.06	0.3	-0.25		

* Bonferroni correction for multiple testing was applied to adjust significant P value at 0.0005. P: p-value, r: Spearman's rank correlation coefficient, BCVA: best corrected visual acuity, MH: metamorphopsia horizontal, MV: metamorphopsia vertical, AH: aniseikonia horizontal, AV: aniseikonia vertical, NEIVFQ-25: National Eye Institute Visual Functioning Questionnaire-25.

TABLE 4. Visual Function 12 Months After Surgery in Eyes After Macula-Off RRD

Visual Function	Stage			
	3 Incomplete Foveal Detachment (n = 7)	4 Complete Foveal Detachment (n = 7)	5 Complete Parafoveal Detachment (n = 9)	6 Complete Perifoveal Detachment (n = 7)
BCVA (logMAR), median (IQR)	-0.05 (-0.1 to 0.06)	0.05 (0.0-0.1)	0.1 (0.02-0.2)	0.0 (-0.04 to 0.3)
Low contrast BCVA (logMAR), median (IQR)	0.2 (0.06-0.3)	0.3 (0.2-0.4)	0.3 (0.3-0.5)	0.3 (0.1-0.4)
Metamorphopsia				
M _H score (°), median (IQR)	0.2 (0.0-0.5)	0.4 (0.0-0.6)	0.4 (0.3-0.7)	0.6 (0.4-0.9)
M _V score (°), median (IQR)	0.0 (0.0-0.6)	0.7 (0.0-1.0)	0.6 (0.6-0.8)	0.5 (0.5-0.7)
Color vision (n), median (IQR)	35 (34-36)	34 (33-36)	34 (34-34)	35 (34-36)
Aniseikonia*				
A _H score (%), median (IQR)	0 (-4 to 0)	0 (-1 to 0)	-3 (-5 to 0)	-5 (-7 to 0)
A _V score (%), median (IQR)	0 (0-0)	0 (-1 to 0)	-2 (-4 to 0)	0 (-3 to 1)
Stereopsis (seconds of arc), median (IQR)	200 (80-200)	170 (40-200)	400 (270-800)	140 (40-170)

Patients are classified according to the extent of macular detachment.

* Measurement failed for two patients because of tilted vision. BCVA: best corrected visual acuity, M_H: metamorphopsia horizontal, M_V: metamorphopsia vertical, A_H: aniseikonia horizontal, A_V: aniseikonia vertical, logMAR: logarithm of the minimal angle of resolution, IQR: interquartile range.

DISCUSSION

This prospective observational study showed a high prevalence of metamorphopsia (88%) and aniseikonia (52%) in patients after anatomically successful surgery for macula-off RRD. Micropsia was perceived by the majority of patients with aniseikonia, which confirms earlier findings.^{6,13} However, the prevalence of aniseikonia in the current study was somewhat lower than in earlier studies. Okamoto et al.⁶ and Murakami et al.¹³ reported a prevalence of 61% and 58% in macula-off RRD patients. Both studies found abnormalities in patients with aniseikonia, which included subretinal fluid and macular hole. These abnormalities were excluded in our study, which may explain our slightly lower prevalence of aniseikonia.

This is the first study to investigate the combination of six visual functions, including metamorphopsia and aniseikonia, on the vision-related quality of life in patients after surgery for macula-off RRD.

Our results show that macula-off RRD mostly affects general vision as it had the lowest score among all vision-related quality of life categories. General vision had the strongest correlation with low contrast BCVA, followed by BCVA and metamorphopsia, whereas aniseikonia showed the lowest correlation. Driving is also compromised because of macula-off RRD and is mostly correlated with stereopsis and low contrast BCVA. Most clinical studies use BCVA as the single visual outcome measure because it is considered to be the major determinant of vision-related quality of life.²³ However, the current study supports the idea that merely measuring BCVA inadequately evaluates vision-related quality of life and visual function in patients after surgery for macula-off RRD. This idea is also supported by Lina et al.,⁷ who investigated three visual function parameters (BCVA, stereopsis and metamorphopsia) and found that vision-related quality of life correlated with metamorphopsia, but not with BCVA.

Of the evaluated visual functions, low contrast BCVA has the highest correlation with most vision-related quality of life scores, which indicates that low contrast BCVA affects daily activities more than BCVA. This is in line with Okamoto et al.⁹ who investigated the associations between vision-related quality of life with BCVA and low contrast visual acuity and found that vision-related quality of life corre-

lated negatively with low contrast visual acuity but not with BCVA. Van de Put et al.²⁴ who correlated three visual function parameters (BCVA, contrast acuity, color vision) with vision-related quality of life found a negative correlation between quality of life and contrast acuity as well. However, BCVA was also correlated with vision-related quality of life, which is not confirmed in our study. This could be due to differences in inclusion criteria, as we only included patients with a duration of macular detachment of 10 days or less, whereas Van de Put et al.²⁴ included patients with a maximum duration of six weeks. Consequently, our study had less variability with a smaller range of BCVA outcomes, which reduced the probability of finding a statistically significant correlation.

Lower BCVA was correlated with lower mental health scores in earlier studies,²⁵⁻²⁷ but BCVA did not statistically significantly correlate with any vision-related quality of life score in the current study. However, results of earlier studies cannot be directly compared to ours as these studies included both macula-off and macula-on cases whereas our study population consists of only macula-off patients and is therefore more homogeneous.

Although macula-off RRD is associated with poor visual function, Brenton et al.¹⁴ have reported that foveal splitting RRD may have a relatively good visual prognosis and should be treated as macula-on RRD. Based on these findings, we hypothesize that the extent of macular detachment could be a predictor of visual function. To investigate this, macula-off RRD patients should not be considered as a homogenous group but should be categorized according to the extent of macular detachment. Therefore we propose a classification for macula-off RRD patients using preoperative OCT. This study has shown that the classification is useful in categorizing macula-off RRD. A classification makes studies more comparable as the definition of macula-off RRD varies among studies: some studies define macula-off RRD as macula-off and fovea-off whereas other studies only consider the fovea. This may explain why the findings of various studies seem to be inconsistent, e.g., with regard to duration of macular detachment as a potential predictor for visual function.²⁸

No patients were categorized in the first two stages because preoperative OCT was not feasible when clinical examination revealed a macula-off RRD without foveal

detachment as these patients were prescribed stringent bedrest while waiting for urgent surgery. Future studies should consider a time efficient way to perform OCT before surgery, as preoperative OCT in the recumbent position may underestimate the extent of superior retinal detachment, because of regression in that position.²⁹

The results of this study are consistent with our hypothesis that the extent of macular detachment could be a potential predictor of visual function, as there is a difference in visual function between the different stages of macular detachment. Stage 5 and 6 macular detachments had the highest percentages of patients with metamorphopsia, aniseikonia and BCVA > 0.1 logMAR, stage 3 and 4 had the lowest percentages. We also noted that macula-off RRD does not necessarily result in poor visual function since stage 3 macular detachments resulted in a median BCVA of -0.5 logMAR and low scores for metamorphopsia and aniseikonia. However, our sample size was not large enough to perform a reliable statistical analysis.

The major limitation of our study is the small sample size, which reduces the probability to detect statistically significant associations between the six visual functions and the many vision-related quality of life categories. Analyzing fewer visual functions can result in statistically significant *P* values but diminishes the comprehensive evaluation of visual function. Also, because of the small sample size, our results may not be representative for the overall macula-off RRD patient population. However, we aim to provide guidance for future research with our results and proposed classification, which will ultimately improve the understanding of visual function after macula-off RRD and its effect on a patient's quality of life and make studies more comparable.

Inclusion of phakic patients can be considered as a limitation of current study. However, all patients underwent ophthalmic examination at 1.5, 3, 6 and 12 months after surgery which included visual function measurement and slit lamp examination to evaluate cataract. Patients would undergo phacoemulsification when the cataract was compromising vision. At 12 months after surgery, all phakic patients had cataract which were not considered as vision compromising; hence, the influence of cataract on visual function, particularly metamorphopsia and aniseikonia, was limited.

Another limitation is the fact that preoperative and postoperative BCVA measurements were not performed in a consistent manner: preoperative BCVA was measured with projector optotypes in an outpatient setting, whereas postoperative BCVA was measured in a study setting with ETDRS charts. However, BCVA was either hand movement or counting fingers in 48% of the patients, which did not require measurement charts.

Strengths of this prospective study are the long follow-up and the quantitative evaluation of six visual functions (metamorphopsia, aniseikonia, BCVA, low contrast BCVA, color vision, stereopsis) for association with vision-related quality of life. Furthermore, all patients were included and interviewed by one investigator who also performed all postoperative visual function assessments.

In conclusion, although surgery for macula-off RRD results in reattachment in most of the cases, many patients suffer from metamorphopsia and aniseikonia. Macula-off RRD particularly affects general vision and driving which are mostly associated with low contrast BCVA and stereopsis. Thus BCVA assessment alone inadequately reflects visual rehabilitation and vision-related quality of life in patients after surgery for macula-off RRD. Visual prognos-

is of macula-off RRD is not necessarily poor: the extent of macular detachment is a potential predictor for visual function and can be graded using the proposed classification.

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