Eye (2021) 35:1431–1439
https://doi.org/10.1038/s41433-020-1021-y

The ROYAL COLLEGE of OPHTHALMOLOGISTS

ARTICLE

Factors affecting visual recovery after successful repair of macula-off retinal detachments: findings from a large prospective UK cohort study

David Yorston[1] · Paul H. J. Donachie[2,3] · D. A. Laidlaw[4] · David H. Steel[5,6] · John M. Sparrow[3,7] · G. W. Aylward[8] · Tom H. Williamson[4] · Members of the BEAVRS Retinal Detachment Outcomes Group

Received: 15 September 2019 / Revised: 4 June 2020 / Accepted: 4 June 2020 / Published online: 24 June 2020

Abstract

Objective To identify risk factors affecting visual outcomes in successfully re-attached macula-off rhegmatogenous retinal detachment (RD) surgery.

Design A prospective study, using online databases, of visual outcomes for 2074 macula-off retinal detachments that were successfully re-attached by vitrectomy and internal tamponade. The database included detailed retinal diagrams of each detachment.

Main outcome measure The probability of achieving a post-operative visual acuity (VA) of ≤0.30 LogMAR (Snellen 6/12 or better).

Results Male patients accounted for 64.9% of the sample and the median age was 63 years old. The median pre-operative VA was counting fingers (LogMAR 1.98); this improved to 0.41 LogMAR post-operatively. A post-operative VA of ≤0.30 LogMAR was achieved for 1012 (48.8%) eyes and the factors affecting this were the patient age and gender, pre-operative VA, duration of central vision loss, PVR grade, lens status, total RD and the presence of any ocular co-pathology where the model area under the receiver operator curve was 71.6%.

Conclusions From the identified risk factors that decrease the probability of achieving a post-operative visual acuity of ≤0.30 LogMAR, the most important modifiable risk factor was the duration of central vision loss. Recent macula-off retinal detachments should be repaired within 72 h of the loss of central vision.

Introduction

The factors that affect anatomical success after retinal detachment (RD) surgery are relatively well understood, and grading systems have been produced that enable surgeons to predict the likelihood of anatomical re-attachment with a single operation [1–5]. The risk of primary anatomical failure after vitrectomy and internal tamponade is increased by proliferative vitreoretinopathy (PVR), a greater extent of RD, and inferior breaks.

However, the factors that determine the final visual outcome, after successful re-attachment of a macula-off RD are less clearly defined [6]. Good pre-operative visual acuity (VA) [7, 8] is associated with better post-operative vision. The height of the foveal detachment, measured by optical

Members of the BEAVRS Retinal Detachment Outcomes Group are listed below Acknowledgements.

Supplementary information The online version of this article (https://doi.org/10.1038/s41433-020-1021-y) contains supplementary material, which is available to authorized users.

✉ David Yorston
dbyorston@btinternet.com

[1] Gartnavel Hospital, Glasgow, UK

[2] Gloucestershire Hospitals NHS Foundation Trust, Cheltenham GL53 7AN, UK

[3] The Royal College of Ophthalmologists' National Ophthalmology Audit, London, UK

[4] Guy's and St. Thomas' NHS Foundation Trust, London, UK

[5] Sunderland Eye Infirmary, Sunderland, UK

[6] Institute of Genetic Medicine, Newcastle University, Newcastle Upon Tyne, UK

[7] Bristol Eye Hospital, Lower Maudlin Street, Bristol BS1 2LX, UK

[8] Moorfields Eye Hospital, City Road, London EC1V 2PD, UK

coherence tomography [9] or ultrasound [10, 11] has also been shown to influence outcome, but this variable is not routinely measured in clinical practice. The effect of duration has been controversial, with some studies suggesting that delay of a few days makes little difference [12, 13], providing surgery is done within 1 week [14]. However, a recent meta-analysis showed that detachments repaired within 3 days were more likely to achieve 6/15 vision or better than those repaired at 4–7 days [15]. Most of the eyes in these studies were treated by an external scleral buckle, but the majority of detachments today are treated by vitrectomy and internal tamponade. Recent studies have confirmed that earlier surgery is associated with better outcomes [8, 16], but the numbers are small.

In order to identify and quantify the factors determining post-operative vision, we examined the visual outcomes in 2074 successfully re-attached macula-off RDs treated by vitrectomy and internal tamponade.

Methods

The data for this analysis include data extracted from two databases that are compliant with the UK national RD dataset [17], these databases are: VITREOR from which the data were extracted in January 2017, and the Britain & Eire Association of Vitreoretinal Surgeons (BEAVRS) RD audit database from which the data were extracted in July 2018. All detachments were treated between October 2011 and March 2018.

The BEAVRS/Euretina database is an online web application for the collection, and analysis of anonymised vitreoretinal surgical data. Data are entered prospectively immediately following surgery and again when follow-up is complete, at least 2 months post surgery. The anatomical details of the RD are recorded using a drawing tool linked to diagnostic codes. This allows the accurate recording of RRD extent, foveal involvement, retinal break location and type, and the presence, severity and extent of PVR using the Silicone oil study grading system.

Eligible operations were successfully re-attached macula-off primary RD operations treated with a vitrectomy with a recorded pre-operative VA, post-operative VA and ocular tamponade. RRD secondary to penetrating injury, severe contusion, vaso-proliferative disorders, inflammatory eye disease and paediatric RRD were excluded. Operations in eyes with a pre-operative VA of ≤0.30 logMAR (Snellen 6/12 or better) were also excluded as these would have a different underlying risk profile for the VA outcome measure. LogMAR values corresponding to count fingers (CF), hand movements (HM), perception of light (PL) and no perception of light (NPL) were substituted with 1.98, 2.28, 2.70 and 3.00, respectively.

The probability of achieving a post-operative VA of ≤0.30 logMAR (6/12 or better) was modelled using multivariable logistic regression. All covariates under consideration were investigated at the univariate level using χ^2 tests. Any covariate with a p value < 0.10 progressed to multivariable modelling where the full model was fitted and backward selection employed. A p value of <0.05 plus assessment of Akaike Information Criterion and the area under the receiver operating curve were used for final covariate selection.

Robust standard errors were calculated using bootstrapping with 250 replications and clustering of the individual consultant responsible for the patient care, where the operations performed by the consultant surgeon were considered as a separate cluster to the operations performed by a trainee surgeon under their supervision.

The covariates considered were the use of laser, cryotherapy, type of tamponade and sub-retinal fluid drainage route during surgery, patient's age and gender, the pre-operative VA, lens status, presence of any ocular co-pathology, number of breaks in the detached retina, number of breaks in the attached retina, the location of the largest break in the detached retina, PVR grade, total RD, the post-surgery posturing and the duration of central vision loss, which was categorised according to rounded quintiles from the sample with a known duration of vision loss.

Sensitivity analysis included different grouping of the durations of central vision loss and re-fitting the final model on the sample with no recorded ocular co-pathology. Co-pathology was defined as the presence of any of amblyopia, age-related macular degeneration, diabetic retinopathy, glaucoma, high myopia or unspecified 'other'.

All analyses were conducted using STATA version 14, (StataCorp. 2009. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP).

Results

Within the study period, data were extracted for 3253 vitrectomy operations for macula-off RD with a known surgery outcome, of which 2722 (83.7%) were re-attached with a single procedure. Of these, 497 (18.3%) operations were excluded: 270 as they had no recorded pre-operative VA, 188 as they had no recorded post-operative VA, and 39 because there was no record of the tamponade used. Of the remaining 2225 operations, a further 151 (6.8%) operations were excluded as the pre-operative VA was ≤0.30 LogMAR (Snellen 6/12 or better) and thus already in the range for VA success, this left 2074 successfully re-attached macula-off primary RD operations eligible for analysis, 1773 (85.5%) from the BEAVRS RD audit database and 301 (14.5%) from the VITREOR database.

Table 1 Univariate analysis of covariates considered for the VA outcome model.

Covariate, *n* (row %)	VA success	VA failure	Total	*p* value
Patient age (years)				
<70	774 (52.2)	710 (47.8)	1484	<0.001
70–79	181 (42.0)	250 (58.0)	431	
≥80	57 (35.8)	102 (64.2)	159	
Patient gender				
Male	696 (51.7)	650 (48.3)	1346	<0.001
Female	316 (43.4)	412 (56.6)	728	
Pre-operative VA				
>6/60	273 (65.9)	141 (34.1)	414	<0.001
6/60–1/60	191 (50.8)	185 (49.2)	376	
CF to NPL	548 (42.7)	736 (57.3)	1284	
Duration of vision loss				
0–2 days	221 (68.0)	104 (32.0)	325	<0.001
3–4 days	174 (55.4)	140 (44.6)	314	
5–7 days	155 (45.7)	184 (54.3)	339	
8–13 days	91 (43.5)	118 (56.5)	209	
≥14 days	95 (32.2)	200 (67.8)	295	
Not recorded/no VA loss	276 (46.6)	316 (53.4)	592	
Ocular co-pathology				
No ocular co-pathology	940 (50.3)	929 (49.7)	1869	<0.001
Any ocular co-pathology	72 (35.1)	133 (64.9)	205	
Lens status				
No previous cataract surgery	618 (44.6)	768 (55.4)	1386	<0.001
Previous cataract surgery	394 (57.3)	294 (42.7)	688	
Number of breaks in the attached retina				
0–3 breaks	990 (48.7)	1042 (51.3)	2032	0.639
>3 breaks	22 (52.4)	20 (47.6)	42	
Number of breaks in the detached retina				
0–3 breaks	837 (49.5)	854 (50.5)	1691	0.179
>3 breaks	175 (45.7)	208 (54.3)	383	
Location of largest break				
9–3 O'clock	917 (48.3)	980 (51.7)	1897	0.346
4 or 8 O'clock	26 (59.1)	18 (40.9)	44	
5–7 O'clock	44 (55.0)	36 (45.0)	80	
No break found	25 (47.2)	28 (52.8)	53	
Total RD				
No	964 (51.1)	924 (48.9)	1888	<0.001
Yes	48 (25.8)	138 (74.2)	186	
PVR grade				
None, A or B	949 (51.6)	890 (48.4)	1839	<0.001
C	63 (26.8)	172 (73.2)	235	
Laser used during surgery				
No	610 (51.5)	574 (48.5)	1184	0.004
Yes	402 (45.2)	488 (54.8)	890	
Cryotherapy used during surgery				
No	229 (42.0)	316 (58.0)	545	<0.001
Yes	783 (51.2)	746 (48.8)	1529	
Tamponade used during surgery				
Gas	989 (49.7)	999 (50.3)	1988	<0.001
Silicone oil	23 (26.7)	63 (73.3)	86	
Sub-retinal fluid drainage route				
Retinotomy	325 (53.1)	287 (46.9)	612	0.038
Through the break	540 (46.8)	614 (53.2)	1,154	
None/not recorded/ other	147 (47.7)	161 (52.3)	308	
Patient post-surgery posture position				
Not prone	639 (50.0)	640 (50.0)	1279	0.178
Prone	373 (46.9)	422 (53.1)	795	

VA success is defined as a post-operative visual acuity of ≤0.30 LogMAR (Snellen 6/12 or better).

The 2074 primary RD operations were performed in 963 (46.4%) left eyes and 1111 (53.6%) right eyes, 1571 (75.8%) operations were performed by 53 consultant surgeons and 503 (24.2%) operations by trainee surgeons under the supervision of the consultant surgeon.

The median age at surgery was 63 years (range; 18–96 years). The operations were performed in 1346 (64.9%) eyes from male patients and 728 (35.1%) eyes from female patients (see Table 1). The detachment extended over one quadrant in 95 (4.6%) eyes, two quadrants in 1109 (53.5%) eyes, three quadrants in in 522 (25.1%) eyes, four quadrants in 162 (7.8%) eyes and total RD in 186 (9.0%) eyes.

Prior cataract surgery was recorded for 688 (33.2%) eyes, age-related macular degeneration for 20 (1.0%) eyes, amblyopia for 32 (1.5%) eyes, diabetic retinopathy for 7 (0.3%) eyes, glaucoma for 26 (1.3%) eyes and high myopia (>6 D myopia) for 84 (4.1%) eyes.

Surgical procedures

Vitrectomy was combined with a scleral buckle in 65 (3.1%) operations and phacoemulsification in 93 (4.5%) operations. Laser was used for 890 (42.9%) operations and cryotherapy for 1529 (73.7%) operations. Both laser and cryotherapy were used for 411 (19.8%) operations. The ocular tamponade used was sulfur hexafluoride gas for 993 (47.9%) operations, perfluoroethane gas for 633 (30.5%) operations, perfluoropropane gas for 348 (16.8%) operations, air for 14 (0.7%) operations and silicone oil for 86 (4.1%) operations. Drainage of sub-retinal fluid was

recorded as through the break for 1154 (55.6%) operations, as retinotomy for 612 (29.5%) operations, as cutdown or needle drainage for 14 (0.7%) operations and was not recorded for 294 (14.2%) operations.

Duration of central vision loss

The duration of central vision loss was either not recorded or unknown for 592 (28.5%) eyes and was recorded for 1482 (71.5%) eyes. For the eyes where the duration was recorded, the median duration of central vision loss was 5 days (range: 0 days to 2.2 years: IQR; 3–10 days). For 325 (21.9%) eyes the duration was ≤72 h, for 314 (21.2%) eyes 3–4 days, for 339 (22.8%) eyes 5–7 days, for 209 (14.1%) eyes 8–13 days and for 295 (19.9%) eyes ≥14 days.

The median age ($p = 0.828$), median pre-operative VA ($p = 0.188$) and the percentage of operations in pseudophakic eyes ($p = 0.446$) were very similar between the no duration recorded and duration recorded eyes. The duration of central vision loss was more often recorded for operations performed in male patients than female patients (72.9% vs. 66.8%; $p = 0.050$), and for operations performed in eyes with any ocular co-pathology than eyes with no ocular co-pathology (83.4% vs. 70.1%; $p < 0.001$).

There was variation in the number of days of central vision loss for these pre-operative factors that could potentially affect the duration of central vision loss, but there was no clear pattern linking any of them to shorter or longer durations, except for a better pre-operative VA in those eyes with <48 h duration of central vision loss.

The proportion of eyes with a post-operative VA of ≤0.30 LogMAR (Snellen 6/12 or better) decreased as the number of days of central vision loss increased. This pattern is a general trend instead of a continuous decrease for each successive day, which may be due to the diminishing sample size for durations of 8–14 days (Table 2), or to decreasing accuracy of recall with longer intervals.

Visual acuity

The median pre-operative VA was CF (range; 0.32—PL). 414 (20.0%) eyes had a pre-operative VA between 0.31 and 1.00 LogMAR (Snellen > 6/12–6/60) and 376 (18.1%) eyes between 1.01 and 1.80 LogMAR (Snellen > 6/60–1/60). The pre-operative VA was CF for 483 (23.3%) eyes, HM for 749 (36.1%) eyes and PL for 52 (2.5%) eyes.

The median post-operative VA was 0.41 LogMAR (Snellen 6/15) (range; −0.20—NPL). 1012 (48.8%) eyes had a post-operative VA of ≤0.30 LogMAR (Snellen 6/12 or better), 816 (39.3%) eyes between 0.31 and 1.00 LogMAR (Snellen > 6/12–6/60) and 186 (9.0%) eyes between 1.01 and 1.80 LogMAR (Snellen > 6/60–1/60). The post-operative VA was CF for 46 (2.2%) eyes, HM for 13 (0.6%) eyes and PL (<0.1%) for 1 eye.

A post-operative VA of ≤0.30 LogMAR (Snellen 6/12 or better) was recorded for 65.9% of eyes with a pre-operative VA between 0.31 and 1.00 LogMAR (Snellen > 6/12–6/60), for 50.8% of eyes with a pre-operative VA between 1.01 and 1.80 (Snellen > 6/60–1/60), for 43.8% eyes with a pre-operative VA of CF or HM and for 17.3% eyes with a pre-operative VA of PL or NPL. The median follow-up was longer for the eyes with a better post-operative VA, where the median follow-up was 12.6, 11.4, 10.5 and 10.6 weeks for eyes with a post-operative VA of ≤0.30, 0.31–1.00, 1.01–1.80 LogMAR and CF or worse, respectively ($p = 0.001$) (Table 3).

VA outcome model

At the univariate level, no association was found between a post-operative VA of ≤0.30 LogMAR (Snellen 6/12 or better) and the number of breaks in the detached retina, number of breaks in the attached retina, the location of the largest break in the detached retina or the post-surgery positioning (Table 1).

In the univariate analysis, eyes treated with laser retinopexy had significantly worse outcomes than those treated by cryopexy. However, this difference was insignificant in the multivariable model, suggesting that laser was more likely to be used in more complex RD with a worse prognosis.

The final best fitting multivariable model included the patient's age and gender, the pre-operative VA, duration of central vision loss (Fig. 1), lens status, presence of any ocular co-pathology, total RD and PVR grade, (Table 4). It did not include any of the surgical procedures, laser, cryotherapy, drainage of sub-retinal fluid or type of tamponade.

The final model had an AUC of 71.6%, (Supplementary Fig. 1). Different categorising of the duration of central vision loss did not improve the model fit. The only difference in covariate significance for the sensitivity analysis model on the eyes with no recorded ocular co-pathology was for PVR grade, which was not significant (data not shown). The median follow-up time varied for some of the covariates.

For a patient with the median age (63 years old) and the median pre-operative VA (CF), the highest probability of achieving a post-operative VA of ≤0.30 LogMAR (Snellen 6/12 or better) is 83.5% for a pseudophakic male patient with no PVR grade C, no total RD, no ocular co-pathologies and 0–2 days central vision loss, this decreases to 76.1% if the duration of central vision loss was 3–4 days and 68.7% if the duration of central vision loss was 5–7 days.

Table 2 The duration of central vision loss according to the patients age, gender, pre-operative VA, lens status, presence of any ocular co-pathology and VA outcome.

Duration of vision loss	*N*	Median age (years)	% Males	Median pre-operative VA (LogMAR)	% Previous cataract surgery	% Any ocular co-pathology	% VA success
Duration recorded	1482	63	66.2	CF	33.7	11.5	49.7
Duration not recorded or no vision loss	592	63	61.7	CF	31.9	5.7	46.6
Number of days of vision loss							
0	32	62	71.9	1.52	37.5	12.5	68.8
1	127	61	69.3	1.48	38.6	7.1	71.7
2	166	63	63.3	CF	30.7	13.3	65.1
3	161	62	67.1	CF	30.4	9.3	53.4
4	153	63	68.0	CF	27.5	13.1	57.5
5	113	62	52.2	CF	29.2	14.2	49.6
6	100	66	70.0	CF	33.0	7.0	48.0
7	126	64	73.8	CF	34.9	9.5	40.5
8	62	64	58.1	CF	27.4	11.3	41.9
9	43	68	76.7	HM	53.5	14.0	48.8
10	36	59	69.4	CF	30.6	16.7	33.3
11	25	64	60.0	HM	28.0	8.0	48.0
12	23	67	52.2	HM	26.1	17.4	47.8
13	20	64	60.0	HM	35.0	10.0	45.0
14	34	72	76.5	1.64	38.2	17.6	44.1
15–31	133	65	67.7	CF	35.3	12.8	39.8
1–3 months	95	66	62.1	HM	36.8	10.5	21.1
>3 months	33	69	69.7	CF	60.6	18.2	21.1

VA success is defined as a post-operative visual acuity of ≤0.30 LogMAR (Snellen 6/12 or better).

Table 3 The percentages of eyes with a specified post-operative visual acuity according to their pre-operative visual acuity, results presented are row percentages.

Row %	Post-operative VA			
Pre-operative VA	≤0.30	0.31–1.00	1.01–1.80	CF or worse
0.31–1.00 (*N* = 414)	65.9	30.7	2.7	0.7
1.01–1.80 (*N* = 376)	50.8	39.6	8.0	1.6
CF or HM (*N* = 1232)	43.8	41.9	11.0	3.4
PL or NPL (*N* = 52)	17.3	46.2	19.2	17.3
Follow-up time (weeks)				
N	1012	816	186	60
Median	12.6	11.4	10.5	10.6
Range	9.3–20.5	8.4–16.9	8.0–15.4	8.8–16.8

Discussion

This study shows that, following successful re-attachment of a macula-off RD, the main variables that determine post-operative VA include age, sex, duration of macular detachment, pre-operative VA, PVR grade C, total detachment and previous cataract surgery.

The main strength of this study is the large number of cases. A meta-analysis [15] looked at over 1300 published papers, and found a total of 602 patients for their study. This study includes data on over 2000 eyes. The data were collected prospectively, by a large number of surgeons, in multiple sites. Analysis of pre-operative characteristics suggests that this sample is broadly representative of the UK experience [18].

A novel feature is the use of a collaborative online audit tool, the BEAVRS RD database. This study demonstrates that useful data may be collected from large numbers of patients, at minimal cost.

Limitations of this study include the absence of patient identifier to use patients as a cluster variable in the modelling; however, we believe that only a relatively small number of patients would have had bilateral macula-off RD. We were not able to verify which of the operations with no recorded time period for the duration of central vision loss were cases with no actual vision loss. The ocular co-pathology data did not allow investigating individual ocular co-pathologies due to the small number of cases with this data recorded. Although there was a minimum follow-up of 2 months, the follow-up period was not standardised, and patients followed for longer had better VA. However, the

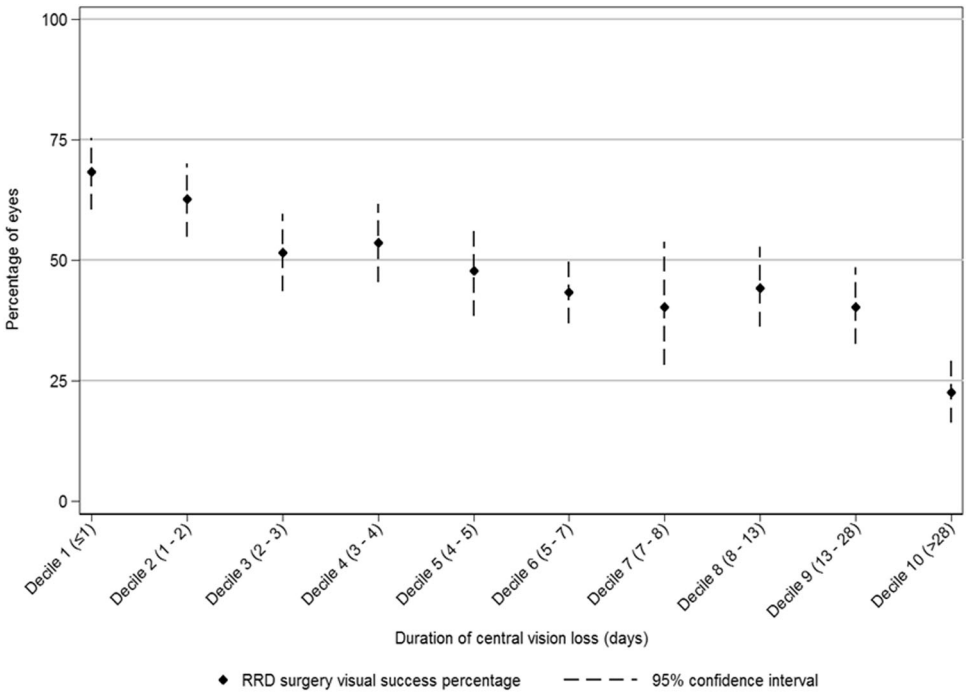

Fig. 1 Visual succes and duration of detachment. Visual success rates by deciles of pre-surgery central vision loss with 95% confidence intervals, for 1482 successfully re-attached Macula-off primary rhegmatogenous retinal detachment operations with a known duration of pre-surgery central vision loss.

variation in follow-up appeared to be evenly distributed between the different predictive factors identified in the multivariable analysis, so it is unlikely to be a source of bias (Supplementary Table 1). Because only data collected as a part of routine clinical care were included, VA measurements were not standardised, and the height of the macular detachment was not measured. Multiple contributors collected data, and it is possible that have led to reduced accuracy, as it was not possible to standardise all data collection.

The duration of the detachment was based on patient recollection, and in many cases this is vague, or non-existent. It is likely that in other cases it is inaccurate [19], and we suspect that this is one of the reasons why our predictive model is not more reliable. However, it is likely that accuracy of recall diminishes with increased duration, and our principal finding relates to an improved prognosis associated with a duration of 72 h or less, when recollection is more accurate.

In a registry study like this, recording of post-operative complications is inconsistent and will depend on length of follow-up among other variables. Post-operative cataract will affect final vision, and our model confirms that pseudophakic eyes have a substantially better visual prognosis. Other post-operative complications, such as epiretinal membrane, raised intraocular pressure or macular hole may also affect final VA. However, these complications were recorded in only a small percentage of patients, and it is unlikely that this would affect the conclusions of the study.

Most of the factors identified are not modifiable. Patient age, sex, pre-operative VA, PVR, co-morbidity and total RD will be determined prior to presentation. However, two can be modified by the surgeon.

The first of these is cataract. Pseudophakic eyes are more likely to achieve good post-operative vision than phakic eyes, probably due to post-operative cataract following vitrectomy. Our model underestimates the benefits of pseudophakia as it only includes factors present at pre-operative assessment. Any eye that had cataract surgery post-operatively would still have been counted as phakic. Combined cataract surgery and vitrectomy has been shown to be safe and effective for some vitreoretinal conditions [20–22], however, combining cataract surgery with vitrectomy for a macula-off RD is less likely to be successful, as obtaining accurate axial length measurements would be difficult. Most phakic patients who have a successful vitrectomy for a RD will require cataract surgery, and this should be an integral part of their post-operative care.

The second modifiable factor is the duration of the detachment. Earlier recognition and referral in the community has a part to play. However, if RD is being recognised and referred earlier, we would expect an increase in the proportion of detachments that are still macula-on at presentation, but there is little evidence of this at present [18, 23]. The only other way to reduce the duration is to operate earlier. Although previous studies have suggested that there is little benefit from earlier surgery, providing the retina is re-attached within

Table 4 Visual outcome model estimates.

Covariate	Odds ratio	Coefficient	*p* value	95% confidence interval for the odds ratio	Median follow-up time (weeks)
Constant	5.920	1.778	<0.001	3.719–9.425	N/A
Patient age (years)					
<70	Ref	Ref	N/A	N/A	11.7
70–79	0.706	−0.348	0.013	0.537–0.929	12.4
≥80	0.552	−0.594	0.027	0.326–0.935	12.2
Patient gender					
Male	Ref	Ref	N/A	N/A	12.0
Female	0.758	−0.277	0.005	0.624–0.920	11.8
Pre-operative VA					
>6/60	Ref	Ref	N/A	N/A	12.0
6/60–1/60	0.584	−0.537	0.023	0.368–0.928	10.8
CF to NPL	0.418	−0.871	<0.001	0.308–0.568	12.1
Duration of vision loss					
0–2 days	Ref	Ref	N/A	N/A	12.0
3–4 days	0.631	−0.460	0.021	0.427–0.932	11.4
5–7 days	0.435	−0.833	<0.001	0.304–0.620	12.0
8–13 days	0.415	−0.878	0.001	0.251–0.687	11.8
≥14 days	0.270	−1.310	<0.001	0.164–0.444	11.8
Not recorded/ unknown	0.429	−0.846	<0.000	0.289–0.637	12.1
PVR grade					
None, A or B	Ref	Ref	N/A	N/A	11.8
C	0.425	−0.855	0.044	0.185–0.976	11.5
Total RD					
No	Ref	Ref	N/A	N/A	11.7
Yes	0.483	−0.728	0.001	0.312–0.739	13.9
Ocular co-pathology					
No ocular co-pathology	Ref	Ref	N/A	N/A	12.1
Any ocular co-pathology	0.532	−0.631	0.001	0.367–0.772	10.1
Lens status					
No previous cataract surgery	Ref	Ref	N/A	N/A	11.8
Previous cataract surgery	2.040	0.713	<0.001	1.572–2.645	12.0

1 week [11, 13, 14, 24, 25], there is growing evidence that surgery within 3 days of macular detachment is associated with a better visual outcome than later surgery [8, 15, 16]. Because of the numerous different factors that affect post-operative VA, small case series are at risk of confounding, and large numbers are required in order to demonstrate an unequivocal relationship between earlier surgery and better visual outcome. Even with more than 2000 cases, our data have not shown a direct linear relationship between duration of macular involvement and VA outcome. It is unclear whether the prognosis deteriorates with every day that passes, or if there is a threshold effect with a step change at different intervals. However, our study confirms that repair within the first 3 days after the macula detaches carries a better visual prognosis than later surgery. This has important implications for service delivery. Patients presenting with a recent macula-off RD on Friday afternoon will have a better visual prognosis if they are operated on Saturday rather than delaying their surgery to the next routine list on Monday. However, the primary aim of RD surgery is anatomical re-attachment of the retina. If anatomical success is more likely to be achieved by delaying surgery, this may outweigh the benefits of an earlier operation. Ideally this would be tested in a randomised clinical trial, however, a trial requiring patients to be randomised to deliberately delayed surgery is unlikely to be feasible.

We believe this to be the largest study conducted so far to investigate the effect of duration of central foveal involvement on recovery of VA. We found a significant inverse relationship between the pre-operative duration of vision loss and the probability of regaining 6/12 or better acuity. We do not have the power/sensitivity in this dataset to identify exact thresholds for visual loss or precise rates of decline, if they exist. However, we can conclude that better visual results would be expected with early surgery for eyes with recent onset (<72 h) fovea involved RD, assuming a high rate of primary anatomical success. The observed effect size in this study was such that an avoidable delay of 48 h between presentation and surgery might be expected to reduce the rate of recovery of 6/12 acuity by 11–15%, depending on the duration and other factors that affect visual outcome.

Summary

What was known before

- Visual acuity after successful re-attachment of a macula-off retinal detachment is usually permanently impaired.
- Previous studies have suggested that earlier surgery may be beneficial, particularly in eyes treated by scleral buckle, but there is uncertainty about the urgency of treating a recent macula-off retinal detachment.

What this study adds

- Factors affecting visual acuity following successful retinal detachment surgery include patient age, sex, duration of foveal detachment, presenting visual acuity, total retinal detachment, presence of PVR grade C, ocular co-morbidity and previous cataract surgery.
- In macula-off retinal detachments treated by vitrectomy and internal tamponade, the visual prognosis is better if the retina is reattached within 72 h of vision loss.

Acknowledgements It is with deep regret that we note the death of our friend and colleague Robert Johnston, who sadly died in September 2016. Without his inspirational vision, determination and career long commitment to quality improvement in ophthalmology this work would not have been possible.

Members of the BEAVRS Retinal Detachment Outcomes Group A.G. Casswell[9], Andrew H.C. Morris[10], Assad Jalil[11], Atiq R. Babar[12], Craig Goldsmith[13], David Steel[14], Diego Sanchez-Chicharro[15], Ed Hughes[9], E.N. Herbert[16], Huw Jenkins[17], Imran J. Khan[18], John D. Ellis[19], Jonathan Smith[14], Kamaljit S. Balaggan[20], Kurt Spiteri Cornish[21], Laura Wakeley[22], Mark Costen[12], Sonali Tarafdar[19], Stephen J. Charles[11], Stephen Winder[21], Timothy Cochrane[23], Tsveta Ivanova[11], Vasileios T. Papastavrou[24], Vaughan Tanner[25].

[9]Sussex Eye Hospital, Brighton, UK; [10]Royal Bournemouth Hospital, Bournemouth, UK; [11]Manchester Royal Eye Hospital, Manchester, UK; [12]Hull and East Yorkshire Eye Hospital, Hull, UK; [13]James Paget University Hospital NHS Trust, Yarmouth, UK; [14]Sunderland Eye Infirmary, Sunderland, UK; [15]Martin University Hospital, Martin, Slovakia; [16]Musgrove Park Hospital, Taunton, UK; [17]Glangwili Hospital, Carmarthen, UK; [18]University Hospitals of North Midlands NHS Trust, Stoke-on-Trent, UK; [19]Ninewells Hospital and Medical School, Dundee, UK; [20]Wolverhampton and Midland Counties Eye Infirmary, Wolverhampton, UK; [21]Sheffield Teaching Hospitals NHS Trust, Broomhall, UK; [22]York Teaching Hospital NHS Foundation Trust, York, UK; [23]Maidstone and Tunbridge Wells NHS Trust, Tunbridge Wells, UK; [24]Spa Medica, Bolton, Manchester, UK; [25]Royal Berkshire Hospital, Reading, UK

Funding The database set up and running has been made possible by funding support from the British and Eire Association of Vitreoretinal Surgeons, and Euretina.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Thompson JA, Snead MP, Billington BM, Barrie T, Thompson JR, Sparrow JM. National audit of the outcome of primary surgery for rhegmatogenous retinal detachment. II. Clinical outcomes. Eye. 2002;16:771–7. http://www.ncbi.nlm.nih.gov/pubmed/12439675.
2. Wickham L, Ho-Yen GO, Bunce C, Wong D, Charteris DG. Surgical failure following primary retinal detachment surgery by vitrectomy: risk factors and functional outcomes. Br J Ophthalmol. 2011;95:1234–8. http://www.ncbi.nlm.nih.gov/pubmed/21156702.
3. Wickham L, Bunce C, Wong D, Charteris DG. Retinal detachment repair by vitrectomy: simplified formulae to estimate the risk of failure. Br J Ophthalmol. 2011;95:1239–44. http://www.ncbi.nlm.nih.gov/pubmed/21325394.
4. Mitry D, Awan MA, Borooah S, Rehman Siddiqui MA, Brogan K, Fleck BW, et al. Surgical outcome and risk stratification for primary retinal detachment repair: results from the Scottish Retinal Detachment study. Br J Ophthalmol. 2012;96:730–4.
5. Williamson TH, Lee EJK, Shunmugam M. Characteristics of rhegmatogenous retinal detachment and their relationship to success rates of surgery. Retina. 2014;34:1421–7. http://www.ncbi.nlm.nih.gov/pubmed/24480842.
6. Wilkinson CP. Mysteries regarding the surgically reattached retina. Trans Am Ophthalmol Soc. 2009;107:55–7. http://www.ncbi.nlm.nih.gov/pubmed/20126482.
7. Doyle E, Herbert EN, Bunce C, Williamson TH, Laidlaw DAH. How effective is macula-off retinal detachment surgery. Might good outcome be predicted?. Eye. 2007;21:534–40. http://www.nature.com/articles/6702260.
8. Williamson TH, Shunmugam M, Rodrigues I, Dogramaci M, Lee E. Characteristics of rhegmatogenous retinal detachment and their

relationship to visual outcome. Eye. 2013;27:1063–9. http://www.ncbi.nlm.nih.gov/pubmed/23788207.
9. Lecleire-Collet A, Muraine M, Menard J-F, Brasseur G. Predictive visual outcome after macula-off retinal detachment surgery using optical coherence tomography. Retina. 2005;25:44–53. http://www.ncbi.nlm.nih.gov/pubmed/15655440.
10. Mowatt L, Tarin S, Nair RG, Menon J, Price NJ. Correlation of visual recovery with macular height in macula-off retinal detachments. Eye. 2010;24:323–7. http://www.nature.com/articles/eye200974.
11. van de Put MAJ, Croonen D, Nolte IM, Japing WJ, Hooymans JMM, Los LI. Postoperative recovery of visual function after macula-off rhegmatogenous retinal detachment. PLoS One. 2014;9:e99787. http://www.ncbi.nlm.nih.gov/pubmed/24927502.
12. Ross WH. Visual recovery after macula-off retinal detachment. Eye. 2002;16:440–6. http://www.nature.com/articles/6700192.
13. Abouzeid H, Wolfensberger TJ. Macular recovery after retinal detachment. Acta Ophthalmol Scand. 2006;84:597–605. http://doi.wiley.com/10.1111/j.1600-0420.2006.00676.x.
14. Liu F, Meyer CH, Mennel S, Hoerle S, Kroll P. Visual recovery after scleral buckling surgery in macula-off rhegmatogenous retinal detachment. Ophthalmologica. 2006;220:174–80. https://www.karger.com/Article/FullText/91761.
15. van Bussel EM, van der Valk R, Bijlsma WR, La Heij EC. Impact of duration of macula-off retinal detachment on visual outcome. Retina. 2014;34:1917–25. http://www.ncbi.nlm.nih.gov/pubmed/25121930.
16. Frings A, Markau N, Katz T, Stemplewitz B, Skevas C, Druchkiv V, et al. Visual recovery after retinal detachment with macula-off: is surgery within the first 72 h better than after? Br J Ophthalmol. 2016;100:1466–9. http://bjo.bmj.com/lookup/doi/10.1136/bjophthalmol-2015-308153.
17. Royal College of Ophthalmologists. Retinal detachment data set. R College Ophthalmol. 2010. https://www.rcophth.ac.uk/standards-publications-research/audit-and-data/clinical-data-sets/retinal-detachment-data-set/.
18. Mitry D, Singh J, Yorston D, Siddiqui MAR, Wright A, Fleck BW, et al. The predisposing pathology and clinical characteristics in the Scottish retinal detachment study. Ophthalmology. 2011;118:1429–34.
19. Ng H, La Heij EC, van Meurs JC. The duration of macular detachment in retinal detachment is difficult to determine. Acta Ophthalmol. 2019. https://www.ncbi.nlm.nih.gov/pubmed/31693277.
20. Madgula IM, Costen M. Functional outcome and patient preferences following combined phaco-vitrectomy for macular hole without prone posturing. Eye. 2008;22:1050–3. http://www.ncbi.nlm.nih.gov/pubmed/17435683.
21. Yorston D, Siddiqui MAR, Awan MA, Walker S, Bunce C, Bainbridge JW. Pilot randomised controlled trial of face-down posturing following phacovitrectomy for macular hole. Eye. 2012;26:267–71.
22. Fajgenbaum MAP, Neffendorf JE, Wong RS, Laidlaw DAH, Williamson TH. Intraoperative and postoperative complications in phacovitrectomy for epiretinal membrane and macular hole. Retina. 2018;38:1865–72. http://www.ncbi.nlm.nih.gov/pubmed/29324594.
23. Sullivan PM, Luff AJ, Aylward GW. Results of primary retinal reattachment surgery: a prospective audit. Eye. 1997;11:869–71. http://www.ncbi.nlm.nih.gov/pubmed/9537149.
24. Ross WH. Visual recovery after macula-off retinal detachment. Eye. 2002;16:440–6. http://www.ncbi.nlm.nih.gov/pubmed/12101451.
25. Mitry D, Awan MAMA, Borooah S, Syrogiannis A, Lim-Fat C, Campbell H, et al. Long-term visual acuity and the duration of macular detachment: findings from a prospective population-based study. Br J Ophthalmol. 2013;97:149–52. http://www.ncbi.nlm.nih.gov/pubmed/23159447.