National Electronic Retinal Detachment Surgery Audit: Feasibility Report

A report commissioned from The Royal College of Ophthalmologists National Ophthalmology Database Audit by the Healthcare Quality Improvement Partnership

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National Electronic Retinal Detachment Surgery Audit: Feasibility Report

This feasibility study was commissioned by HQIP as part of a National Ophthalmology Audit with The Royal College of Ophthalmologists as the Audit Provider.

Executive Summary

Retinal detachment is a potentially blinding eye disease with an incidence of approximately 12 cases per 100,000 people per year. Most commonly the problem occurs as a result of a tear or hole in the sensory retina, allowing fluid to pass through the retinal break and collect beneath the retina. Retinal detachments which occur in this way are referred to as rhegmatogenous retinal detachments (RRD). The accumulating sub-retinal fluid internally peels the sensory retina away from the outer retina and choroid lining the wall of the eye. The problem is essentially a mechanical one requiring a mechanical solution, i.e. an operation. Surgery is undertaken by highly trained subspecialist vitreoretinal eye surgeons with the majority of procedures involving removal of the vitreous gel from within the eye and closure of the break through the creation of an inflammatory adhesion around it.

Positioning the retina back up against the wall of the eye usually involves filling the posterior cavity of the eye with a gas bubble or oil, or alternatively, in a minority of operations the outer wall of the eye or sclera is buckled inwards by suturing an implant onto the outside of the eye to cause an indent with closure of the break. Left untreated the vast majority of eyes with a retinal detachment progress to total retinal detachment and blindness, with surgery however around four out of five operations achieve a successful reattachment of the retina. Recovery of visual acuity (VA) is powerfully dependent upon whether the central retina was detached or was not detached preoperatively (macula off or macula on detachments respectively).

In this collaborative feasibility study the British and Eire Association of Vitreoretinal Surgeons (BEAVRS) retinal detachment dataset was used for data definitions. This dataset has been adopted as a data standard by The Royal College of Ophthalmologists. Data were extracted and aggregated from three electronic sources, the Medisoft Electronic Medical Record (EMR) system, the BEAVRS retinal detachment audit database and the VITREOR EMR database. Data for eligible procedures were

available for 10,054 primary RRD operations undertaken between 2011 and 2016 by 178 surgeons. 5,522 (54.9%) were derived from the Medisoft EMR from 13 centres, 3,504 (34.9%) from the BEAVRS RD database (unknown number of centres) and 1,028 (10.2%) from the VITREOR EMR database from two centres. Data completeness varied between data sources with VITREOR providing the most complete data and Medisoft the least complete, with a minority of these latter centres recording the full range of BEAVRS dataset variables.

Outcomes

In this feasibility study anatomical reattachment of the retina and postoperative VA were considered as candidate outcomes. Definitions for surgical anatomical success were agreed by expert consensus and varied slightly between the data sources according to data availability. The overall primary RRD reattachment success rate was 81.1% (7,236/8,923) and was similar for each of the data sources. Crude results for individual surgeons were calculated and have been summarised on an unadjusted funnel plot. Guided by previous work involving analysis of the BEAVRS data, a prediction model for surgical failure was piloted to assess the feasibility of case complexity adjustment in a possible future national audit. In this exercise data derived from the Medisoft EMR were excluded as insufficient relevant variables for complexity adjustment were available from this data source. Based on the BEAVRS and VITREOR data a logistic regression analysis produced a model with an encouraging C-Stat = 0.77, which was used to risk adjust the results of individual surgeons. As a methodological example, a case complexity adjusted funnel plot has been produced for individual surgeons. This proof of concept exercise has illustrated that case complexity adjustment would be feasible in a possible future national audit of RRD surgery. High levels of pre- and post-operative missing VA data prevented a similar exercise for a functional outcome.

Feasibility of a National Audit of RRD Surgery

An audit of surgical outcome in retinal detachment appears to be feasible in methodological terms. The main limitations would be the completeness of collection of relevant data in the existing data collection systems and possible overlap for a surgeon recording data on more than one system. Currently centre ID is not collected on the BEAVRS database and surgeon ID is anonymised so any future HQIP commissioned collaborative audit would need to be contingent upon these information items being available from all three data sources. Surgeons are unlikely to engage in duplicate data collection if they are aware that their data can be accessible to a national audit via any one of the

three routes. The availability of an agreed national dataset serves to facilitate data compatibility between systems and merging data from these three interoperable sources has proven to be feasible for RRD surgery. The availability of a web based data collection tool, which can be accessed by any vitreoretinal surgeon undertaking this type of work would avoid any need for a possible future national audit to provide data collection software. A potential problem is that any changes to data collection on the BEAVRS RD audit database, namely a centre and surgeon identifier, would need to be approved by the BEAVRS membership. Senior members of the organisation have however expressed the view that this is unlikely to pose a significant obstacle.

As with most national audits, data completeness has been observed to be an issue. For the Medisoft EMR option, provided system users utilise the available functionality on their system all the necessary data can be collected. Not all system users choose to do this however, collection of the full nationally agreed set of data requires local activation of an 'additional functionality switch'. Patients undergoing this surgery are invariably followed up by the surgical team so there is less reliance of other professional groups to return postoperative VA data as this should be available to the surgical centre.

In summary, this study has demonstrated the feasibility of a national audit for NHS RRD surgery. Merging data from three sources has been possible and data collection tools already exist which are available to all UK surgeons undertaking this procedure. The members of the vitreoretinal subspecialist organisation, BEAVRS, would need to agree to collect and release centre and surgeon ID. Case complexity adjusted anatomical outcomes are feasible for this surgery and improved collection of VA data could provide a functional outcome in addition to anatomical reattachment of the retina.

National Electronic Retinal Detachment Audit Feasibility Report

1. Background

When the retina becomes detached and separated from its underlying tissue, the light sensitive photoreceptors are no longer able to function. If the central retina (macula) becomes detached, permanent, partial loss of central visual function (visual acuity) occurs. VA does however remain normal as long as the central retina remains attached. The vast majority of retinal detachments are caused by retinal breaks (tears or holes) and are called rhegmatogenous detachments. The retina may also become detached as a result of inflammation or intraocular tumours (exudative), or as a result of contracting scar tissue (traction). This report considers only rhegmatogenous retinal detachment which is the most common indication for vitreoretinal surgery in the UK, with an estimated incidence of 12/100,000 per annum.

Retinal detachment is more common in men than women, and the peak incidence is in the seventh decade. The risk of retinal detachment is greater in people who are short sighted (myopic), or who have had cataract surgery, particularly if the operation was complicated.

Most retinal detachments occur as a result of aging changes in the vitreous gel. This leads to separation of the gel from the retina. If there are abnormal attachments between the vitreous gel and the retina, the retina may be torn as the vitreous separates. Fluid can then pass through the retinal tear, detaching the retina from the underlying tissue. In some cases, the retina may detach without a vitreous separation. These detachments are more slowly progressive and occur in younger people.

Unlike cataract, retinal detachment must be treated urgently to avoid permanent loss of sight. Current guidelines suggest that retinal detachments that have not spread to involve the macula should be treated within 24 hours in order to prevent loss of central vision. Even if the macula is involved, there is increasing evidence that urgent surgery leads to better visual outcomes.

There is no medical treatment for retinal detachment which is a mechanical problem requiring a mechanical solution. Virtually all patients will require surgery to re-attach the retina. The principle goals of surgery are to close the retinal break, and to create a scar around the break leading to permanent adhesion between the retina and the underlying retinal pigment epithelium, thus sealing

the hole. This can be achieved by either an internal, or an external approach. In the UK, 90% of retinal detachments are treated with an internal approach, using an operation called a three port pars plana vitrectomy. The external approach is reserved for retinal detachments in young people in whom the vitreous gel is not separated.

Vitrectomy involves removal of the vitreous gel from the eye and can be performed under local anaesthesia. Using modern instrumentation, this part of the procedure can be completed in around 30 minutes, with no sutures required. Following removal of the vitreous, the retinal breaks are identified using the operating microscope, and the retina is pushed back up against the wall of the eye by injecting an air bubble into the evacuated vitreous cavity to displace the sub-retinal fluid. The retina around the breaks is treated with either cryotherapy or laser to damage the outer retina, and through normal healing processes, to stimulate the formation of a permanent adhesion between the sensory retina and the retinal pigment epithelium. The air is then replaced with an insoluble gas, or occasionally silicone oil, that holds the retinal holes or breaks against the pigment epithelium (wall of the eye) long enough for a scar to form around the hole.

External surgery relies on suturing a plastic implant to the sclera, causing an indent that plugs the break. The retina is similarly treated with cryotherapy or laser to create a permanent seal around the break.

A national audit by The Royal College of Ophthalmologists (RCOphth) in 1997 showed that the success rate for surgery was variable. Specialist retinal surgeons had a significantly higher success rate than non-specialists (80% vs. 71%, $p<0.01$). As a direct result of this audit, almost all retinal detachment surgery in the UK is now performed by approximately 150 specialist vitreoretinal consultant surgeons and their teams. More recently the Scottish retinal detachment survey also found a success rate of approximately 80%. Both The RCOphth audit and the Scottish national audit identified risk factors for failure, showing that some retinal detachments were much more likely to require multiple operations than others.

Because pre-operative risk factors have an important effect on success rates, it is essential that any published figures on the outcomes of retinal detachment surgery are adjusted to take into account the variable complexity of each case.

In 2014, The Healthcare Quality Improvement Partnership (HQIP) commissioned a National Ophthalmology Audit which included three feasibility studies for electronic audits. These were for glaucoma, to include trabeculectomy surgery and visual field preservation, for age-related macular

degeneration (AMD) treatment and for rhegmatogenous retinal detachment (RRD) surgery, in addition to the main focus of the National Audit, which was cataract surgery. These additional studies were commissioned in order to assess the feasibility of undertaking national audits in the three conditions based purely on data extracted from specialty specific electronic medical record systems (EMRs) and in the case of RRD surgery, a national audit database.

This feasibility study was undertaken, using prospectively collected data from a specialist society database (BEAVRS), an EMR database (VITREOR) and an ophthalmology EMR system (Medisoft), in order to determine if it is possible to collect, analyse and present comparative risk-adjusted outcome data for centres and surgeons for retinal detachment surgery in the UK.

2. Context of the Feasibility Studies

The National Ophthalmology Database Audit is primarily concerned with publishing comparative cataract surgical results for named surgeons (excluding trainees) and named centres (including trainees) and sits within the National Clinical Audit and Patient Outcomes Programme (NCAPOP). The main cataract surgical audit and the three feasibility studies are based on routine clinical care data which is extracted from specialty specific Electronic Medical Record (EMR) systems. By far the most widely used system is the Medisoft EMR, with the OpenEyes EMR currently contributing cataract surgery data from a single very large centre, with a small number of bespoke local databases also providing data. The remit of the feasibility studies is to investigate the feasibility of the use of electronic data derived from EMRs (and for RRD, a national audit database) to assess the potential for future full scale national audits in one or more of these three topics. This report is based on multicentre data collected as a by-product of routine clinical work using the Medisoft EMR, the VITREOR EMR database and the British and Eire Association of Vitreoretinal Surgeons (BEAVRS) RD audit database.

The audit provider is The Royal College of Ophthalmologists (RCOphth) which has engaged a number of subcontractors to deliver various elements of the audit. The brief from the audit commissioners included a requirement that these audits should build on the work of The RCOphth National Ophthalmology Database project which previously extracted, aggregated and analysed EMR derived data and published surgical benchmarks for a number of high volume ophthalmological procedures. A small working group based at The RCOphth obtains permissions and coordinates the work in conjunction with the 'NOD Delivery Unit' based in Cheltenham, the EMR providers Medisoft and

OpenEyes, the representatives from the VITREOR and BEAVRS databases and a web design company. The NOD Delivery Unit forms the 'engine room' of the audit where the extracted data are aggregated and analysed following extraction by the data providers. The Medisoft EMR cataract module and optometric data return tools are provided by the audit as needed to allow currently paper based centres to collect cataract surgery data as part of routine clinical activity. The national audit is overseen by a RCOphth based multi-professional steering committee with Patient and Public Involvement (PPI) which reports via the Informatics and Audit Sub-committee to the Professional Standards Committee and ultimately to the College Council. Regular contract review meetings are held with the audit commissioners.

3. Aims of the Retinal Detachment Surgery Feasibility Audit

The National Audit tender for the retinal detachment surgery feasibility study focuses of primary rhegmatogenous retinal detachment (RRD) surgery and the feasibility of centre and surgeon level case-mix adjusted outcomes of primary RRD surgery.

4. Methodology

4.1 Data Extraction

The data for this analysis comprises data extracted from three contributing data collection systems, the VITREOR EMR database; the BEAVRS RD audit database and the Medisoft EMR. Data was extracted from both the VITREOR EMR and the BEAVRS RD databases in September 2016. Both of these data collection systems supplied data compliant with the national RD dataset. Data was extracted from 40 centres using the Medisoft EMR in autumn 2015, with a supplementary extraction to resolve a number of issues in the original extraction. Of the 40 centres using the Medisoft EMR, 13 had data for primary RRD operations and the files used from the Medisoft data extraction were as follows:

- Intraocular pressure measurements
- Ocular co-pathology
- Operative data (Indications for surgery, operative procedures, cataract surgery and vitreoretinal surgery specific data)
- Operative complications

- Patient details
- Post-operative complications
- Refraction
- Visual acuity

4.2 Inclusion and Exclusion Criteria for the Retinal Detachment Surgery Feasibility Audit

Eligibility

- Primary RRD operations undertaken on adult patients (18 or older)
- Primary RRD operations performed from 1st October 2011 up to the date of data extraction for each data collection system
- Primary RRD operations with a valid surgeon identifier and surgeon grade
- Primary RRD surgery that included either a pars plana vitrectomy (PPV) or a Scleral buckle
- A patient may contribute two eyes to the audit as both eyes could undergo primary RRD surgery

Exclusion

- Non primary RRD surgery and not compliant with the eligibility criteria
- RRD surgery for ocular trauma or combined tractional RD surgery, this included all eyes that had previously undergone a vitrectomy operation prior to the index RRD surgery
- RRD surgery not including either a PPV or a Scleral buckle, assumed to be operations performed using Pneumatic Retinopexy which is a rare procedure in the UK

4.3 Surgical Case Complexity

Reporting surgical success or failure rates provides a limited insight into the performance of individual surgeons as their case complexity is likely to vary. In order to accommodate variations in case complexity, risk models for surgical success are needed. Parameters for model construction were defined with a view to exploring the data for predictors of success versus failure. A model referring to recorded outcome of success or failure for the operations performed using a vitrectomy (PPV only and PPV + Scleral buckle) recorded on the BEAVRS RD and VITREOR EMR databases was constructed. Operations recorded on the Medisoft EMR were not included due to the data extraction being performed only a short time after the full national retinal detachment dataset of data items was incorporated into the EMR system.

4.4 Composite outcome definition for surgical outcome

Surgeons using either the VITREOR EMR or the BEAVRS RD databases record the success or failure of the primary RRD surgery, while surgeons using the Medisoft EMR cannot do so and clinical indicators are used to infer success or failure. Primary RRD surgery outcome was defined as follows:

- Success
    - For the VITREOR and BEAVRS RD databases – Surgeon recorded success
    - For the Medisoft EMR – No record of a repeat RRD operation within six months of primary RRD surgery. If silicone oil was used during primary RRD surgery – a record of removal of silicone oil within six months of primary RRD surgery.
- Failure
    - For the VITREOR and BEAVRS RD databases – Surgeon recorded failure. Cross checking was performed for those operations with at least six months potential follow up, where failure was inferred if the number of post-operative operations was >2, or silicone oil was used during primary RRD surgery and there was no record of removal within six months of primary RRD surgery.
    - For the Medisoft EMR – Repeat RRD surgery within six months of primary RRD surgery. If silicone oil was used during primary RRD surgery – no record of removal of silicone oil within six months of primary RRD surgery.
- Unknown
    - For the VITREOR and BEAVRS RD databases – Surgeon recorded unknown outcome
    - For the Medisoft EMR – <6 months potential follow up

Note: operations for the removal or silicone oil or a scleral buckle which are not full blown repeat RRD operations are not considered as failed surgery.

Unadjusted for case-mix primary RRD surgery failure results were produced for centres and surgeons. Case-mix adjusted results were only produced for operations that included a vitrectomy (PPV only and Scleral buckle + PPV) recorded on the BEAVRS RD and VITREOR EMR databases with a known surgical outcome. As a 'proof of concept' example, a case-mix adjusted logistic regression model was produced for surgical failure, where the individual surgeons were fitted as clusters for calculation of robust standard errors. A surgeon who had recorded data as both a trainee and as a consultant was counted as a separate surgeon for each grade.

Details about the coding for each variable under consideration in the case-mix adjustment model are provided in Appendix 1.

4.5 Statistical Analysis

For all graphs displaying results by participating centre, the data from VITREOR EMR and BEAVRS RD are considered as a 'centre', this is because neither source of data contained a centre identifier, this is not recorded on the BEAVRS RD system and was not provided by VITREOR, but can recorded on this system. As vitrectomy surgery is a sub-specialty of ophthalmological surgery, it is not uncommon for a smaller centre to have only one vitreoretinal (VR) surgeon, therefore in some instances the centre and surgeon results would be the same.

All analyses were conducted using STATA version 14, (StataCorp. 2009. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP). For the Medisoft centres, participation was affirmed by agreement from the Trust Caldicott Guardian and Clinical Lead for Ophthalmology.

5. Results

5.1 Eligibility and Sample Selection

In total 13,407 RRD operations were recorded on the three contributing data collection systems, 3,811 (28.4%) on the BEAVRS RD system, 1,084 (8.1%) on the VITREOR system and 8,512 (63.5%) on the Medisoft EMR.

In total, 3,353 (25.0%) operations were excluded from analysis, 307 operations from the BEARVS RD system, 56 operations from the VITREOR system and 2,990 operations from the Medisoft EMR. The reasons for exclusion were as follows:

- 2,561 operations were performed prior to 1st October 2011
- 115 operations were performed on patients aged <18 years
- 419 eyes had a record of a previous retinal detachment surgery prior to the first record of RRD surgery in the combined database
- 12 eyes had records of traumatic RRD surgery or previous ocular surgery for trauma
- 168 eyes had a record of vitrectomy surgery prior to their first record of RRD surgery in the combined database
- 71 operations had no record of either a PPV or a scleral buckle being used and were assumed to be pneumatic retinopexy operations.
- One operation was recorded as being performed by a nurse (assumed data entry error)
- Six operations had no date of surgery

In total 10,054 primary RRD operations from 10,054 eyes were eligible for analysis, 3,504 (34.9%) from the BEAVRS RD audit database, 1,028 (10.2%) from the VITREOR EMR database and 5,522 (54.9%) from the Medisoft EMR.

The 10,054 primary operations were performed by 178 surgeons, 8.4% were performed in the partial 2011 NHS year, rising to 27.3% for the 2014 NHS year. The only included operations performed in the partial 2016 NHS year were recorded on the BEAVRS RD audit database.

PPV only was used for 8,618 (85.7%) operations, Scleral buckle only for 929 (9.3%) operations and PPV + Scleral buckle for 507 (5.0%) operations. A slightly higher proportion of operations including a Scleral buckle were recorded on the Medisoft EMR than either the BEAVRS RD or VITREOR systems and only three operations recorded on VITREOR were performed using Scleral buckle only. The VITREOR

representative has confirmed that approximately 10% of primary RRD operations on VITREOR used Scleral buckle only, but these operations were not provided for this analysis, **Table 1**.

Table 1: Operative details for primary RRD surgery by data collection system

Variable, n (column %)	BEAVRS RD	VITREOR	Medisoft	Overall
Number of operations	3,504	1,028	5,522	10,054
Number of surgeons	50	16	112	178
Number of operations per NHS year				
2011	114 (3.3)	42 (4.1)	689 (12.5)	845 (8.4)
2012	581 (16.6)	155 (15.1)	1,530 (27.7)	2,266 (22.5)
2013	847 (24.2)	284 (27.6)	1,602 (29.0)	2,733 (27.2)
2014	742 (21.2)	298 (29.0)	1,701 (30.8)	2,741 (27.3)
2015	795 (22.7)	249 (24.2)	N/A	1,044 (10.4)
2016	425 (12.1)	N/A	N/A	425 (4.2)
Number of operations per treatment comparison group				
PPV only	3,054 (87.1)	916 (89.1)	4,648 (84.2)	8,618 (85.7)
Scleral buckle only	384 (11.0)	3 (0.3)	542 (9.8)	929 (9.3)
PPV + Scleral buckle	66 (1.9)	109 (10.6)	33 2(6.0)	507 (5.0)

5.2 Surgeons

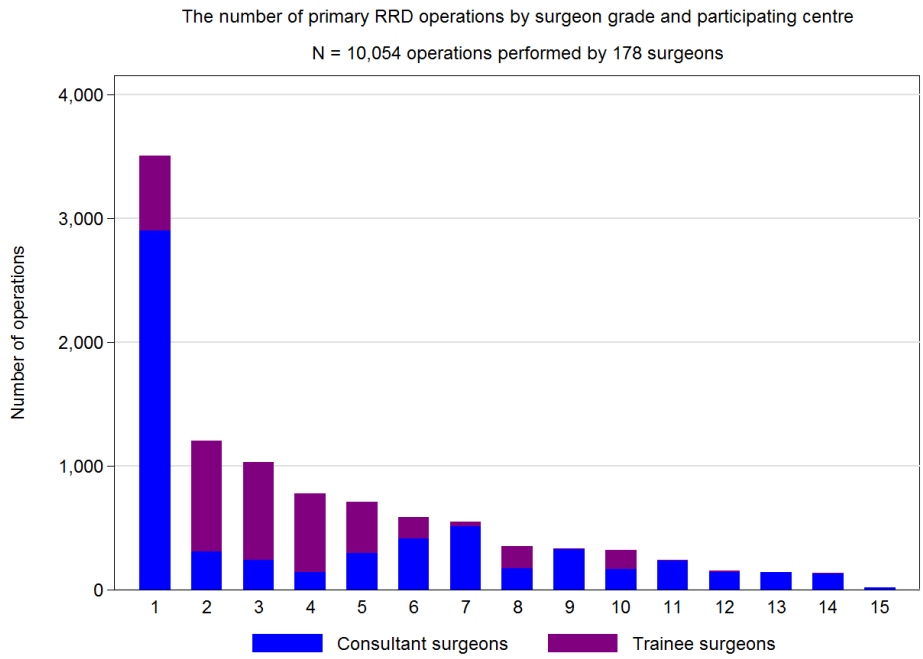
From 178 Surgeons who performed the 10,054 primary RRD operations, 50 recorded data on the BEAVRS RD system, 16 on the VITREOR system and 112 on the Medisoft EMR. Operations performed on more than one grade were recorded by 26 surgeons.

The number of surgeons and operations at each surgeon grade were:

- 95 consultant surgeons performed 6,138 (61.1%) operations; this included 15 operations performed by independent non-consultant surgeons.
- 109 trainee surgeons performed 3,916 (38.9%) operations

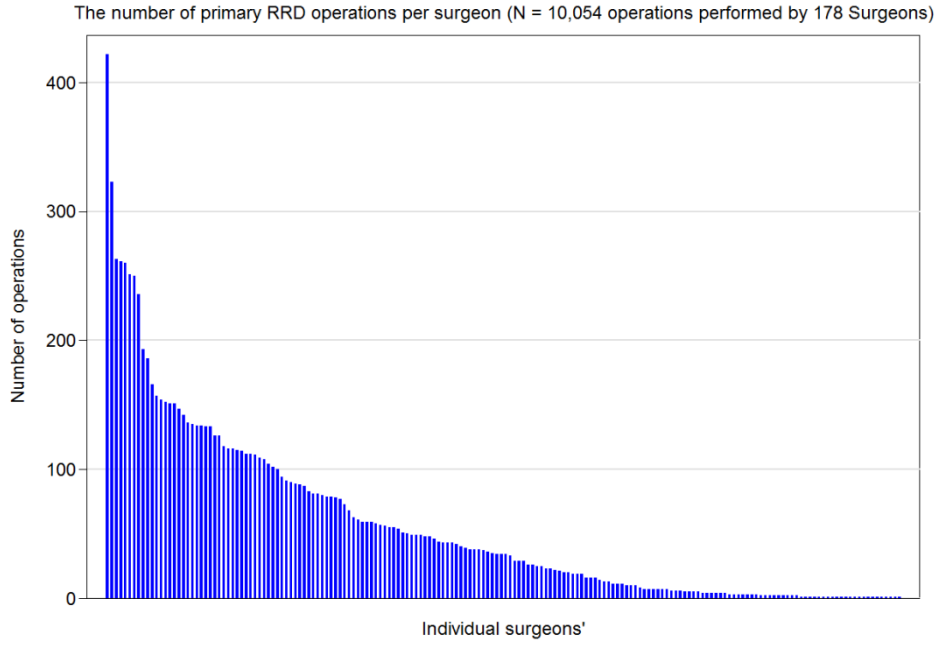
The number of primary RRD operations performed by each grade of surgeon in each participating centre varied between the centres, **Figure 1**.

Figure 1: The number of primary RRD operations by surgeon grade per participating centre.



The median number of primary RRD operations performed by each surgeon was 118 (IQR; 73 – 186), 110 surgeons had recorded fewer than 50 operations and 38 surgeons had recorded more than 100 operations, figure 2.

Figure 2: The number of primary RRD operations for each surgeon.



5.3 Patients

The 10,054 operations were performed in 4,468 (44.4%) left eyes and 5,586 (55.6%) right eyes. The gender was recorded as males for 2,202 (62.8%) BEAVRS operations, 649 (63.2%) VITREOR operations and 3,413 (61.8%) Medisoft operations. The gender was not recorded for one VITREOR operation and eight Medisoft operations.

The median (IQR) age at the time of surgery for each contributing data collection system was 60 (51 – 69) years for BEAVRS operations, 60.7 (53.4 – 67.6) years for VITREOR operations and 60.7 (51.3 – 68.4) years for Medisoft operations.

The median (IQR) age at the time of surgery for each surgical technique was 62 (54 – 69.1) years for PPV only operations, 37.2 (28 – 49.4) years for Scleral buckle only operations and 58.0 (47.0 – 66.9) years for PPV + Scleral buckle operations. The age was missing for one operation from VITREOR and one operation from Medisoft.

The index of multiple deprivations (IMD) was calculable for 5,072 (91.9%) Medisoft operations, but was not calculable for the operations recorded on either the BEAVRS or VITREOR systems as The RCOphth NOD does not have permission to receive the patients' full postcode which is require for directly calculating IMD data. For this reason, no results for IMD are provided.

The above results cannot be provided at the patient level, i.e. for first and second eye surgery separately. This is because the data from both the BEAVRS RD and VITREOR EMR databases did not include a pseudonymised patient identifier. The BEAVRS system does include an option for a pseudonymised patient identifier which is rarely used, and the VITREOR EMR database does have the facility to record a pseudonymised patient identifier, although this information was not included in the data used in this analysis. Both of these databases can record if the fellow eye had a retinal detachment, using this information an estimate of 5.9% (205/3,504) BEAVRS operations and 5.1% (52/1,028) VITREOR operations were performed in patients who had retinal detachments in both eyes, but this does not necessarily mean that patients had surgery on both eyes or that the retinal detachment was rhegmatogenous. The data from Medisoft does contain a pseudonymised patient identifier; from this system 2.7% (147/5,522) operations were performed in patients who had both eyes undergo primary RRD surgery.

5.4 Pre-operative Visual Acuity

From the 10,054 primary RRD operations a pre-operative VA was recorded for 6,632 (66.0%) eyes and missing for 3,422 (34%) eyes. The percentage of eyes with a missing pre-operative VA varied between the three data sources as well as between the 13 Medisoft centres. Pre-operative VA was missing for 14.4% of eyes from the BEAVRS RD system, for 1.0% of eyes from the VITREOR system and for 52.8% of eyes from the 13 Medisoft centres combined, **Figure 3**.

The median pre-operative VA was 0.60 LogMAR (IQR; 0.18 – CF) where 771 (11.6%) eyes had CF, 1,323 (19.9%) eyes had HM, 166 (2.5%) eyes had PL and five (<0.1%) eyes NPL. The pre-operative VA was 0.30 LogMAR or better for 2,577 (38.9%) eyes, 0.60 LogMAR or better for 3,265 (49.2%) eyes and 1.00 LogMAR or better for 4,169 (62.9%) eyes. The general spread of pre-operative VA was consistent between centres, although the median pre-operative VA did vary considerably, **Figure 4**.

The above visual acuity results do not reveal the true nature of VA for eyes undergoing retinal detachment surgery, this is because the vision in an eye with a retinal detachment is strongly linked to the macular status at the time of surgery, i.e. macular on or macular off. Typically, macular on eyes have better vision than macular off eyes. For this analysis the data of macular status was not available from VITREOR or Medisoft, but was recorded for 2,977 (99.3%) eyes from the BEAVRS database and the following VA results are only produced for the operations recorded on the BEAVRS system.

From 1,370 macular on eyes, the median (IQR) VA was 0.18 LogMAR (0.00 – 0.30). The pre-operative VA was 0.30 LogMAR or better for 1,110 (81.0%) eyes, 0.60 LogMAR or better for 1,209 (88.2%) eyes and 1.00 LogMAR or better for 1,274 (93.0%) eyes. The pre-operative VA was CF for 43 (3.1%) eyes, HM for 42 (3.1%) eyes and PL for four (0.3%) eyes.

From 1,607 macular off eyes, the median (IQR) VA was CF (1.00 – HM). The pre-operative VA was 0.30 LogMAR or better for 73 (4.5%) eyes, 0.60 LogMAR or better for 252 (15.7%) eyes and 1.00 LogMAR or better for 510 (31.7%) eyes. The pre-operative VA was CF for 337 (21.0%) eyes, HM for 621 (38.6%) eyes and PL for 59 (3.7%) eyes.

Figure 3: The percentage of primary RRD operations with a missing pre-operative visual acuity.

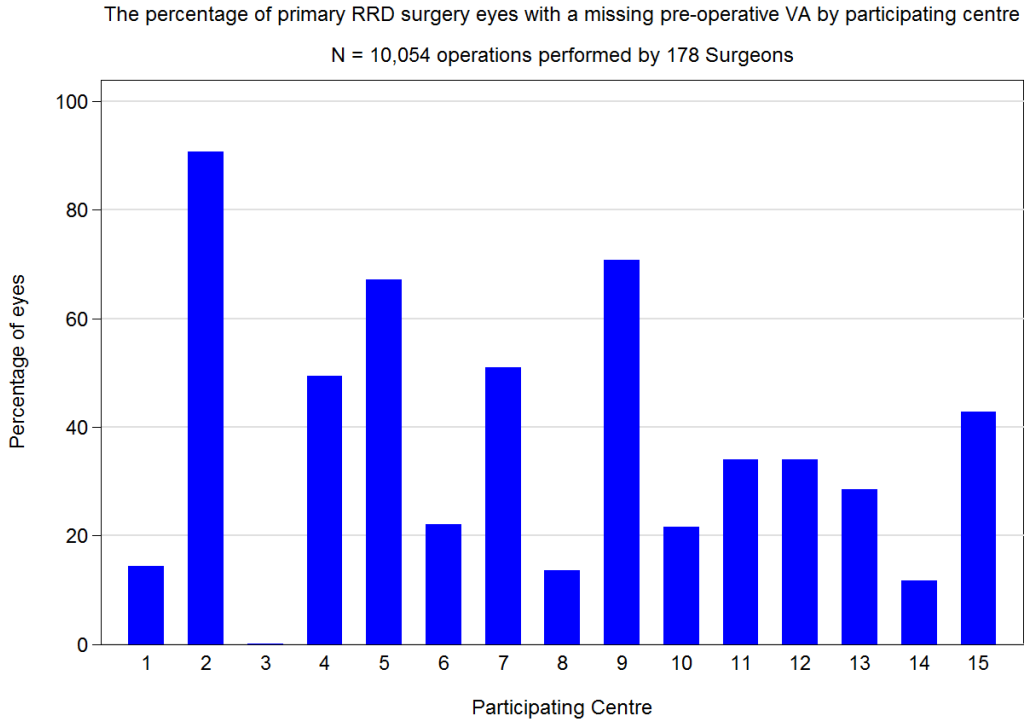
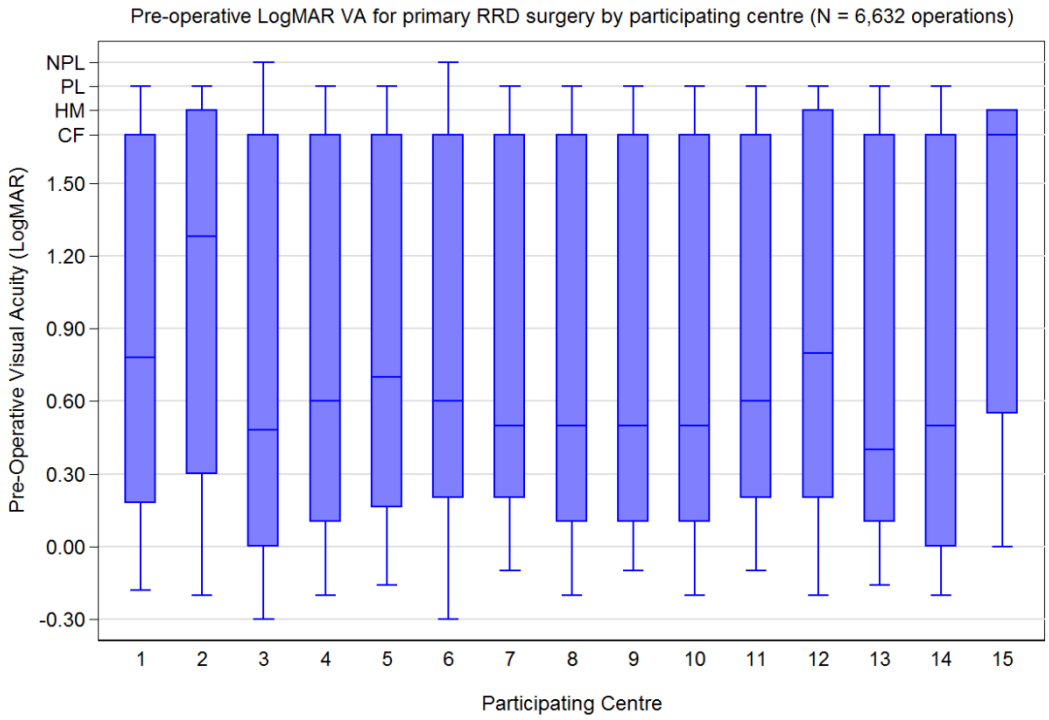


Figure 4: Box and whisker plot of pre-operative visual acuity for each participating centre.



5.5 Pre-operative Co-pathology

Data for the presence of an ocular co-pathology was provided for the BEAVRS RD database and the Medisoft EMR, but not for the VITREOR EMR database. An ocular co-pathology was recorded for 148 (4.2%) eyes from the BEAVRS RD database and for 1,880 (34.0%) of eyes from the Medisoft EMR. Given the big difference in the proportion of eyes with a recorded ocular co-pathology between two of the data sources and no ocular co-pathology data supplied by the third data source, no further information about ocular co-pathology is provided.

5.6 Surgical details

5.61 Operative procedures

The type of laser used was recorded for 8,928 (88.8%) of primary RRD operations, where cryotherapy alone was used in 55.8% operations, retinopexy alone for 17.4% operations and cryotherapy was combined with retinopexy in 15.5% operations. The type of laser used was very different for Scleral buckle only surgery than surgery including a vitrectomy (PPV only or PPV + Scleral buckle), where 83.7% of Scleral buckle only operations used cryotherapy alone and only 0.5% of Scleral buckle only operations used retinopexy alone.

The choice of tamponade varied depending on the surgical approach (PPV and/or Scleral buckle); from 44.8% of PPV only operations using SF6 gas to 38.7% of PPV + Scleral buckle operations using silicone oil. For 87.9% of Scleral buckle operations, no tamponade was recorded, however tamponade is not usually used for Scleral buckle only surgery, Table 2.

Drainage of sub-retinal fluid was used for 5,628 (56.0%) operations and cataract extraction for 438 (4.4%) operations. Many other operative procedures were recorded, with the most frequent being PVR membrane peel (327 operations) and vitreoretinal examination under anaesthesia (301 operations); otherwise no other operative procedure was used for more than 60 operations. Full list not shown

Table 2: Operative procedures performed during primary RRD surgery

Operative procedures n (column %)	PPV only	Scleral buckle only	PPV + Scleral buckle	Overall
Number of operations	8,618	929	507	10,054
Main RRD operative procedures				
Drainage of sub-retinal fluid	4,998 (58.0)	349 (37.6)	281 (55.4)	5,628 (56.0)
Cataract extraction	419 (4.9)	1 (0.1)	18 (3.6)	438 (4.4)
Laser				
Cryotherapy alone	4,576 (53.1)	778 (83.7)	258 (50.9)	5,612 (55.8)
Retinopexy alone	1,632 (18.9)	5 (0.5)	118 (23.3)	1,753 (17.4)
Cryotherapy + Retinopexy	1,493 (17.3)	17 (1.8)	51 (10.1)	1,561 (15.5)
No laser recorded	917 (10.6)	129 (13.9)	80 (15.8)	1,126 (11.2)
Tamponade				
Silicone oil	917 (10.6)	N/A	196 (38.7)	1,113 (11.1)
Air	82 (1.0)	79 (8.5)	2 (0.4)	163 (1.6)
Sulfurhexafluoride (SF6)	3,857 (44.8)	27 (2.9)	103 (20.3)	3,987 (39.7)
Hexafluoroethane (C2F6)	2,187 (25.4)	4 (0.4)	112 (22.1)	2,303 (22.9)
Octafluoropropane (C3F8)	1,193 (13.8)	2 (0.2)	76 (15.0)	1,271 (12.6)
Not recorded	382 (4.4)	817 (87.9)	18 (3.6)	1,217 (12.1)

5.7 Intra-operative complications

From the 10,054 primary RRD operations, 568 (5.6%) experienced one or more intra-operative complication. For 9,481 (94.3%) operations, no intra-operative complications were reported, for 520 (5.2%) operations one intra-operative complication was reported and for 44 (0.5%) operations two or more intra-operative complications were reported.

The intra-operative complication rate was 4.8% for BEAVRS RD operations, 4.0% for VITEOR operations and 6.6% for Medisoft operations.

The intra-operative complication rate was 5.1% for PPV only surgery, 9.9% for Scleral Buckle only surgery and 7.3% for PPV + Scleral Buckle surgery.

The most frequently recoded intra-operative complications were iatrogenic tears, lens touch and choroidal / suprachoroidal haemorrhage which were reported for 1.7%, 1.0% and 0.9% of operations, **Table 3**.

The approach to surgery is relevant for specific intra-operative complications, for example a Lens touch is impossible with Scleral buckle only surgery and iatrogenic retinal breaks are virtually impossible. Inadvertent SRF drainage is impossible with surgery not including a Scleral buckle.

As primary RRD surgery can be combined with cataract extraction intra-operative complications can be recorded which are due to the cataract extraction and not the RRD element of the surgery. For this sample posterior capsular rupture ± vitreous loss was recorded for 17 (<0.1%) eyes and both of torn iris / damage from the phacoemulsification and zonule rupture with no vitreous loss were recorded for one eye each.

Table 3: Recorded intra-operative complications for primary RRD surgery

Intra-operative complications n (column %)	PPV only	Scleral buckle only	PPV + Scleral buckle	Overall
Number of operations	8,618	929	507	10,054
Number of intra-operative complications				
0	8,174 (94.8)	837 (90.1)	470 (92.7)	9,481 (94.3)
1	399 (4.6)	85 (9.1)	36 (7.1)	520 (5.2)
≥2	45 (0.5)	7 (0.8)	1 (0.2)	53 (0.5)
Recorded intra-operative complications				
Iatrogenic tear	160 (1.9)	4 (0.4)	7 (1.4)	171 (1.7)
Lens touch	95 (1.1)	N/A	1 (0.2)	96 (1.0)
Choroidal / suprachoroidal haemorrhage	59 (0.7)	25 (2.7)	5 (1.0)	89 (0.9)
Iatrogenic retinal trauma	38 (0.4)	2 (0.2)	6 (1.2)	46 (0.5)
Cut suture	8 (0.1)	14 (1.5)	6 (1.2)	28 (0.3)
Sub-retinal haemorrhage	14 (0.2)	13 (1.4)	1 (0.2)	28 (0.3)
Inadvertent SRF drain	N/A	18 (1.9)	5 (1.0)	24 (0.2)
Retinal incarceration	19 (0.2)	0 (0.0)	1 (0.2)	20 (0.2)
Infusion cannula in sub-retinal/suprachoroidal space	15 (0.2)	0 (0.0)	2 (0.4)	17 (0.2)
Conjunctival buttonhole	10 (0.1)	2 (0.2)	1 (0.2)	13 (0.1)
Corneal epithelial abrasion	2 (<0.1)	10 (1.1)	0 (0.0)	12 (0.1)
Unspecified other*	52 (0.6)	13 (1.4)	3 (0.6)	68 (0.7)

The unspecified other included the following intra-operative complications with the number of cases given in parenthesis; Hyphaema (8), retinal haemorrhage (8), globe perforation, (5), vitreous haemorrhage (5), sub-retinal heavy liquid (4), retinal splippage (3), suprachoroidal silicone oil (3), torn muscle (2), corneal oedema (1), iris prolapse (1), iris trauma (1), scleral rupture (1), slipped muscle (1).

5.8 Post-operative Visual Acuity

From the 10,054 primary RRD operations, 8,923 operations were performed in eyes where there was a known surgical outcome recorded on the BEAVRS or VITREOR EMR databases or with six months potential follow up if the operation was recorded on the Medisoft EMR.

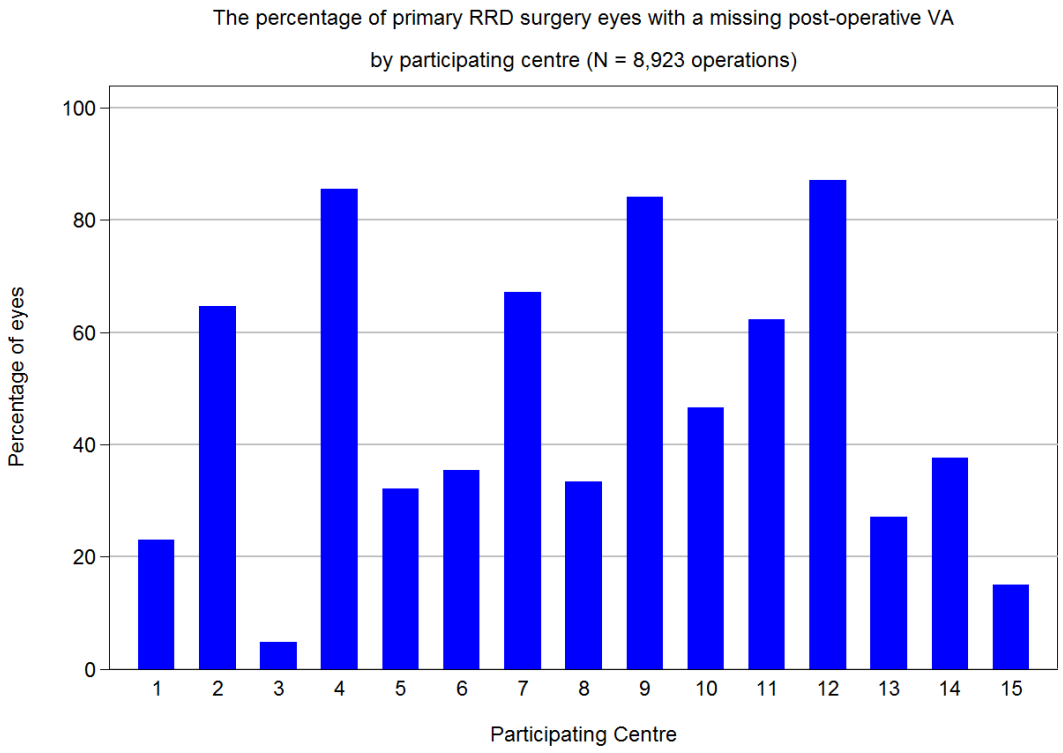
Of these 5,419 (60.7%) had a post-operative VA measurement. The percentage of eyes with a missing post-operative VA varied between centres with six centres having more than 60% of eyes with a missing postoperative VA, **Figure 5**.

Visual acuity in an eye with a retinal detachment is strongly linked to the macular status at the time of surgery, i.e. macular on or macular off and only the data from BEAVRS provided the macular status. For these reasons post-operative VA results are restricted to the 2,458 (99.2%) eyes from the BEAVRS database with a recorded outcome and post-operative VA data.

From 1,189 macular on eyes, the median (IQR) VA was 0.18 LogMAR (0.00 – 0.30). The post-operative VA was 0.30 LogMAR or better for 994 (83.6%) eyes, 0.60 LogMAR or better for 1,104 (92.9%) eyes and 1.00 LogMAR or better for 1,161 (97.6%) eyes. The post-operative VA was CF for 16 (1.3%) eyes, HM for five (0.4%) eyes and PL for three (0.3%) eyes.

From 1,269 macular off eyes, the median (IQR) VA was 0.48 (0.18 – 0.78). The post-operative VA was 0.30 LogMAR or better for 588 (46.3%) eyes, 0.60 LogMAR or better for 924 (72.8%) eyes and 1.00 LogMAR or better for 1,133 (89.3%) eyes. The post-operative VA was CF for 61 (4.8%) eyes, HM for 26 (2.0%) eyes and PL for six (0.5%) eyes.

Figure 5: The percentage of primary RRD operations with a missing post-operative visual acuity by participating centre.



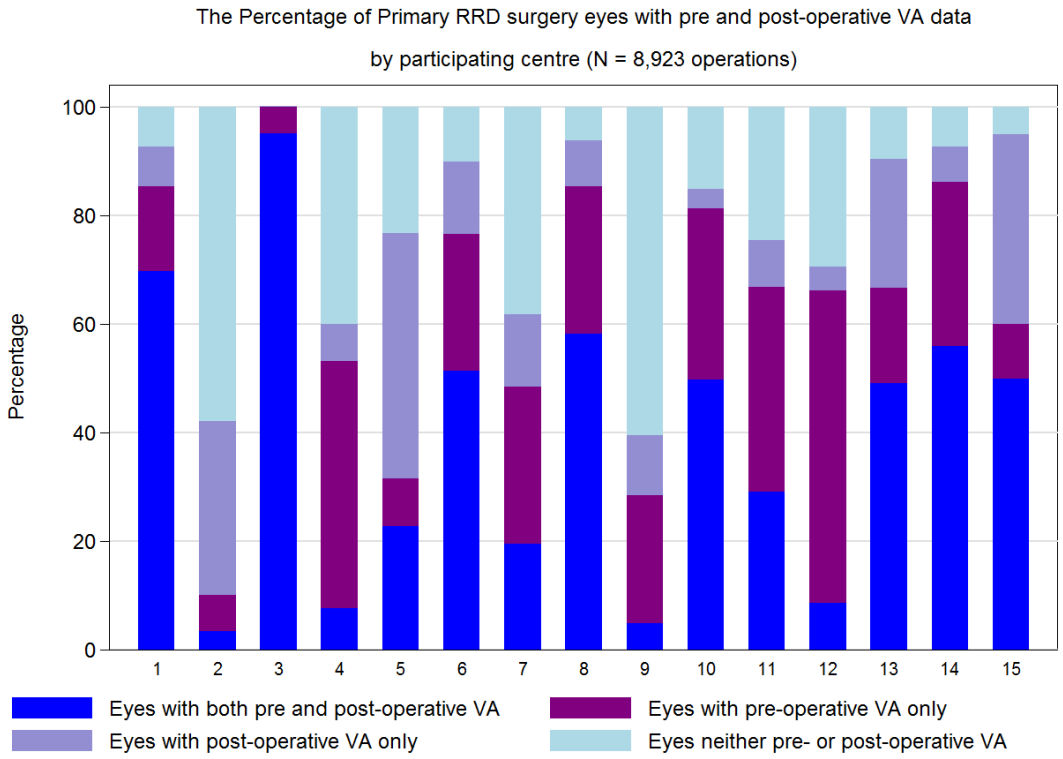
5.9 Change in Visual Acuity (VA) from baseline to six months post-operatively

From the 10,054 primary RRD operations, 8,923 operations were performed in eyes where there was a known surgical outcome recorded on the BEAVRS or VITREOR EMR databases or with six months potential follow up if the operation was recorded on the Medisoft EMR.

Of these 4,278 (47.9%) had both a pre and post-operative VA measurement and were eligible for change in VA analysis. The percentage of eyes with both preoperative VA and post-operative VA varied considerable between contributing centres with only two centres having more than 60% of eyes with both pre and post-operative VA, **Figure 6**.

From the 2,458 operations recorded on the BEAVRS database with a recorded outcome and post-operative VA data, 2,246 (91.4%) also had a pre-operative VA measurement. From 1,051 macular on eyes, the median (IQR) change in VA was 0.00 LogMAR (-0.12 loss – 0.18 gain) and for 1,176 macular off eyes, the median (IQR) change in VA was 1.32 LogMAR gain (0.42 gain – 1.92 gain).

Figure 6: The percentage of eyes with pre and post-operative VA data by participating centre.



5.10 Surgical Outcome

5.11 Unadjusted primary RRD surgery results for surgeons and centres

From the 10,054 primary RRD operations, 8,923 operations were performed in eyes where there was a known surgical outcome recorded on the BEAVRS or VITREOR EMR databases or with six months potential follow up if the operation was recorded on the Medisoft EMR.

The overall primary RRD failure rate was 18.9% (1,687/8,923), while the primary RRD failure rates were 17.5% (563/3,222) for BEAVRS RD operations, 19.4% (195/1,003) for VITREOR operations and 19.8% (929/4,698) Medisoft operations.

The primary RRD failure rates were 19.0% (1,446/7,610) PPV only operations, 10.1% (85/841) Scleral buckle only operations and 33.1% (156/472) PPV + Scleral buckle operations.

The mean primary RRD surgery failure rate per surgeon was 16.3% (IQR; 9.3% - 25.0%) and 10 surgeons had a failure rate >50%.

As examples, unadjusted for case complexity primary RRD failure graphs are produced in **Figure 7** for individual surgeons and in **Figure 8** for contributing centres.

Figure 7: Unadjusted for case complexity primary RRD surgery failure graph for surgeons

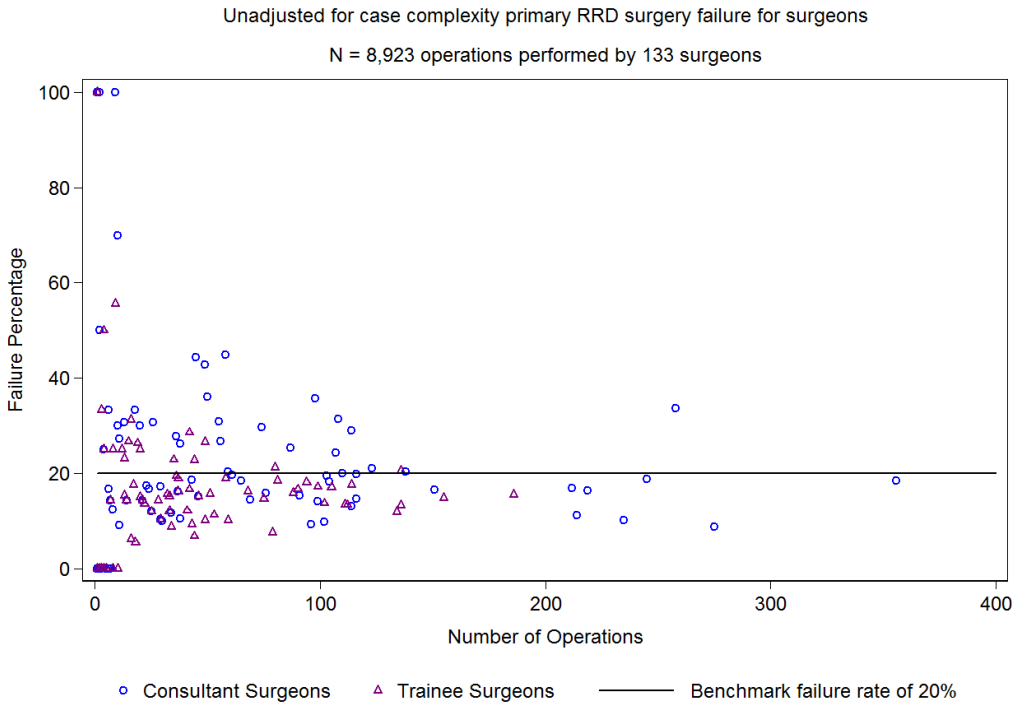
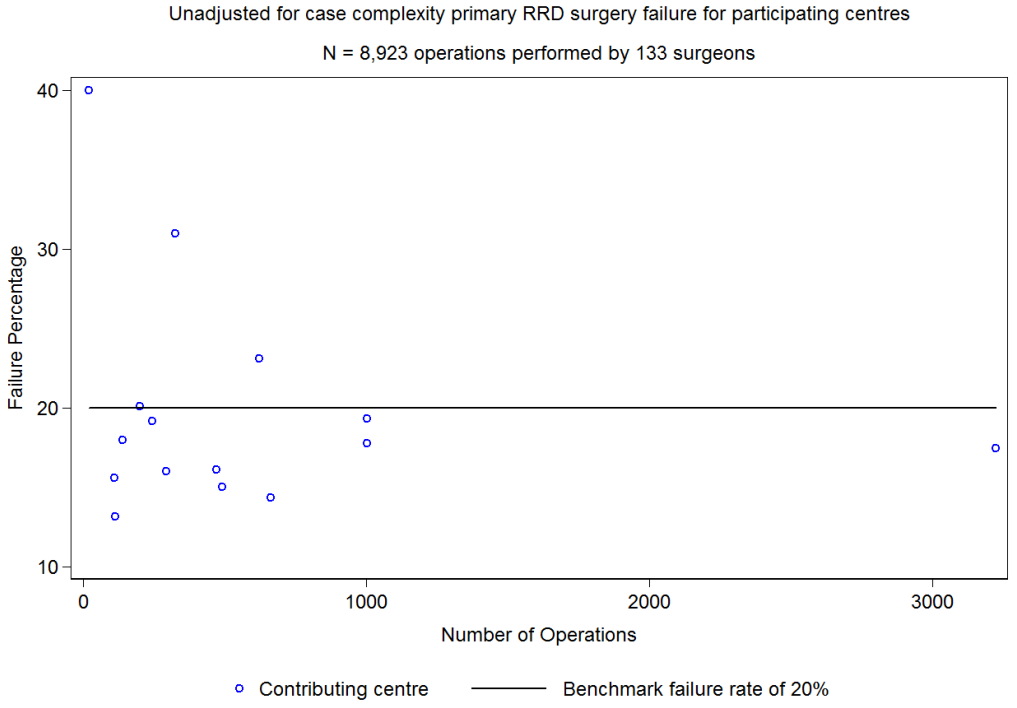


Figure 8: Unadjusted for case complexity primary RRD surgery failure graph for participating centres



5.12 Risk model for failure

To illustrate proof of concept, a pilot investigation of a risk model for primary RRD surgery failure was undertaken. The outcome of interest was primary RRD failure versus success. Primary RRD surgery using a vitrectomy (PPV only and Scleral buckle + PPV) were included, all operations from the Medisoft EMR were excluded as were operations from BEAVRS RD and VITREOR EMR with an unknown surgical outcome.

Candidate covariates that were significant at the 10% level from univariate χ^2 tests were fitted to the model, these were; surgeon grade, patient's gender and age, surgeon grade, number of quadrants detached, PVR grade, presence of schisis, inferior break, and the following operative procedures used during surgery, retinopexy laser, cryotherapy, cataract extraction, type of tamponade (silicone oil, air, C2F6, C3F8 or SF6 gases). The variables retained in the resulting logistic regression multi-variable model are shown in **Table 4** (C-Stat = 0.77, **Figure 9**).

It should be emphasised however that this model is presented simply as an illustration and that there are a variety of issues with the model which would need to be addressed prior to any implementation as a working tool for surgical case complexity adjustment. Issues include small numbers of recorded operations for many surgeons (e.g. of the 178 individual surgeons, 110 surgeons had performed <50 operations), potential other candidate variables that were not considered due to time constraint, these include the number of breaks in the detached retina and in the still attached retina, and the choice of age categories which could be further explored.

As a proof of concept however this exercise has value in demonstrating the feasibility of developing this approach for primary RRD surgery including a vitrectomy in the future. With this in mind, the model has been applied to the results for surgeons for illustrative purposes.

A similar approach could be explored for Scleral buckle only surgery, but this model would need a far larger sample than present in this study before being sufficiently robust for use in a prospective audit.

Figure 9: Area under the receiver operator curve for the primary RRD surgery case complexity adjustment failure model

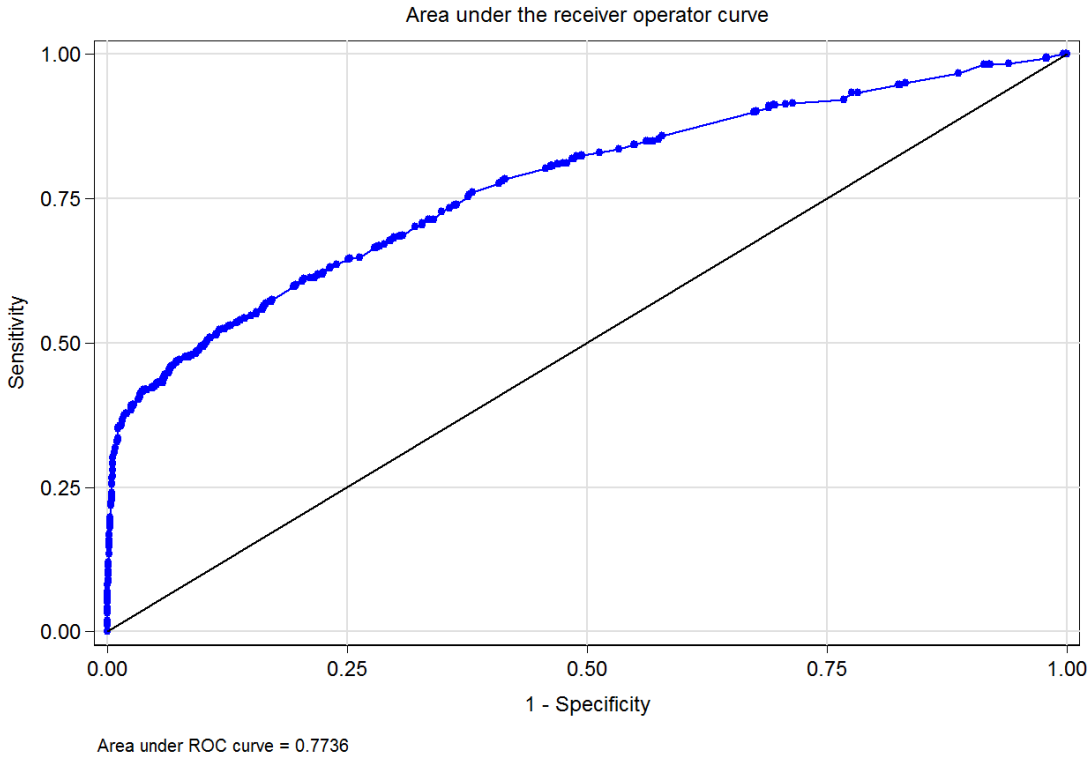


Table 4: Primary RRD surgery failure model estimates (N = 3,694 operations)

Model C-Stat (AUROC) = 0.7736	Odds ratio	Coefficient	p-value	95% confidence interval for the coefficient
Constant	N/A	0.692	0.031	0.062 to 1.321
Surgeon grade				
Consultant surgeons	REF	0	N/A	N/A
Trainee surgeons	0.755	-0.281	0.015	-0.508 to -0.054
Number of quadrants detached				
1	REF	0	N/A	N/A
2	1.413	0.346	0.001	0.135 to 0.557
3	1.950	0.668	0.000	0.306 to 1.030
4	2.730	1.004	0.000	0.589 to 1.419
Inferior break	1.508	0.411	0.003	0.142 to 0.680
Schisis	2.465	0.902	0.019	0.145 to 1.659
PVR grade C	1.342	0.294	0.000	0.168 to 0.420
Retinopexy - Endolaser	1.362	0.309	0.043	0.010 to 0.607
Retinopexy - Cryotherapy	0.601	-0.510	0.001	-0.803 to -0.216
Tamponade use				
Silicone oil	REF	0	N/A	N/A
Air	0.041	-3.190	0.000	-4.780 to -1.600
C2F6	0.062	-2.788	0.000	-3.315 to -2.260
C3F8	0.106	-2.245	0.000	-2.841 to -1.648
SF6	0.075	-2.594	0.000	-3.108 to -2.081

5.13 Case complexity adjusted primary RRD surgery results for surgeons

Based on the definition for failure, **Figure 10** illustrates a case complexity adjusted funnel plot for surgeons and **Figure 11** is the same graph for the surgeons with an adjusted failure rate of <40%. The equivalent graph for centres cannot be produced as the model only included data from the data sources that did not supply a centre identifier. Had this centre identifier been available this result would have been possible.

Figure 10: Adjusted for case complexity primary RRD failure graph

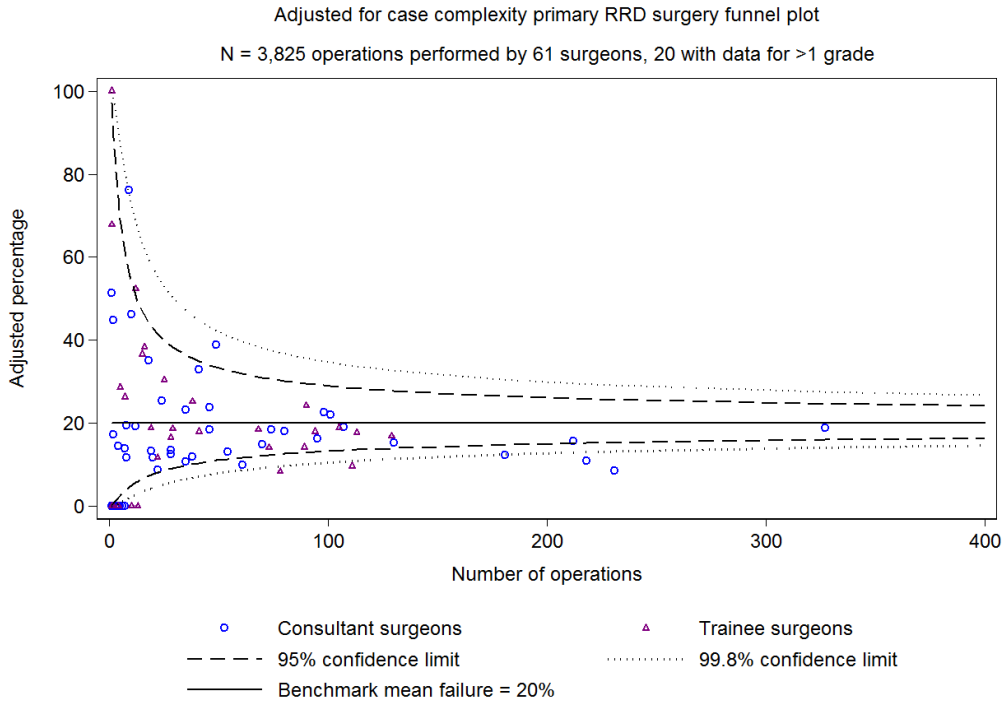
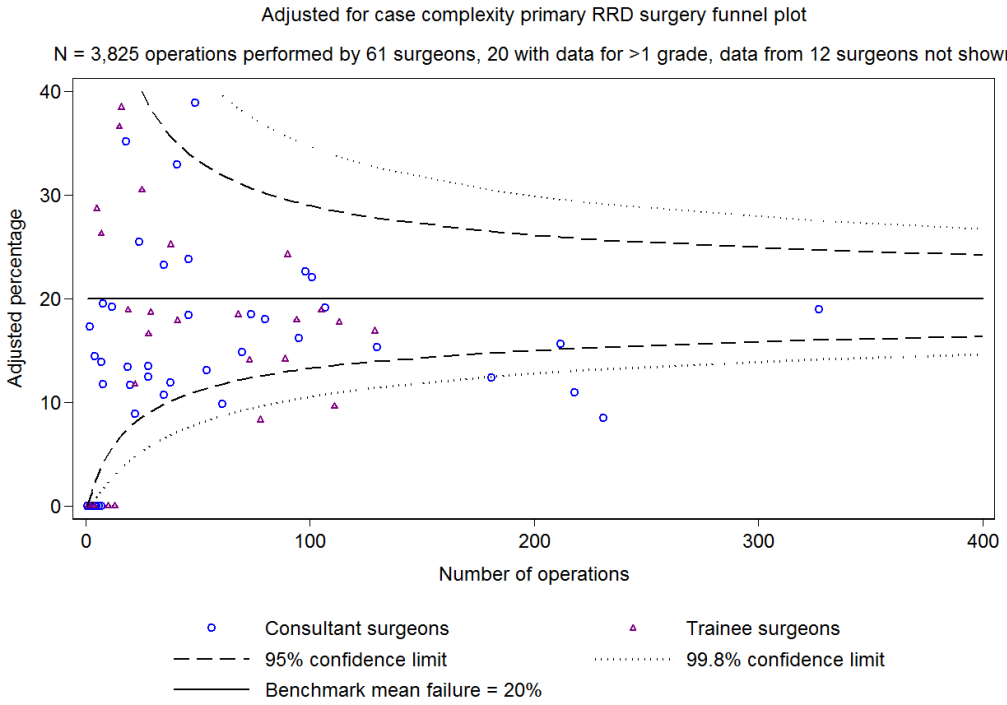


Figure 11: Adjusted for case complexity primary RRD failure graph for surgeons with an adjusted failure rate <40%



6. Conclusions for the Retinal Detachment Surgery Audit

6.1 Missing data

Significant issues with missing data have been identified, mainly due to the late implementation of the national RD data into the Medisoft EMR and failure to activate this locally at centres. Many centres apparently have been unaware of the need to activate this software switch so this issue need not affect future data collection and analysis in the same way.

There is also an issue with missing visual acuity data, mainly for the Medisoft centres. It is likely that this reflects the fact that in many centres the EMR is currently only used in the operating theatre and not in the outpatients. Fuller use of the available Medisoft EMR functionality would improve this issue. Missing data was less of an issue for the BEAVRS RD and VITREOR EMR databases.

6.2 Effectiveness of surgery

Based on the available information it would appear that most surgeons have a similar 20% rate of anatomical surgical failure, good visual acuity can be maintained in macular on eyes and visual acuity improvement is possible for many macular off eyes.

6.3 Risk model and adjustment of outcomes for case complexity

As a proof of concept exercise a risk adjustment model has been derived and applied to primary RRD anatomical surgical failure for operations with a known outcome recorded on the BEAVRS RD and the VITREOR EMR databases. Results for surgeons have been presented and similar results for centres would be possible if a centre ID were available. This illustrates the feasibility of the approach, although it should be noted that despite an encouraging C-Stat of 0.77 the model requires further work and data completeness would need to improve in order to apply this methodology across many centres in a comparative audit.

7. Feasibility of a National Audit for Retinal Detachment

This rhegmatogenous retinal detachment audit feasibility study directly addresses the main surgical objective of primary RRD surgery, namely the success of the operation in anatomical reattachment of the retina. Three data collection systems can record data compliant with the national RD dataset, and this dataset is established within the vitreoretinal surgeons' community with a dedicated online audit database freely available to members of the British and Eire Association of Vitreoretinal surgeons.

7.1 Recommendations for improving the feasibility of a national retinal detachment surgery electronic audit

- Centres using the Medisoft EMR should be encouraged to collect the full set of national RD compliant data that can be recorded on this system. Centres need to be made aware that the functionality is already available to do so but needs local activation within the software.

- Ways to decrease the amount of missing data on all systems, especially for visual acuity should be considered, with data quality emphasised locally for centres and vitreoretinal specialist surgeons. BEAVRS have confirmed that pre-operative VA will in the future be a mandatory data item on their audit database.

- Surgeons working in centres who have not contributed data should be contacted and encouraged to collect their data. The BEAVRS database is available to all VR surgeons at no cost.

- Funding for any HQIP commissioned audit would be contingent upon surgeon and centre ID being available and named results being placed in the public domain. Surgeon GMC number and centre ID would thus be required.

- If any linkage to other patient details was required, then either a section 251 exemption or an IG compliant pseudonymised patient identifier would be required. The Medisoft EMR data extraction includes a pseudonymised patient identifier and the VITREOR EMR database can also do so, but this information was not included in this VITREOR data used in this analysis. The BEAVRS system does include an option for a pseudonymised patient identifier which is rarely used. One reason for the rarity of use of this option is problems with information governance, the BEAVRS system is an online tool freely available to vitreoretinal surgeons in

the United Kingdom and the Republic of Ireland, and the information governance rules can vary between countries and devolved regions of the United Kingdom.

- If social deprivation data was of interest in a prospective audit, ways to collect this data without breaching patient confidentiality rules need to be considered. Tried and tested methods include determination of the IMD behind the centre firewall prior to data extraction.

- There is a possibility that surgeons could be simultaneously collecting data on more than one of the data collection systems, something that would need to be resolved in advance of any prospective national audit. It seems unlikely however that surgeons would engage in duplicate data collection if they were aware that this was not necessary.

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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.

Appendix 1. Variables Considered in the Case Complexity Model

Variable	Categorisation	Additional information
Age at surgery	< 50 years old 50 – 59 years old 60 – 69 years old 70 – 79 years old ≥ 80 years old	
Gender	Male Female	
Surgeon grade	Consultant* Trainee	*Includes independent non-consultant surgeons
PVR grade	Not grade C Grade C	Includes no grade and grades A and B
Schisis	No Yes	
Inferior breaks	No Yes	
Number of quadrants detached	1 2 3 4	If not recorded, assume as 1 quadrant as at least one quadrant has to be detached for a retinal detachment operation
Cataract extraction	No Yes	
Laser retinopexy	No Yes	
Laser cryotherapy	No Yes	
Tamponade	Silicone oil Air C2F6 C3F8 SF6	If missing assume, exclude from this model

Appendix 2. Interpreting the Retinal Detachment Surgery Graphs

1. Among the results there are three types of graphs. The labelling of centres is a ranking of the total number of operations contributed by each centre for all years, so that centre one is the centre that contributed the highest number of operations and centre 15 the least.
2. Bar charts – the horizontal axis consists of the categorical element, for example participating centre. For stacked bar charts the horizontal axis category is sub-divided by another category, for these graphs the vertical height of each bar indicates the quantity of interest for that bar chart as read from the vertical axis.
3. Box and Whisker plots – the spread for the variable of interest is shown for each of the contributing centres. Within the box, the central line is the median or 'middle' value and the outlines represent the inter quartile range (25% and 75% centiles). The horizontal lines above and below the box (whiskers) terminate at the values corresponding to ±1.5 times the IQR. Extreme values are the dots beyond that.
4. Funnel plots – The spread of dots on these look like a funnel going from left to right. Each dot represents a result for a surgeon or centre as read off the vertical axis (proportion or rate). The funnel effect results from increasing statistical precision as the numbers get higher going along the horizontal axis. Some of the plots have lines on them showing what is expected. A result above the top line (three standard deviations) would be deemed unacceptably high, a dot between the lines is deemed on the high side but not alarmingly so, and may be viewed as an alert signal.

Appendix 3. Glossary

Abbreviation	Description
%	Percentage
<	Less than
>	Greater than
BEAVRS	British and Eire Association of Vitreoretinal Surgeons
C2F6	Hexafluoroethane
C3F8	Octafluoropropane
CF	The ability to count fingers
C-Stat	A measure of goodness of fit and equal to the area under the receiver operator curve
EMR	Electronic Medical Record
HM	The ability to distinguish hand movements
HQIP	Healthcare Quality Improvement Partnership
IG	Information Governance
IMD	Index of Multiple Deprivation
IQR	Inter Quartile Range
LogMAR	An eye chart comprising of rows of letters which can be used to estimate visual acuity
NCAPOP	National Clinical Audit and Patient Outcomes Programme
NHS	National Health Service
NOD	National Ophthalmology Database
NPL	No Perception of Light
P (for example p<0.001)	Hypothesis test derived probability
PL	Perception Light
PPI	Patient and Public Involvement
PPV	Pars Plana Vitrectomy
PVR	Proliferative vitreoretinopathy
RCOphth	The Royal College of Ophthalmologists
RD	Retinal Detachment
ROC	Receiver Operator Curve
RRD	Rhegmatogenous Retinal Detachment

S251 exemption	Approval for exemption from section 251 of the NHS Health and Social Care Act 2006 which allows for certain uses of patient identifiable data
SF6	Sulfahexafluoride
UK	United Kingdom
VA	Visual Acuity
VITREOR	Vitreoretinal database used by surgical teams in three London hospitals
$\chi 2$	Chi-Squared distribution used for Chi-Squared hypothesis based testing

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