Original Investigation

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Evaluation of Surgical Success Rate and Influencing Factors in Patients with Primary Rhegmatogenous Retinal Detachment Treated with Pneumatic Retinopexy

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ABSTRACT

Objective: This study aims to evaluate the anatomical and visual success rates of primary pneumatic retinopexy (PR) in patients with rhegmatogenous retinal detachment (RRD) and to investigate the factors influencing surgical outcomes.

Methods: A retrospective review was conducted on patients with RRD treated with primary PR at University of Health Sciences Türkiye, Kartal Dr. Lütfi Kırdar City Hospital between May 2011 and May 2024. Demographic data, best-corrected visual acuity (BCVA), lens status, number and location of retinal breaks, macular involvement, gas tamponade type, intraocular pressure, and anatomical success were analyzed. Patients with failed PR underwent pars plana vitrectomy (PPV).

Results: The study included 32 eyes of 32 patients (19 males, 13 females) with a mean age of 53 years. PR achieved anatomical success in 17 patients (53.1%). Success was significantly higher in macula-on cases (85.7%) compared to macula-off cases (27.8%) (p=0.001). Preoperative BCVA improved significantly postoperatively (1.61 to 1.25 logMAR; p=0.003). PPV performed in 15 patients yielded significant visual improvement (2.14 to 0.93 logMAR; p=0.001). Macular involvement was a negative prognostic factor, while tamponade type and lens status were not statistically significant.

Conclusion: PR is a minimally invasive and cost-effective alternative to vitrectomy in selected RRD cases. PR should be considered for patients with superior retinal breaks and no macular involvement.

Keywords: Rhegmatogenous retinal detachment, pneumatic retinopexy, retinal surgery

INTRODUCTION

Retinal detachment (RD) is one of the most significant causes of vision loss among the working-age population. Rhegmatogenous RD (RRD) occurs as a result of a full-thickness retinal break, allowing liquefied vitreous to enter the subretinal space and separate the neurosensory retina from the underlying retinal pigment epithelium (1). Its annual incidence is approximately 1 in 10,000, and nearly 50% of cases develop spontaneously (2). Contemporary management of RRD primarily relies on three established surgical approaches: scleral buckling (SB), pars plana vitrectomy (PPV), and pneumatic retinopexy (PR) (3).

PR was first described in the mid-1980s by Dominguez (4), Hilton and Grizzard (5) as a treatment modality for RRD. PR is based on the principle of intravitreal expansile gas injection combined with postoperative positioning to achieve temporary retinal break tamponade, followed by definitive retinopexy. The most important advantages of PR include its minimally invasive nature, the absence of a requirement for sedation or general anesthesia, its applicability under outpatient clinic conditions in a short time, and a lower risk of surgical complications. In addition, compared to SB and PPV, PR is preferred due to its faster visual rehabilitation, the ability to be performed without extensive preparation, and its cost-effectiveness (6). However, despite all these advantages, uncertainties regarding the efficacy of PR have caused the technique to remain controversial.

In this study, we aimed to evaluate the functional (visual) and anatomical success rates of patients who underwent primary PR for the treatment of RRD, as well as to investigate the factors affecting surgical success.

METHODS

A retrospective review was conducted of patients who were diagnosed with RRD at the Eye Clinic of University of Health Sciences Türkiye, Kartal Dr. Lütfi Kırdar City Hospital between May 2011 and May 2024, had superior retinal breaks, and underwent primary PR.

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Patients who were followed for at least 6 months were included in the study. Preoperative and postoperative best-corrected visual acuity (BCVA), intraocular pressure (IOP), and detailed anterior and posterior segment examinations were evaluated in all included patients. For statistical purposes, all BCVA values were standardized and expressed in logMAR units. Standard logMAR conversion values were used for low visual acuity measurements (e.g., counting fingers, hand movements, light perception), such as 2.0 logMAR for counting fingers and 2.3 logMAR for hand movements. In addition, lens status, number and localization of retinal breaks, presence of macular involvement, type of gas tamponade used [sulfur hexafluoride (SF_6) or perfluoropropane (C_3F_8)], and anatomical success rates were analyzed.

In cases in which primary PR failed, PPV combined with phacoemulsification and intraocular lens implantation was performed. In these patients, preoperative and postoperative visual acuity as well as the development of proliferative vitreoretinopathy (PVR) were also evaluated.

The inclusion criteria were RRD cases with retinal breaks located between the 8 and 4 o'clock positions. Exclusion criteria included inferior quadrant retinal breaks, retinal breaks larger than one clock hour, cases in which retinal breaks could not be detected by fundus examination or could not be visualized due to media opacities (such as cataract or vitreous hemorrhage), presence of PVR, history of previous retinal surgery, and inability to comply with the recommended postoperative positioning.

Ethical Approval

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Local Institutional Review Board of University of Health Sciences Türkiye, Kartal Dr. Lütfi Kırdar City Hospital (approval number: 2025/010.99/17/28, date: 25.06.2025). Due to the retrospective nature of the study, the requirement for informed consent was waived.

Surgical Technique and Postoperative Management

All procedures were performed according to a standardized protocol by one of two experienced vitreoretinal surgeons (M.N.B. or G.A.). After all retinal breaks were identified by fundus examination, patients were informed in detail about the procedure, alternative treatment options, and possible complications, and written informed consent was obtained from all participants. Written informed consent for the surgical intervention was obtained from all patients prior to surgery.

All surgeries were performed under topical anesthesia in an outpatient setting. Intravitreal gas injection was administered through the pars plana at a distance of 3.5 mm in pseudophakic eyes and 4 mm in phakic eyes using a 26-gauge needle, delivering either 0.5-0.6 mL of pure SF_6 or 0.3 mL of pure C_3F_8 to create a single gas bubble. Following the injection, anterior chamber paracentesis was performed to prevent IOP elevation, and light perception was checked immediately after the procedure.

All patients were instructed to maintain appropriate postoperative head positioning to ensure that the gas bubble effectively tamponaded the retinal break. Within the first three days after gas injection, 2-3 rows of laser photocoagulation were applied around the retinal tear. Postoperative topical antibiotic and corticosteroid eye drops were prescribed routinely.

Patients were followed up at postoperative 1 week, and at 1, 3, and 6 months, and subsequently at 6-month intervals. At each visit, BCVA, IOP, and detailed anterior and posterior segment examinations were performed.

Complications and Secondary Surgical Protocol

Postoperative complications such as elevated IOP, cataract progression, vitreous hemorrhage, re-detachment, and the development of PVR were carefully recorded throughout the follow-up period.

In cases in which primary PR failed to achieve anatomical retinal reattachment, secondary surgical intervention with PPV combined with phacoemulsification and intraocular lens implantation was performed when indicated. During secondary surgery, standard three-port PPV was applied, subretinal fluid was drained when necessary, endolaser photocoagulation was applied around the retinal breaks, and long-acting gas tamponade was used. The development of postoperative PVR and final anatomical and functional outcomes were evaluated in these patients.

Statistical Analysis

Statistical analysis was performed using SPSS software. Descriptive statistics were presented as mean ± standard deviation or median (interquartile range) for continuous variables, and as frequencies (n) and percentages (%) for categorical variables. Visual acuity measurements were converted to logMAR values for statistical comparisons. For patients with very low vision, standard logMAR conversion values were assigned: 2.0 logMAR for counting fingers and 2.3 logMAR for hand movements.

The normality of the data distribution was tested using the Shapiro-Wilk test. Preoperative and postoperative functional (BCVA) and physiological (IOP) parameters were compared using the Wilcoxon signed-rank test (for non-normally distributed data). Categorical variables were compared using the chi-square test or Fisher's exact test. A p-value of <0.05 was considered statistically significant.

RESULTS

Thirty-two eyes of 32 patients (19 male, 13 female) were included in the study. The mean age of the patients was 51.41±14.27. While macular involvement was not observed in eighteen patients, RD with macular involvement was present in 14 patients. The mean number of tears was determined to be 1.3. (Table 1).

SF_6 was used as an gas tamponade in 14 patients, and C_3F_8 was used in 18 patients. While anatomical success was achieved in 17 patients (53.1%) after PR, retinal reattachment could not be achieved in 15 patients (46.9%), and 100% final anatomical success was achieved in all patients with secondary surgery.

While the preoperative median BCVA was 2.3 logMAR, the postoperative BCVA was 1.00 logMAR. This change was statistically significant (p=0.003). In patients where anatomical success could not be achieved with PR and who subsequently underwent PPV, the preoperative BCVA was measured as 2.3 logMAR, and the postoperative BCVA as 0.8 logMAR; this difference was statistically significant (p=0.001). Overall, a statistically significant improvement in BCVA was observed across the entire cohort (p=0.003), with a more pronounced gain in patients requiring secondary PPV (p<0.01) (Table 2).

Among the 18 patients with macular involvement, surgical failure occurred in 13, whereas failure was observed in only 2 of the 14 patients without macular involvement (fovea-on). The anatomical success rate of primary PR was 85.7% in macula-on RRD compared with 27.8% in macula-off RRD. Macular involvement was identified as a statistically significant risk factor for surgical failure (p=0.001).

With respect to the type of tamponade, surgical failure occurred in 6 of the 18 patients treated with C_3F_8 and in 9 of the 14 patients treated with SF_6; however, the difference between the two groups was not statistically significant (p=0.08). Similarly, according to lens status, surgical failure developed in 9 of the 18 phakic patients and in 6 of the 14 pseudophakic patients. This difference was also not found to be statistically significant (p=0.68) (Table 3).

Table 1. Demographic and clinical characteristics of the patients

Parameter	Value
Age (years), mean ± SD	51.41±14.27
Laterality (right/left), n (%)	17 (53.1)/15 (46.9)
Sex (male/female), n (%)	19 (59.4)/13 (40.6)
Macular status (on/off), n (%)	14 (43.8)/18 (56.3)
Number of retinal breaks, mean (min-max)	1.3 (1-3)
Gas type (SF_6/C_3F_8), n (%)	14 (43.8)/18 (56.3)
Lens status (phakic/pseudophakic), n (%)	18 (56.3)/14 (43.8)
Retinal status after PR (attached/detached), n (%)	17 (53.1)/15 (46.9)

PR: Pneumatic retinopexy, SF_6: Sulfur hexafluoride, C_3F_8: Perfluoropropane, SD: Standard deviation

Table 2. Comparison of preoperative and postoperative clinical parameters

Parameter	Median (IQR)	p-value
Preoperative BCVA (logMAR)	2.3 (0.1-2.7)	0.003
Postoperative PR BCVA (logMAR)	1.0 (0.1-2.7)	
Preoperative IOP (mmHg)	14 (11-18)	0.165
Postoperative IOP (mmHg)	15 (12-17)	
Preoperative PPV BCVA (logMAR)	2.3 (0.3-2.7)	0.001
Postoperative PPV BCVA (logMAR)	0.8 (0.2-1.3)	

Wilcoxon signed rank-test
BCVA: Best-corrected visual acuity, IOP: Intraocular pressure, PR: Pneumatic retinopexy, PPV: Pars plana vitrectomy, IQR: Interquartile range

The median preoperative IOP was 14 mmHg, while the median postoperative IOP was 15 mmHg. No clinically or statistically significant IOP elevation was observed following PR, and no cases of secondary glaucoma developed during follow-up.

DISCUSSION

PR represents a minimally invasive and cost-effective alternative to vitrectomy in the management of selected cases of RRD. In the present retrospective study, primary PR achieved an anatomical success rate of 53.1%. Although this rate appears moderate, it falls within the broad range of outcomes reported in the literature, reported single-procedure success rates for PR show considerable variability across published series (7). Importantly, all cases with primary PR failure achieved complete retinal reattachment following secondary PPV combined with phacoemulsification and intraocular lens implantation, yielding a final anatomical success rate of 100%. These findings support the concept that PR can be safely positioned as an initial, less invasive step within a stepwise surgical strategy for appropriately selected patients.

In our study, patient selection was based on the PIVOT eligibility criteria, which are also applied in our routine clinical practice. One potential explanation for the relatively lower primary success rate observed is that PR was performed only once in all patients, and repeat PR was not attempted in cases of primary failure. Instead, these patients were directly referred for PPV. This pragmatic approach, while reducing cumulative procedural burden, may have contributed to the lower single-procedure success rate compared with series allowing repeated PR attempts.

Chandelier-assisted PR, as described by Habib et al. (8), has been reported to significantly enhance single-procedure success by facilitating improved visualization of peripheral retinal breaks, achieving success rates of 91.7% after one procedure and 100% after a second intervention. The authors emphasized the ability of this technique to reduce the likelihood of missed small peripheral breaks and to minimize intraoperative complications such as iatrogenic lens injury. In our cohort, missed small peripheral retinal tears likely contributed to primary surgical failure, particularly in eyes with extensive RD. Consistently, we observed that primary

Table 3. Surgical success rates among patient subgroups

Variable	Retina detached, n	Retina attached, n	p-value
Macular status			0.001[a]
Macula-on	2	12	
Macula-off	13	5	
Gas type			0.082[b]
C_3F_8	6	12	
SF_6	9	5	
Lens status			0.688[b]
Phakic	9	9	
Pseudophakic	6	8	

[a]: Chi-square test, [b]: Fisher's exact test, C_3F_8: Perfluoropropane, SF_6: Sulfur hexafluoride

PR failure occurred more frequently in cases with widespread detachment and foveal involvement.

Lens status did not significantly influence anatomical success in our cohort. While earlier studies reported higher PR success rates in phakic eyes compared with pseudophakic or aphakic eyes (9), our results are consistent with the observations of Fabian et al. (10), who also reported comparable outcomes between these groups. The prevailing hypothesis underlying reduced success in pseudophakic and aphakic eyes is the higher probability of multiple missed retinal breaks. Accordingly, meticulous peripheral retinal examination remains essential when considering PR in pseudophakic RRD.

Macular status emerged as the most significant predictor of surgical outcome in our series. While an anatomical success rate of 85.7% was achieved in macula-on RRD, this rate decreased dramatically to 27.8% in macula-off cases (p=0.001). In our cohort, macular status emerged as the strongest predictor of anatomical outcome following PR. These findings are in strong agreement with previous reports (11). Grizzard et al. (12) previously demonstrated that increasing extent of detachment is associated with poorer PR outcomes. In extensive RRD, visualization of small and peripheral breaks becomes increasingly challenging due to media disturbance caused by subretinal fluid accumulation, thereby predisposing these eyes to residual undetected breaks and subsequent surgical failure. Our findings further support this mechanistic explanation.

Similarly, the type of gas tamponade (C_3F_8 vs. SF_6) was not significantly associated with surgical success in our analysis (p=0.08), in agreement with the findings reported by İpekli et al. (13) These authors suggested that injected gas volume, rather than gas type itself, may be the principal determinant of tamponade efficacy. Unfortunately, due to the retrospective nature of our data and limited sample size, quantitative analysis of gas volume as a prognostic variable could not be performed.

From a functional standpoint, PR resulted in a statistically significant improvement in BCVA (p=0.003), underscoring the functional benefit of this minimally invasive technique and its ability to facilitate rapid visual rehabilitation. Moreover, patients who required secondary PPV after PR failure also demonstrated a marked improvement in BCVA (p=0.001), confirming the effectiveness of PPV as a highly reliable second-line intervention. These findings are consistent with prior reports and with the PIVOT study, which similarly demonstrated favorable visual outcomes following PPV after primary PR failure (11,14).

Study Limitations

The principal limitation of this study lies in its retrospective design. Additional limitations include the relatively small sample size and the short follow-up duration of six months. Nevertheless, data from the PIVOT trial have demonstrated that eyes achieving stable retinal reattachment within the first three months exhibit a negligible risk of late redetachment. Future prospective, multicenter studies with longer follow-up periods are warranted to further refine real-world estimates of primary and final reattachment rates, patient-reported visual outcomes, and late recurrence patterns under standardized PIVOT-guided surgical protocols. Additionally, the retrospective design precluded standardized assessment of patient-reported outcomes and precise quantification of injected gas volume.

CONCLUSION

In conclusion, optimal patient selection, strict postoperative positioning, close follow-up, and high patient compliance are critical determinants of PR success. Based on our findings, PR should primarily be considered in patients with macula-on RRD and superiorly located retinal breaks, in whom it offers an effective, minimally invasive, and vision-preserving first-line treatment option. When applied in carefully selected macula-on RRD cases with superior breaks, PR represents an effective first-line strategy that preserves the option of highly successful secondary surgery without compromising final anatomical or functional outcomes.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the local Institutional Review Board of University of Health Sciences Türkiye, Kartal Dr. Lütfi Kırdar City Hospital (approval number: 2025/010.99/17/28, date: 25.06.2025).

Informed Consent: Due to the retrospective nature of the study, the requirement for informed consent was waived.

Footnotes

Author Contributions: Surgical and Medical Practices - K.B., G.A.; Concept - K.B., D.Ç.Y., Y.C.A., G.A.; Design - K.B., D.Ç.Y., Y.C.A., G.A.; Data Collection and/or Processing - K.B., D.Ç.Y., Y.C.A., G.A.; Analysis and/or Interpretation - K.B., D.Ç.Y., Y.C.A., G.A.; Literature Search - K.B., D.Ç.Y., Y.C.A., G.A.; Writing - K.B., D.Ç.Y., Y.C.A., G.A.

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