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Title: The Manchester Buckle Study: Fifteen-Year Outcomes and Predictive Factors for Success in Scleral Buckling for Primary Rhegmatogenous Retinal Detachment

Running head: Efficacy, Complications, and Contributing Factors in Scleral Buckling

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Declarations

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Ethical approval / consent to participation

As this was a retrospective anonymized study, as per our local protocol, this study had ethical approval exemption. Patients were diagnosed and treated according to local guidelines and agreements and this study does not report on the use of new or experimental protocols.

Consent to publication
Not applicable

Patient and public involvement
Patients and the public were not involved in this study due to its retrospective design.

Data Availability statement
Data are available upon reasonable request.

Key words: Scleral buckle, Retinal detachment, Episcleral surgery, Long-term outcomes, Intra and post-operative complications, Surgical success rate.

Precis: This fifteen-year study of scleral buckle for retinal detachment demonstrated high anatomical success with significant visual gains. Older age, macula-off status, and ocular trauma predicted poorer surgical success, while trauma and macula-off also worsened vision.

Word count: 3434

Abstract

Aims: To assess the long-term anatomical and visual outcomes of primary scleral buckle (SB) surgery for rhegmatogenous retinal detachment (RRD) and identify predictors of surgical and functional success.

Methods: All primary SB procedures performed at Manchester Royal Eye Hospital between January 2008 and December 2023 were reviewed retrospectively. Pre-, intra- and postoperative data were extracted from electronic records. Primary end-points were single-surgery anatomical success (SSAS) and final best-corrected visual acuity (BCVA); univariate and multivariate regression analyses examined predictive variables and complications.

Results: 608 eyes were included. SSAS was achieved in 515 eyes (85%) and final anatomical success in 602 eyes (99%). Mean BCVA improved from 0.62±0.85 to 0.32±0.49 logMAR ($p < 0.01$). On multivariate analysis, age>40 years (OR 0.55, 95% CI 0.37–0.83; p=0.004), macula-off status (OR 0.65, 95% CI 0.44–0.97; p=0.034), and ocular trauma (OR 0.40, 95% CI 0.19–0.82; p=0.012) independently reduced SSAS. For visual outcomes, macula-off detachment (β=+0.36; $p<0.001$) and ocular trauma (β=+0.42; $p<0.001$) were independent predictors of worse postoperative BCVA. The most common complications were subretinal haemorrhage (4.6%), inadvertent deep sutures (3.9%), and postoperative ocular hypertension (7.4%).

Conclusions: Primary SB provided high anatomical success, significant visual improvement, and a favourable safety profile in this large single-centre study. Age above 40 years, macula-off status, and ocular trauma predicted poorer SSAS; trauma and macula-off status were also associated with worse postoperative BCVA on multivariate logistic regression.

Key Messages

What is already known on this topic

Scleral buckle (SB) has long been a cornerstone treatment for rhegmatogenous retinal detachment (RRD). Despite this, SB use has declined sharply worldwide over the last decades, with pars plana vitrectomy (PPV) now accounting for most primary RRD repairs and greatly reducing trainee exposure to SB. A large, contemporary series of SB alone is therefore needed to clarify its long-term anatomical, visual and safety outcomes and to define which patients still benefit most from this technique.

What this study adds

This large (608 eyes), single-centre series over 15 years shows that primary SB provides favourable anatomical and functional outcomes with low complication rates in young patients with non-PVD RRDs. We report a single-surgery anatomical success (SSAS) of 85% and final anatomical success of 99%. It demonstrates that higher SSAS is associated with macula-on status, absence of ocular trauma

and age under 40 years. The study also shows that better postoperative visual acuity is linked to macula-on status and absence of trauma.

How this study might affect research, practice or policy

These findings support the continued role of primary scleral buckle as an effective and safe option for selected RRD cases, particularly in appropriately chosen patients such as non-PVD RRDs in young patients. The results may inform surgical decision-making and case selection for scleral buckling versus alternative approaches, and highlight the need for ongoing training and dissemination of SB techniques to ensure this remains a vital skill enabling optimal patient outcomes.

Introduction

Since the introduction of scleral buckle (SB) surgery by Custodis and Schepen [1,2] , this technique remains a cornerstone in the management of rhegmatogenous retinal detachment (RRD). Indeed, SB surgery has reported success rates between 82 and 91% [3–5] and, for many years, was the preferred method for RRD repair. Nonetheless, over the decades, various advancements in vitreoretinal surgery have been introduced, such as the advent and refinement of pars plana vitrectomy (PPV) surgery [6,7] . While comparable reattachment rates between PPV and SB (primary rates of 86.5% vs. 84.8% and final rates of 96.7% vs. 97.7% respectively) have been reported in a large meta-analysis [8]; randomized clinical trials have demonstrated superior anatomical outcomes for PPV in pseudophakic and aphakic RRDs, while no significant difference was observed between PPV and SB in phakic RRDs [9–11]. Nonetheless, over the past two decades, the use of SB for RRD has markedly declined [4,12,13]. In one 7-year study, SB procedures decreased from 40.5% in 2009 to just 2.7% in 2014, while PPV increased from 38% to over 90% in the same period [12]. Similarly, data from 2014 showed SB accounting for only 5% of RRD repairs in the United States, compared to 83% for PPV [13]. In the UK, between 2002 and 2010, only 12.1% of 3403 RRD surgeries were performed using SB alone [4], highlighting a consistent global shift away from SB toward PPV with consequent lower exposure and knowledge of SB in newly trained vitreoretinal surgeons.

This study presents a 15-year retrospective analysis of SB surgeries performed at Manchester Royal Eye Hospital. We aim to provide insight into the long-term success rates and complications associated with this procedure. Additionally, we assess predictive factors for single surgery anatomical success (SSAS) and postoperative best-corrected visual acuity (BCVA). To the best of our knowledge, this represents the largest series of patients in published literature for SB surgery alone to date.

Methods

This study was a retrospective, single-centre, interventional cohort. As a retrospective and anonymized analysis, it was exempt from ethical approval according to our local protocol. All diagnoses and treatments followed standard local guidelines, without the use of new or experimental protocols. Patient data were retrieved from an electronic surgical database, identifying all eyes diagnosed with RRD that underwent SB at Manchester Royal Eye Hospital, over a 15-year period from January 1, 2008, to December 31, 2023. Only eyes with a minimum follow-up of 8 weeks after surgery were included in the analysis of surgical outcomes. Exclusions comprised patients younger than 18 years of age, eyes treated with combined procedures such as SB with PPV, cases of recurrent RRD, duplicate entries or incomplete records. RRDs associated with proliferative vitreoretinopathy grade C (PVR-C) were also excluded, as SB alone is not performed for these cases at Manchester Royal Eye Hospital according to local clinical guidelines. In line with these guidelines, primary SB procedures are reserved almost exclusively for non–posterior vitreous detachment (non-PVD)–related RRDs, while PPV remains the standard treatment for PVD-related RRDs.

A systematic case note review was performed for all the eyes. Data collection included pre-operative characteristics such as sex, age, pre-operative BCVA (defined as the visual acuity measured with optimal refraction, as recorded at each clinical visit), lens status (phakic, pseudophakic or

aphakic), macula status (on or off), history of high myopia (defined as an axial length greater than 26 mm or a refractive error exceeding –6 diopters), history of ocular trauma (defined as a significant injury to the eye or head that is considered by the treating ophthalmologist to be causally related to the RRD), presence of a retinal dialysis or amblyopia; intra-operative characteristics such as grade of the surgeon performing the SB (resident, fellow or consultant), intra-operative complications; and post-operative characteristics such as post-operative BCVA, SSAS and final anatomical success rate, follow-up period, post-operative complications. SSAS was defined as complete retinal reattachment following the initial scleral buckle procedure, without the need for any additional surgical intervention for RRD, with a minimum follow-up of 8 weeks. Final anatomical success referred to complete retinal reattachment after the last vitreoretinal procedure.

Statistical Analysis

Statistical analyses were performed using SPSS software (Version 20.0; IBM Corporation, Armonk, NY, USA) and Stata 17.1 (Statacorp, Texas, USA). Normality of continuous data was evaluated using the Shapiro–Wilk test. For normally distributed data, Student's t-test was applied, while the Mann–Whitney U test was utilized for skewed data. Differences between groups for categorical variables were assessed using either Fisher's exact test or chi-square test. Univariate and multivariate logistic regression was performed to assess predictive factors for SSAS. A receiver-operating characteristic (ROC) curve was generated to assess the strength of the multivariate model. Linear regression analysis was performed to assess for factors affecting the BCVA. Homoscedasticity of the multivariate model was assessed using a residual versus fitted plot. The adjusted R^2 was used to assess the strength of the model. Statistical significance was defined as a p-value less than 0.05.

Results

Out of 752 patients who underwent SB surgery as primary procedure in Manchester Royal Eye Hospital for RRD, 31 were omitted because of revisional surgery with no records of the first procedure (probably performed in other hospitals), 50 were omitted due to missing or incorrect notes, 10 because of duplicate notes, 49 were paediatric cases, and 4 underwent combined SB and PPV. Therefore, the final number of patients included in the study was 608. The number of surgeries per year was 23 in 2008, 66 in 2009, 56 in 2010, 76 in 2011, 59 in 2012, 36 in 2013, 25 in 2014, 29 in 2015, 11 in 2016, 17 in 2017, 38 in 2018, 66 in 2019, 35 in 2020, 33 in 2021, and 38 in 2022. The mean number of surgeries per year decreased from 48.7 during 2008–2014 to 33.4 during 2015–2022; however, this difference was not statistically significant ($p = 0.09$).

Demographics clinical and intraoperative characteristics

At the time of surgery, the mean ± SD age was 36 ± 12 years (median 35, range 18–75). Of the patients, 306 (50%) were male and 302 (50%) were female. Surgeries were performed on 311 right eyes (51%) and 297 left eyes (49%). A non-dialysis RRD was present in 453 patients (75%), and a dialysis-related RRD in 155 (25%). The macula was attached in 358 patients (59%) and detached in 250 (41%). In total, 411 patients (68%) were phakic, 11 (2%) were pseudophakic, and lens status was unknown in 186 (30%). Eighty-eight patients (14%) were highly myopic, 33 (5%) had recent ocular

trauma in the affected eye, and 12 (2%) patients had amblyopia in the operated eye. The mean ± SD preoperative BCVA was 0.62±0.85 logMAR in all eyes, 0.23±0.24 logMAR in macula on eyes, and 1.22±0.71 logMAR in macula off eyes. A total of 442 (72%) surgeries were performed by fellows, 156 (26%) by consultants, and 10 (2%) by senior registrars. Table 1 shows the demographics and clinical characteristics of the patients included in the study.

Postoperative outcomes and complications

SSAS was achieved in 515 eyes (85%). Of the 93 patients (15%) who initially had unsuccessful SSAS, all underwent additional surgery for retinal reattachment, which consisted of revisional SB in 34 (37%) patients and PPV in 59 (63 %) patients. Final anatomical success was achieved in 602 eyes (99%).

Mean postoperative BCVA improved to 0.32 ± 0.49 logMAR ($p < 0.01$). Macula-on eyes achieved a mean postoperative BCVA of 0.16 ± 0.34 logMAR, whereas macula-off eyes recorded 0.54 ± 0.59 logMAR. Among macula-on eyes, the postoperative median BCVA was 0.10 (IQR 0.00–0.20), whereas macula-off eyes showed a median BCVA of 0.34 (IQR 0.12–0.80). For the overall cohort, the median postoperative BCVA was 0.13 (IQR 0.00–0.37). A total of 42.2% of patients demonstrated an improvement in BCVA of at least two Snellen lines. The median follow-up period was 14.1 months (IQR 4.1–34.6 months).

Postoperative laser treatment was required in 68 eyes (11% of all cases): 60 around retinal tears and 8 for persistent peripheral subretinal fluid. Intraoperative complications included subretinal haemorrhage in 28 surgeries (4.6% of all cases), inadvertent deep suture placement in 24 (3.9% of all cases), iatrogenic retinal breaks in 3 (0.5% of all cases), ruptured muscle in 3 (0.5% of all cases), scleral perforation in 1 (0.16% of all cases), and endophthalmitis in one case following inadvertent deep suture placement (0.16% of all cases). Thirty-one patients (5%) developed postoperative macular complications: 10 (1.6%) developed cystoid macular oedema, 18 (2.9%) developed epiretinal membrane, and 3 (0.5%) developed full-thickness macular hole. High intraocular pressure (IOP) occurred postoperatively in 45 patients (7.4%). Seven patients required glaucoma surgery (1.1%), performed at a mean interval of 50.6 ± 51.8 months postoperatively. Persistent diplopia occurred in 29 patients (4.8%) and 7 patients (1.1%) underwent squint surgery at a mean interval of 38.8 ± 26.4 months postoperatively.

Predictive characteristics for single surgery anatomical success

Mean ± SD age in the SSAS group was 36 ± 12 years, compared with 38 ± 11 years in the non-SSAS group ($p = 0.58$). By surgeon grade, the success rates were 84% (371/442) for fellows, 94% (136/156) for consultants, and 90% (9/10) for registrars; these differences were not statistically significant ($p = 0.60$). Among macula-on eyes, the SSAS rate was 87% (308/356), compared to 82% (207/252) for macula-off eyes ($p = 0.12$). SSAS did not differ significantly based on the presence or absence of dialysis RRD (84% vs. 85%; $p = 0.88$), or high myopia (86% vs. 85%; $p = 0.79$). However, the presence of recent ocular trauma in the affected eye significantly reduced the SSAS rate (70% vs. 86%; $p = 0.049$). Table 1 compares various factors between the group that achieved SSAS and the group that did not.

Table 1: Demographics and clinical characteristics of 608 treated with scleral buckle.

Demographics and Clinical Characteristics	**Total** 608 eyes	**SSAS group** 515 eyes	**Non-SSAS group** 93 eyes	**p-value (SSAS VS non-SSAS)**
Age (years)				
Mean ± SD	36 ± 12	36 ± 12	38 ± 11	0.58
Median	35	35	38.5	
Range	18–75	18–75	18–66	
> 40 years (%)	398 (65 %)			
≤ 40 years (%)	210 (35 %)			
Type of Retinal Detachment n (%)				
Non-Dialysis	453(75%)	384 (75%)	69 (74%)	0.94
Dialysis	155 (25%)	131 (25%)	24 (26%)	
Macula Status n (%)				
Macula On	358(59%)	308 (60%)	50 (54%)	0.12
Macula Off	250 (41%)	207 (40%)	43 (46%)	
Lens Status n (%)				p = 0.062 (between phakic vs pseudophakic)
Phakic	411(68%)	354 (68.7%)	58 (62.3%)	
Pseudophakic	11(2%)	7 (1.4%)	4(4.3%)	
Unknown	186 (30%)	154 (29.9%)	32 (34.4%)	
High Myopia n (%)	89 (14.6%)	75 (14.6%)	14 (14.9%)	0.88
Ocular Trauma n (%)	33 (5%)	24 (5%)	9 (10%)	**0.049**
Amblyopia n (%)	13 (2.1%)	11 (2.1%)	2 (2.1%)	1

BCVA: Best corrected visual acuity; SD: standard deviation.
SSAS: Single surgery anatomical success

In the multivariate logistic regression model (Table 2), age > 40 years (OR=0.55, 95% CI 0.37–0.83; p=0.004) and ocular trauma (OR=0.40, 95% CI 0.19–0.82; p=0.012) remained independent predictors of reduced SSAS. Additionally, macula-off presentation was associated with a lower likelihood of SSAS (OR=0.65, 95% CI 0.44–0.97; p=0.034). Surgeon grade and high myopia were not significantly associated with SSAS in the multivariate model. Receiver operating characteristic (ROC) analysis (Table 2) of the multivariate model yielded an area under the curve (AUC) of 0.621 (supplemental material 1), indicating modest discriminatory ability, above the line of no discrimination but with limited overall predictive strength.

Table 2: Univariate and multivariate logistic regression analysis for SSAS

Predictive factor	**Odds ratio**	**95% CI**	**p-value**
Univariate			
Age > 40 years	0.62	0.42-0.92	0.016

Trauma	0.43	0.22-0.88	0.021
Grade of Surgeon - *Fellow* - *Consultant* - *Registrar*	 Reference group 1.29 2.97	 0.81-2.05 0.38-23.2	 0.278 0.300
High Myopia	0.97	0.53-1.81	0.934
Macula off	0.69	0.47-1.02	0.066
Dialysis	0.94	0.61-1.44	0.763
Multivariate			
Age > 40	0.55	0.37-0.83	0.004
Trauma	0.40	0.19-0.82	0.012
Grade of Surgeon - *Fellow* - *Consultant* - *Registrar*	 Reference group 1.27 3.26	 0.80-2.04 0.41-26.03	 0.306 0.265
High Myopia	0.66	0.39-1.12	0.129
Macula off	0.65	0.44-0.97	0.034

Predictive factors for postoperative best corrected visual acuity

The mean±SD postoperative BCVA was 0.16±0.34 logMAR in macula-on eyes, significantly better than the 0.54±0.59 logMAR observed in macula-off eyes (n=250; p<0.01). Post-operative BCVA also differed significantly based on the presence of a dialysis RRD, with eyes having a non-dialysis RRD (n=453) showing better BCVA (0.27 ±0.45 logMAR) than those dialysis RRD (n=155; 0.47±0.68 logMAR; p<0.01). The presence of trauma was associated with significantly worse BCVA (0.63±0.87 logMAR in trauma eyes (n=33) vs. 0.30±0.45 logMAR in non-trauma eyes (n=575; p<0.01). BCVA did not differ significantly with the presence of high myopia (p=0.10). Successful SSAS group had better postoperative BCVA (0.30±0.46 logMAR, n=515) compared to unsuccessful group (0.43±0.61 logMAR, n=93; p=0.04). Table 3 presents predictive factors for postoperative BCVA.

Table 3. Univariate analysis of factors associated with postoperative BCVA.

Parameter	**Subgroup Findings**	**p-Value**
Macula	Macula on (n = 358): 0.16 ± 0.34 Macula off (n = 250): 0.54 ± 0.59	<0.01
Dialysis	Yes (n = 155): 0.47 ± 0.58 No (n = 453): 0.27 ± 0.45	<0.01
High Myopia	Yes (n = 91): 0.24 ± 0.35 No (n = 517): 0.34 ± 0.51	0.10
Trauma	Yes (n = 33): 0.63 ± 0.87 No (n = 575): 0.30 ± 0.45	<0.01
SSAS	Yes (n = 515): 0.30 ± 0.46 No (n = 93): 0.43 ± 0.61	0.04

SSAS: Single surgery anatomical success

BCVA: Best corrected visual acuity

For postoperative BCVA, univariate linear regression (Table 4) showed that age > 40 years (β = +0.11, 95% CI +0.02 to +0.19; p = 0.011), ocular trauma (β = +0.49, 95% CI +0.32 to +0.66; p < 0.001), and retinal dialysis (β = +0.21, 95% CI +0.13 to +0.30; p < 0.001) were significantly associated with worse visual outcomes. Macula-off status showed a borderline association (β = +0.38, 95% CI +0.30 to +0.46; p = 0.066). High myopia and surgeon grade were not significant predictors in univariate analysis. In the multivariate model, ocular trauma (β = +0.42, 95% CI +0.19 to +0.82; p < 0.001) and macula-off status (β = +0.36, 95% CI +0.39 to +1.12; p < 0.001) remained independent predictors of worse postoperative BCVA. Retinal dialysis demonstrated a borderline association (β = +0.08, 95% CI +0.44 to +0.97; p = 0.060), while age > 40 years, high myopia, and surgeon grade were not independently associated. The adjusted R^2 for the multivariate model was 0.18.

Table 4: Univariate and multivariate regression analysis of factors predicting BCVA

Predictive factor	**β Coefficient**	**95% CI**	**p-value**
Univariate			
Age > 40 years	0.11	0.19-0.02	0.011
Trauma	0.49	0.32-0.66	<0.001
Grade of Surgeon - *Fellow* - *Consultant* - *Registrar*	 reference 0.06 0.08	 -0.04 – 0.15 -0.21- 0.37	 0.244 0.576
High Myopia	-0.05	-0.16 -0.06	0.369
Macula off	0.38	0.30-0.46	0.066
Dialysis	0.21	0.13-0.30	<0.001
Multivariate			
Age > 40 years	-0.04	0.37-0.83	0.300
Trauma	0.42	0.19-0.82	<0.001
Grade of Surgeon - *Fellow* - *Consultant* - *Registrar*	 reference 0.08 0.04	 0.80-2.04 0.41-26.03	 0.059 0.785
High Myopia	-0.009	-0.11-0.09	0.858
Macula off	0.36	0.39-1.12	<0.001
Dialysis	0.08	0.44-0.97	0.060

BCVA: Best corrected visual acuity

To identify predictors of good postoperative vision (VA ≥ 70 letters) in macula-off eyes, logistic regression analyses were performed (Table 5). In univariate analysis, ocular trauma was associated with markedly lower odds of achieving good vision (OR 0.14, 95% CI 0.03–0.65; p = 0.012), while increasing age showed a borderline association with higher odds (OR 1.02 per year, 95% CI 1.00–1.04; p = 0.047). High myopia and surgeon grade were not significantly associated with visual outcomes. In the multivariate model, trauma remained an independent negative predictor of good visual recovery (OR 0.16, 95% CI 0.04–0.74; p = 0.019). Age, high myopia, and surgeon grade did not reach statistical significance after adjustment.

Table 5: Predictors of good post-operative vision (visual acuity ≥ 70 letters) in macula off detachment

Predictor	Odds ratio (95%CI)	p-value
Univariate		
Trauma	0.14 (0.03-0.65)	0.012
Age	1.02 (1.00-1.04)	0.047
High Myopia	1.13 (0.57-2.23)	0.727
Grade of surgeon	0.75 (0.46-1.24)	0.265
Multivariate		
Trauma	0.16 (0.04-0.74)	0.019
Age	1.02 (1.00-1.04)	0.122
High Myopia	1.13 (0.56-2.27)	0.738
Grade of surgeon	0.75 (0.44-1.24)	0.254

Discussion

To our knowledge, this is the largest published single-centre series to date involving SB surgery performed as a standalone procedure for primary RRD. The study demonstrated good anatomical and functional outcomes, as well as low complication rates, reinforcing SB as a primary, effective and safe treatment for non-PVD RRDs.

At Manchester Royal Eye Hospital, SB is considered the gold standard for eyes without PVD, typically in younger patients, while PPV is preferred for eyes with PVD. This practice aligns with the mean patient age of 36 years in our study, lower than the 60–65 years reported in older studies [9,10] but comparable to recent reports of 25–35 years [14,15]. Historically, SB was the primary treatment for all RRDs, but the advent of PPV and pneumatic retinopexy has gradually restricted its use: consistent with recent literature [10,14,17], nowadays SB remains favoured exclusively for phakic non-PVD RRDs. The narrowing of indications for SB procedures has led to reduced surgical exposure for modern day vitreoretinal surgeons [4,12,18]. A similar declining trend was also observed in our fifteen-year study period: while substantial fluctuation in the annual number of SB procedures can be observed, a gradual reduction in case volume in the latter half of the study is clearly visible, although a marked dip in surgical numbers in 2020 and 2021 is plausibly attributable to the COVID-19 pandemic. Nonetheless, despite the declining rate of procedures, our study demonstrates consistently good anatomical and functional outcomes for young patients undergoing SB surgery.

In our study, we report a final anatomical success rate of 99% while SSAS was achieved in 85% of eyes, which is comparable to other studies reporting SSAS rates between 82% and 91% [3-5, 14]. We observed that fellows had a lower success rate compared to consultants; however, this difference was not statistically significant. One possible explanation is the impact of structured scleral buckling simulation training at our institution, which may help bridge the experience gap and improve surgical outcomes among fellows and trainees. While our study was not specifically designed to evaluate the effect of simulation training, these findings suggest that such training programs could play an important role in standardizing surgical proficiency and maintaining high success rates across different

levels of surgical experience. SSAS was similar between dialysis and non-dialysis RRD, as reported by Mahiul et al. [14] and high myopia did not affect outcomes as previously shown in the scientific literature [19]. Macula-off detachments had lower odds of SSAS, probably due to a longer duration of detachment as well as larger detached surface area with more subretinal fluid. We identified lower odds of SSAS for patients over 40, consistent with Dimakopoulou et al. [16]. This likely reflects older patients with more often extensive RRD, foveal involvement, PVR or age-related vitreous changes [20], making SB alone less effective. Finally, trauma was associated with a lower SSAS following SB repair. While previous papers did not investigate this possible correlation (5, 9, 14), our finding is in contrast with Kannan et al. [21]. A possible explanation is that trauma-related RRDs in our cohort may have been more complex, with larger breaks, associated vitreoretinal pathology, or early PVR, all of which are known to adversely affect surgical outcomes. Our findings therefore highlight the importance of carefully considering aetiology when selecting surgical techniques for RRD repair.

Following SB surgery, mean BCVA improved significantly from 0.62±0.85 to 0.32±0.49 logMAR. For postoperative BCVA, both macula-on RRD and absence of trauma—factors linked to higher SSAS—were associated with better visual outcomes on multivariate analysis. The favourable outcomes in macula-on RRD are likely explained by preservation of the photoreceptors and outer retinal layers, particularly at the fovea, which maintains the potential for central visual recovery. Conversely, ocular trauma is linked to poorer outcomes as it may induce structural and functional retinal damage, trigger intraocular inflammation, all of which can limit visual recovery despite anatomically successful repair. Age over 40 was a significant predictor of poorer vision on univariate analysis, likely due to age-related retinal changes that limit recovery and slow subretinal fluid absorption. Dialysis-related RRDs are known to present more frequently with macula-off detachments and poorer preoperative BCVA [14], which may account for the better postoperative BCVA observed in non-dialysis RRDs on univariate analysis in our study. Moreover, dialysis RRD is often trauma-related [15], and both the association with trauma and the resulting lower rates of SSAS generally lead to poorer postoperative BCVA outcomes.

Subretinal haemorrhage was the most common intraoperative complication (4.6%). This rate is comparable to Hilton et al. (5%) [22] but higher than Muqit et al. (0.2%) [14], likely due to differences in reporting criteria. We included small, localized haemorrhages at the drainage site, whereas other studies may have reported only macula-involving cases. Notably, visually significant haemorrhage occurred in just two patients (0.3%), consistent with Muqit et al. [14]. Postoperative maculopathy occurred in 5.1% cases with cystoid macular oedema in 1.6%. Previous studies reported higher rates (6.9%) of cystoid macular oedema (23), probably due to older age and higher rate of macular detachment in their cohort, both known risk factors [23]. Persistent diplopia occurred in 29 patients (4.8%), comparable to Goezinne et al.[24]. Elevated intraocular pressure (IOP) developed in 45 eyes (7.4%), a rate that is lower than the 28.9% described in cases of an encircling band [25]. Differently, the majority of patients in our study underwent segmental buckling—possibly explaining the lower incidence of IOP elevation in our series. Overall, these findings demonstrate that SB is a safe and effective method, with a low rate of possible complications, for managing RRD in young patients.

A major limitation of this study is the strict selection criteria applied for choosing patients for SB, which may have introduced a selection bias. Consequently, the findings should be interpreted within the context of a selected patient population, potentially limiting the generalisability of the

results to all cases of primary RRD. Another limitation of our study is its retrospective design, which may have contributed to underreporting of ocular trauma (5%) and high myopia (14%) compared to another primary SB study reporting rates of 10.6% and 33.3%, respectively [14]; this difference likely reflects the challenges inherent in retrospective data collection. In addition, the predictive accuracy of the models was limited because we analysed uncommon features such as ocular trauma. The low frequency of these cases likely restricted the model's ability to detect statistically significant associations, emphasizing the need for larger, multicentric datasets to better assess predictors in rare subgroups. Indeed, regression models of the present study were limited in their ability to explain the predictive factors for outcomes, with an AUC of 0.62 and an adjusted R^2 of 0.18 (supplemental material 1). However, the strength of this study is its large single-centre series—which, to our knowledge, is the largest reported—providing a valuable resource for assessing long-term outcomes and complications after SB. In addition, all patients were treated using the same local guidelines, which negates the differences that may arise from varying protocols in a multicentre study.

In summary, our findings demonstrate favourable anatomical and functional outcomes, accompanied by a strong safety profile, in young patients with RRD. Higher rates of SSAS were associated with macula-on status, absence of ocular trauma, and age under 40 years. On multivariate analysis, better postoperative BCVA was linked to macula-on status and absence of trauma, while absence of retinal dialysis, age under 40 years, and achievement of SSAS resulted as predictors of improved visual outcomes on univariate analysis. Our study underscores the continuing importance of SB surgery in managing phakic non-PVD RRDs in young patients. These findings provide vitreoretinal surgeons and ophthalmologists with robust long-term evidence to guide patient selection and prognostic counselling. Ongoing training and dissemination of SB techniques are essential to ensure that SB remains a vital skill, enabling optimal patient outcomes.

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