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Molecular And Clinical Predictors Of The Effectiveness Of Primary Vitrectomy And Extracleral Filling In Phakic Patients With Regmatogenic Retinal Detachment

Tasmila Ruslambekovna Askharova[1], Zareta Saipuddievna Alieva[1], Muminat Ayubovna Gaysumova[1], Kalimat Akhmadulaevna Salmanova[2], Dzhamilya Shakhbanovna Kasumova[2], Isa Shamilevich Dadaev[2], Olga Mikhailovna Omelchuk[3], Gulbagomed Ismailovich Gulbagomedov[2], Sabila Visanievna Zolaeva[4]

[1] Astrakhan State Medical University, Astrakhan, Russian Federation
[2] Dagestan State Medical University, Makhachkala, Russian Federation
[3] I. M. Sechenov First Moscow State Medical University (Sechenovskiy University); Institute of Clinical Medicine named after N.V. Sklifosovsky, Moscow, Russian Federation
[4] Kabardino-Balkarian State University named after H.M. Berbekov, Nalchik, Russian Federation

Abstract. Goal. To evaluate the clinical outcomes and complications of primary vitrectomy compared with extracleral filling in phakic patients with regmatogenic retinal detachment, taking into account the localization and number of ruptures. Materials and methods. A prospective study involving twenty-three patients was conducted at the Multidisciplinary Hospital No. 2 in St. Petersburg from October 2024 to May 2025. The patients were randomly divided into two groups: the primary vitrectomy group (twelve patients) and the scleral filling group (eleven patients). All operations were performed according to modern standards of surgical treatment, followed by follow-up for nine months. Results. The primary indicator of anatomical retinal fit was 83.3 percent in the vitrectomy group and 81.8 percent in the filling group, while the differences did not reach statistical significance. After nine months, the final retinal fit was achieved in all cases in both groups. Visual acuity improved significantly in both groups, but faster recovery was noted in patients after scleral filling. At the same time, cataract development was more often detected in patients after vitrectomy, whereas cases of residual subretinal fluid and infection in the buckle area were observed after filling. Conclusions. Both methods provide high efficiency in the treatment of regmatogenic retinal detachment in phakic patients. The choice of surgical tactics should take into account the location and number of ruptures, which increases the likelihood of a successful outcome and minimizes complications. The significance of the study lies in the fact that it helps doctors to choose a reasoned treatment method, taking into account the risks of complications and the features of the clinical picture.

Key words: regmatogenic retinal detachment, vitrectomy, scleral filling, phakic patients, cataract, anatomical success.

INTRODUCTION. Regmatogenic retinal detachment remains one of the leading causes of vision loss: approximately 10-18 cases per 100,000 population per year are registered in the world, and about 9-13 per 100,000 in Russia, which makes it critically important to correctly choose primary tactics in phakic patients [1]. The effectiveness of the intervention is largely determined by the pattern of ruptures: with single upper peripheral defects, the filling often provides a comparable or more stable fit with a lower risk of accelerated cataractogenesis, whereas multiple, lower or giant ruptures, as well as pronounced traction, more often require vitrectomy [2-4].

Both strategies have a different profile of undesirable outcomes: after vitrectomy, the risks of recurrence persist against the background of early proliferation and accelerated clouding of the lens, whereas extracleral surgery is associated with myopic refractive shift, diplopia and folded deformities, but potentially gentler for the natural lens [5].

The choice of a tamponing agent remains unresolved: gases are convenient for spontaneous resorption and lack of repeated surgery, but require prolonged positioning and control lower ruptures worse; silicone oil provides stable tamponade in complex anatomy; however, it is associated with an increase in intraocular pressure, emulsification and the need for removal [9]. When upper and lower tears are combined, combined ("binary") tamponade patterns are discussed: gains in the frequency of primary fit are often accompanied by an increase in cataracts and emulsification, which emphasizes the need to individualize tactics for localization and the number of defects [12]. Experimental alternatives - biocompatible optically transparent materials that mimic the vitreous body (for example, hyaluronic acid-based hydrogels) - show promise, but require further validation and long-term safety assessment. The relevance of the study is due to the high cost of error in choosing the first intervention (relapses, repeated operations, loss of vision) and underestimation of the role of topography and the number of ruptures as key factors of stratification in phakic eyes.

Thus, the aim of the study is to provide a clinical justification for the individualization of the approach to the treatment of regmatogenic retinal detachment through the analysis of the relationship between macular status, localization of defects and risks of complications after various surgical interventions.

Materials and methods. The study was performed on the basis of Multidisciplinary Hospital No. 2 in Moscow.In the period from October 2024 to May 2025, 23 patients with primary phakic regmatogenic retinal detachment were included in the study. All participants in the study signed an informed consent, which allowed them to comply with the current norms of bioethics. The design was a prospective, single-center, 1:1 randomization trial using sealed envelopes, which minimized systematic errors and maintained group comparability.

The inclusion criteria were phakic status, the presence of an identified retinal tear, transparent optical media, and the absence of proliferative vitreoretinopathy of grade C or higher, which ensured sample uniformity. On the contrary, the exclusion criteria included traumatic etiology, aphakia or pseudophakia, pronounced turbidity of the media, previous intraocular interventions and detachment without an identifiable rupture, which made it possible to eliminate factors that distort the results.

In the scleral filling group, cryopexy was performed around the rupture and a segmental splint with a circumferential band was installed; if necessary, external drainage of the subretinal fluid was performed and gas support was introduced, which met the standards of modern surgery. In the primary vitrectomy group, a three–port microinvasive operation (25-27 G) was performed with induction of posterior vitreous detachment, if necessary, liquid–air exchange, circular endolaser retinopexy and tamponade with C3F8 gas (14%), which ensured complete elimination of the traction component.

Postoperative management included head positioning for two weeks and standard topical therapy, and follow-up visits were scheduled on day 7, after 1, 3, 6, and 9 months, which made it possible to track the dynamics of recovery. The anatomical fit of the retina by the sixth month was considered the primary endpoint, while the best corrected visual acuity, intraocular pressure, cataractogenesis, and complication profile were considered secondary; the analysis was performed taking into account the location and number of ruptures, which made it possible to identify the most significant clinical and anatomical outcome factors.

To analyze categorical variables in both groups, conjugacy tables were generated and verified using the exact Fisher criterion, which allowed for correct interpretation of the data with a small sample size. Continuous indicators, including visual acuity in LogMAR and intraocular pressure, were compared using the nonparametric Mann–Whitney test, and the statistical significance level was set to $p < 0.05$. All calculations were performed using the R software (version 4.3.1) using specialized packages for biostatistics.

Results. The comparative analysis showed that the groups of extracleral filling and the pars vitrectomy plan did not differ in key preoperative characteristics, including the age of patients, gender, side of the affected eye, and duration of detachment (Table 1). The configuration of retinal detachment, macular status, degree of proliferative vitreoretinopathy, and the number of retinal tears were distributed comparably in both cohorts. The indicators of preoperative visual acuity and intraocular pressure also did not reveal statistically significant differences, which confirms the initial uniformity of the sample. All included patients were monitored for at least 9 months, which ensured reliable tracking of anatomical and functional outcomes.

Table 1: Comparative preoperative characteristics of patients with regmatogenic retinal detachment (n = 23)

Indicator	Vitrectomy group (n=12)	Sealing group (n=11)	p-value
Age, years (average ± SD)	44 ± 13	39 ± 15	0.42
Gender, % (m/w)	58% (7) / 42% (5)	64% (7) / 36% (4)	0.73
Laterality of the eye, % (right)	50% (6)	55% (6)	0.81
PP duration, days (average, range)	18 (3–60)	21 (4–70)	0.67
Macula-oh, % (n)	25% (3)	18% (2)	0.68
BCVA LogMAR (cf. ± SD, median)	1.60 ± 0.85, 1.55	1.48 ± 0.90, 1.50	0.54
PVR Status (A/B)	83% (10) / 17% (2)	82% (9) / 18% (2)	0.95
Risk factors, % (n)	42% (5)	45% (5)	0.88
Myopia > −6D	17% (2)	18% (2)	-
Peripheral degeneration	17% (2)	9% (1)	-
Both risk factors	8% (1)	18% (2)	-
Preoperative IOP (mmHg, cf. ± SD)	12.0 ± 3.2	11.5 ± 2.8	0.71
Number of gaps: 1	67% (8)	73% (8)	0.77
Number of gaps: 2	17% (2)	18% (2)	-
Number of breaks: ≥3	16% (2)	9% (1)	-
Total PVD, % (n)	58% (7)	64% (7)	0.72
Smoking experience, % (n)	25% (3)	27% (3)	0.89
Systemic diseases (DM/AH), % (n)	33% (4)	27% (3)	0.77

Note: PP - regmatogenic retinal detachment; BCVA - best corrected visual acuity; LogMAR - logarithm of the minimum angle of resolution; PVR - proliferative vitreoretinopathy; PVD - posterior vitreous detachment; IOP - intraocular pressure; DM - diabetes mellitus; AH - arterial hypertension.

It should be noted that the primary indicator of anatomical success (Table. 2) was 83.3% (10 out of 12 cases) in the primary vitrectomy group and 81.8% (9 out of 11 cases) in the extracleral filling group, while the differences did not reach statistical significance (p = 0.24). An analysis of the causes of surgical failures showed that in the vitrectomy group, open retinal tears persisted in two cases, and in one case, the development of proliferative vitreoretinopathy was revealed. In the filling group, relapses were associated with missed tears in two eyes and technical difficulties in positioning the seal in one case. In all cases, repeated interventions were performed using vitrectomy, which made it possible to achieve the final fit of the retina. After 9 months of follow-up, the final anatomical success rate was 100% in both groups, which confirms the effectiveness of both methods with proper patient selection. Thus, the location and number of ruptures remained the key factors influencing the outcome of treatment, regardless of the chosen surgical tactics.

Table 2: Surgical outcomes in patients with regmatogenic retinal detachment

Variable	Vitrectomy group (n=12)	Filling group (n=11)
Primary anatomical success (%)	83.3% (10/12)	81.8% (9/11)
Causes of surgical failures	2 cases: open ruptures1 cases: PVR	2 cases: missed ruptures 1 case: incorrect filling position
Final visual acuity (median)	0.5 LogMAR (≈6/18)	0,6 logMAR (≈6/24)
BCVA Range (LogMAR)	1,3 – 0,2 (≈2/60 – 6/9)	1,4 – 0,0 (≈1/60 – 6/6)
Final anatomical success after 9 months	100% (12/12)	100% (11/11)
Postoperative complications	1 a case of cataract	1 case of diplopia

Note. PVR - proliferative vitreoretinopathy; BCVA - best corrected visual acuity; LogMAR - logarithm of the minimum angle of resolution.

According to the results of the analysis, there were no statistically significant differences in the final best corrected visual acuity (NCOC) between the primary vitrectomy group and the scleral filling group (p = 0.41). Nevertheless, interim data showed that as early as 1 week after surgery, the median NCOSIS in the filling group was 0.65 LogMAR (mean 0.72 ± 0.38; range 0.18–1.40), while in the vitrectomy group this indicator was significantly worse - 1.9 LogMAR (mean 1.85 ± 0.61; range 0.7–2.8), the difference it turned out to be statistically significant (p < 0.001).

After 1 month, the advantage of the filling group remained: the median NCOSIS reached 0.60 LogMAR (mean 0.68 ± 0.40; range 0.1–1.5), while in the vitrectomy group there was a median 1.1 LogMAR (mean 1.2 ± 0.7; range 0.3–2.7), the difference was also significant (p = 0.008). By the 3rd month of follow-up, the indicators had converged, but the faster restoration of vision in patients after filling retained clinical significance.

After 6 months, the median NCOC values were 0.5 LogMAR in the filling group and 0.6 LogMAR in the vitrectomy group, which demonstrated comparable effectiveness of both methods in the medium term. By the 9th month of follow-up, there were no differences between the groups: the median NCOS stabilized at 0.45–0.50 LogMAR in both groups, confirming the long-term equivalence of approaches. The graphical dynamics of changes in visual functions throughout the entire period is shown in Figure 1, which clearly shows an earlier improvement in the filling group and a gradual alignment of indicators by 9 months.

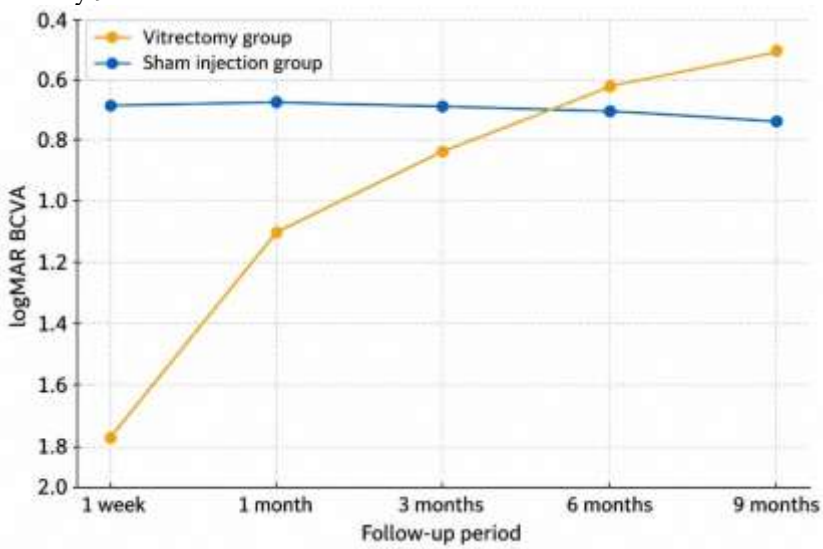

Figure 1. Dynamics of the best corrected visual acuity (LogMAR) in the vitrectomy and filling groups during 9 months of follow-up

According to Table 3, in the primary vitrectomy group, the median of the best corrected visual acuity (NCOC) improved from a preoperative value of 1.6 LogMAR (≈2/60; mean 1.55 ± 0.80, range 0.4–2.8) to a median of 0.7 LogMAR (≈6/30; mean 0.72 ± 0.38, range 0.2–1.5). In this group, 7 eyes (58%) achieved visual acuity better than 0.6

(6/24), one patient showed a decrease of ≥ 1 line according to Snellen, and two eyes (17%) retained their baseline values. In the scleral filling group, the median NCOS increased from the preoperative level of 1.4 LogMAR (≈3/60; average 1.48 ± 0.85, range 0.3–2.9) to median 0.6 LogMAR (≈6/24; average 0.64 ± 0.36, range 0-1.7). At the same time, 8 eyes (73%) managed to achieve visual acuity better than 0.6, two eyes (18%) retained their initial level, and one case showed a decrease of ≥ 1 line.

Table 3: Final visual results in patients with regmatogenic retinal detachment

Variable	Vitrectomy Group (n=12)	Sealing group (n=11)
Preoperative median NCOSIS (LogMAR)	1,6 (≈2/60)	1,4 (≈3/60)
Preoperative mean ± SD (LogMAR)	1,55 ± 0,80 (0,4–2,8)	1,48 ± 0,85 (0,3–2,9)
Postoperative median NCOSIS (LogMAR)	0,7 (≈6/30)	0,6 (≈6/24)
Postoperative mean ± SD (LogMAR)	0,72 ± 0,38 (0,2–1,5)	0,64 ± 0,36 (0-1,7)
Patients with NCOs > 0.6 (6/24)	58% (7 eye)	73% (8 eye)
Drop ≥ 1 row	1 case (8%)	1 case (9%)
Maintaining the preoperative level	2 cases (17%)	2 cases (18%)
Complications	Cataract - 4 cases (33%) Iatrogenic ruptures - 2 cases (17%)	Buckle infection - 1 case (9%) Subretinal fluid - 3 cases (27%)

Note. NCOSIS is the best corrected visual acuity; LogMAR is the logarithm of the minimum angle of resolution.

Intraoperatively, two episodes of iatrogenic ruptures (17%) were recorded in the vitrectomy group, which were limited by laser coagulation, while no serious complications such as scleral perforation or vitreous loss were observed. In the filling group, there were three cases of residual subretinal fluid (27%), two of which required repeated intervention, as well as one episode of buckle infection (9%). Late complications included the development of cataracts in four patients (33%) after vitrectomy and increased intraocular pressure in three cases (13%) in both groups, which underscores the need for a differentiated approach to surgical tactics.

Discussion. The results of the study showed comparable effectiveness of primary vitrectomy and scleral filling in phakic patients with regmatogenic retinal detachment, which is reflected in similar indicators of primary anatomical success (Table 2). Similar data are provided by Safadi et al. [9], which also noted the absence of statistically significant differences in long-term retinal fit, however, the authors pointed out higher risk of cataractogenesis after vitrectomy. In our study, a similar trend was confirmed: the incidence of cataracts after PPV was higher, whereas complications associated with residual subretinal fluid and buckle infection were more typical for the filling group.

At the same time, the data from Radice et al. [10] indicate the advantage of a standardized approach to sealing in terms of faster restoration of vision in the early stages, which is consistent with the advantage we identified for NCOS in the first months of follow-up. At the same time, according to a review by Gupta et al. [11], vitrectomy provides better results in patients with multiple or inferior tears, which coincides with our observation of the importance of localization and number of defects as key outcome factors.

The limitations of our study include a small sample size (23 patients), a single-center design, and a limited follow-up period of 9 months, which reduces statistical power and makes it impossible to assess long-term outcomes, including cataract progression or epiretinal membrane formation. An additional factor is the inability to completely stratify patients by location of ruptures due to a limited sample, which requires caution in interpreting the results.

It is recommended to conduct multicenter studies with a larger number of patients and long-term follow-up, which will clarify the role of anatomical factors and optimize the algorithm for choosing between vitrectomy and filling. The results obtained confirm the need for a personalized approach that takes into account both the clinical characteristics of the eye and the potential complications of each technique.

Conclusion. The study showed that primary vitrectomy and extracleral filling have comparable efficacy in phakic patients with regmatogenic retinal detachment. In the first days after surgery, faster recovery of visual acuity was observed in the filling group, while vitrectomy made it possible to more reliably eliminate multiple or lower tears. The main complications in the PPV group were cataractogenesis and iatrogenic ruptures, and in the SB group, residual subretinal fluid and buckle infection. The practical benefit of the study is to confirm the importance of localization and the number of ruptures when choosing surgical tactics and the need for a personalized approach.

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Contribution of the authors

The authors have made an equal and significant contribution to the collection of empirical data, their processing and the writing of the article.

Conflict of interests. The authors declare that there is no conflict of interest

Information about the authors

Tasmila Ruslambekovna Askharova – student, Astrakhan State Medical University, Astrakhan, Russian Federation, e-mail: tasmilaaskharova@gmail.com, https://orcid.org/0009-0001-9765-2704

Zareta Saipuddievna Alieva – student, Astrakhan State Medical University, Astrakhan, Russian Federation, e-mail: zareta.aliyeva@list.ru

Muminat Ayubovna Gaysumova – student, Astrakhan State Medical University, Astrakhan, Russian Federation, e-mail: gaysumov1.5@gmail.com

Kalimat Akhmadulaevna Salmanova – student, Dagestan State Medical University, Makhachkala, Russian Federation, e-mail: skal1ma@mail.ru, https://orcid.org/0009-0002-4773-0468

Dzhamilya Shakhbanovna Kasumova – student, Dagestan State Medical University, Makhachkala, Russian Federation, e-mail: kasumovadzamila@gmail.com, https://orcid.org/0009-0007-6911-3096

Isa Shamilevich Dadaev – student, Faculty of Pediatrics, Dagestan State Medical University, Makhachkala, Russian Federation.

Olga Mikhailovna Omelchuk – student, Federal State Autonomous Educational Institution of Higher Education I.M.Sechenov First Moscow State Medical University of the Ministry of Health of the Russian Federation (Sechenovskiy University), Institute of Clinical Medicine named after N.V. Sklifosovsky, Moscow, Russian Federation, e-mail: oomelchuk02@mail.ru, https://orcid.org/0009-0009-5330-1185

Gulbagomed Ismailovich Gulbagomedov – student, Dagestan State Medical University, Makhachkala, Russian Federation, e-mail: ggulbagomedov@mail.ru? https://orcid.org/0009-0005-2245-0381

Sabila Visanievna Zolaeva – student, Kabardino-Balkarian State University named after H.M. Berbekov, Nalchik, Russian Federation, e-mail: sabilazolaeva@mail.ru? https://orcid.org/0009-0003-6894-2352