Original Article

Outcomes after giant peripheral retinotomy and anterior flap retinectomy for rhegmatogenous retinal detachments with advanced proliferative vitreoretinopathy using small gauge vitrectomy

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Purpose: To analyze the visual and anatomical outcomes for eyes with rhegmatogenous retinal detachment (RRD) and advanced proliferative vitreoretinopathy (PVR) undergoing giant peripheral retinotomy (GPR) using 25-gauge pars plana vitrectomy (PPV). **Methods:** In this retrospective multi-center study, patients with RRD with either anteroposterior or circumferential retinal shortening and advanced PVR requiring more than 90-degree GPR with/without relaxing retinotomy were included. Subjects of either gender, any age group, and with complete surgical notes were included. Outcome measures of the study included anatomical success (i.e. complete retinal re-attachment) at 6 months using survival analysis, visual outcomes, and post-operative complications. **Results:** Forty-one eyes of 41 patients (33 males) with a mean age of 44.9 ± 21.4 years were included. At 6 months follow-up, anatomical success was seen in 29 eyes (70.7%) with a cumulative re-attachment rate of 66% (95% confidence interval = 48 = 79%). All re-detachments occurred at ≤6 months with a peak at 4–6 months (n = 9). Twenty-three eyes (56%) achieved ambulatory vision (5/200) or better. Direct perfluorocarbon liquid-silicone oil exchange was performed in 20 eyes. Intra-operative complications included persistent retinal folds (2 eyes), subretinal air (1 eye), and subretinal bleed (1 eye). Eleven eyes (26.8%) developed secondary glaucoma (2 eyes required a drainage device), and hypotony of ≤6 mmHg was noted in 3 eyes (7.3%). Corneal decompensation was noted in 8 eyes (19.5%), and 3 eyes (7.3%) underwent re-surgery for re-RRD. **Conclusion:** After GPR using small gauge PPV, two-thirds achieve anatomical success, and over half have ambulatory vision, but overall post-operative complications can occur in more than half of the eyes.

Key words: Perfluorocarbon liquids, proliferative vitreoretinopathy, retinotomy, rhegmatogenous retinal detachment, silicone oil

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The techniques of surgical management of complex rhegmatogenous retinal detachment (RRD) and other types of retinal detachments have significantly improved due to the introduction of modern vitreoretinal equipment and instrumentation with better design.[1–3] However, proliferative vitreoretinopathy (PVR) remains the principal cause of surgical failure and recurrence of RRD.[4–6] PVR is characterized by epiretinal, intraretinal, or subretinal proliferation of non-neuronal cells such as the retinal pigment epithelium (RPE) and Müller cells in a detached retina.[7] These proliferative changes lead to retinal contracture and shortening, intraretinal fibrosis, and subretinal bands.[8]

The basic principle of vitreoretinal surgery in the setting of PVR is to relieve all the traction by removing all the proliferative

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membranes and subretinal bands. Additional procedures such as relaxing retinotomies and peripheral retinectomies may be required to manage retinal contracture and shortening and achieve higher surgical success.[9,10] In advanced cases, authors including Machemer *et al*.,[11] Lim *et al*.,[12] and Hocaoglu *et al*.[13] have demonstrated large circumferential retinectomy with relaxing radial retinotomies to obtain retinal re-attachment.

In the literature, the utility of such giant peripheral retinectomies (GPRs) has been analyzed using larger gauge vitrectomy systems (20- and 23-gauge) with limited cut rates (<2500 per second). However, in the past 5 years, there is a paucity of literature on the use of small gauge systems in the management of such complex cases of RRD. Thus, in this retrospective study, we analyzed the experience of several surgeons from around the world in the management of complex retinal detachments requiring GPR (more than 3 clock hours) and anterior flap retinectomies using small gauge vitreoretinal instrumentation.

Methods

Study subjects

This retrospective study was conducted by establishing a collaboration of five large tertiary care centers (eight surgeons) from different countries. Patients who were operated between January 2017 and October 2022 were included in the analysis. Clearance from the institute ethics committee/review board from each clinical center was obtained. The study adhered to the Health Insurance Portability and Accountability Act (HIPAA) of 1996.

The study included eyes with primary RRD or those undergoing re-surgery after a failed previous operation for RRD. Computerized databases with electronic medical records or operation theater registers were scanned for RRD surgeries, and after reviewing the notes, eyes with GPR were identified. Eyes with RRD due to trauma and open-globe injuries were excluded. We also excluded eyes with giant retinal tear or dialysis and eyes with choroidal detachments. We included both adults and children (more than 5 years of age) for the study. Only those eyes which required more than 3 clock hours/90 degrees of circumferential peripheral retinotomies (with/without radial relaxing retinotomies) and anterior flap retinectomy (AFR) were included. The other inclusion criteria were the use of 25-gauge vitrectomy systems, presence of anterior and/or circumferential retinal shortening/contracture, a minimum follow-up of 6 months, and patients with complete surgical notes. It was mandatory for the patients to have fundus photographs available at 3 months post-operative period to be included in the study. We excluded subjects with incomplete follow-up or surgical notes, incomplete data (including best-corrected visual acuity, intra-ocular pressure (IOP), and anterior/posterior segment findings), and retinal detachments in the presence of other retinal abnormalities.

Study variables

The study variables included the following assessments performed at baseline and follow-up visits: demographic profile (age, gender, ethnicity), best-corrected visual acuity (BCVA) measurement (converted from Snellen's acuity to logMAR units for statistical analysis), IOP measurement (measured using Goldmann applanation tonometry except in the immediate post-operative period, or non-contact tonometry), phakic status, ocular pathology, presence of systemic co-morbidities, and previous surgical interventions. Other parameters included the extent and location of RRD (in clock hours); location, number, and position of retinal breaks; and presence of high myopia (defined as > 6 diopters of spherical power). The extent of PVR was measured as per the Retina Society Classification system.[14] In the post-operative follow-up visits, the parameters included BCVA, IOP, anatomical outcome (including retinal re-attachment), and complications such as epiretinal membrane and need for re-surgery. IOP values of more than 25 mm Hg were considered elevated (ocular hypertension), and hypotony was defined as IOP of less than 6 mm Hg. Any other complications in the post-operative period were also noted.

Surgical techniques

While the surgical technique varied depending upon the case and the surgeon, all vitrectomies were performed with standard three-port instruments using an Alcon Constellation® system (Alcon Inc., Fort Worth, Texas, USA). The basic steps of surgery remained the same in all cases: after insertion of the three standard pars plana ports for endo-illumination, vitrector and infusion cannula, core vitrectomy was initiated. All the vitreous was removed up to the vitreous base using 360-degree shaving with scleral depression. The posterior hyaloid was stained using triamcinolone acetonide (40 mg/mL) injected intravitreally. Induction of posterior vitreous detachment (PVD) was ensured in all cases. All the retinal traction including retinal fixed folds and epiretinal membranes were removed to ensure retinal flattening [Fig. 1]. ILM peeling was optional, and the surgeons could perform dye-based ILM peeling with the help of ILM forceps.

Retinal shortening was considered when even after removal of all the epiretinal and subretinal traction, the retina could not be flattened. GPR (circumferential) (>3 clock hours) was performed in all cases along with AFR. The location and extent of the retinotomy were at the discretion of the surgeon and the status of the RRD. If the surgeon deemed fit, additional radial relaxing retinotomy was also performed. The clock hours and extent of the retinotomies were noted. The retinotomies were performed after endo-diathermy to avoid intra-operative bleeding [Fig. 2]. Once the retina was mobile and free, it was flattened using perfluorocarbon liquid (PFCL). Subsequently, laser photo-coagulation was applied to all the retinal breaks and edges of the retinotomy. Silicone oil was used for internal tamponade in all cases. The surgeon had the choice of performing a direct PFCL-silicone oil exchange or exchanging the PFCL first with air and subsequently with silicone oil. For direct PFCL-silicone oil exchange, the surgeons could use the bimanual aspiration-injection function on the Constellation system.

Additional procedures such as the application of scleral band/buckle, pars plana lensectomy, or combined phacoemulsification with intra-ocular lens (IOL) implantation were based on the surgeon's decision. None of the patients received additional adjuvants such as intravitreal methotrexate. Post-operative management included prone positioning (at least for 1 week) in all cases, along with antibiotic and corticosteroid eye drops with a tapering regimen. Oral

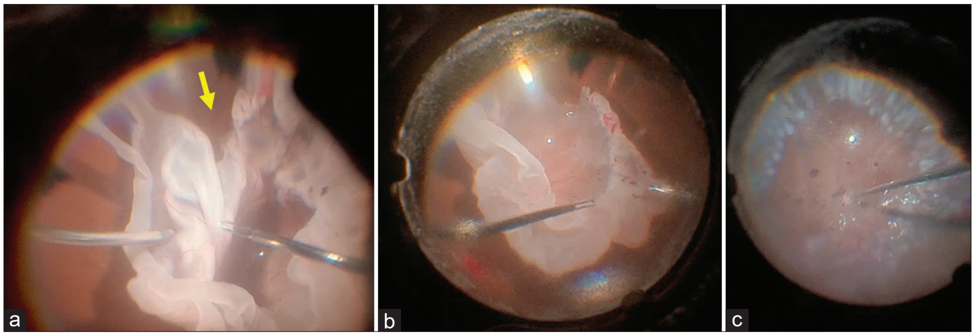

Figure 1: A patient with a complex RRD who required 360-degree retinectomy and a relaxing retinotomy (yellow arrow) due to severe retinal contracture (a). Intra-operatively, the patient had severe proliferative vitreoretinopathy which required bimanual dissection with perfluorocarbon liquid tamponade (b). Once the retina was successfully flattened, the perfluorocarbon liquid was exchanged with silicone oil (c)

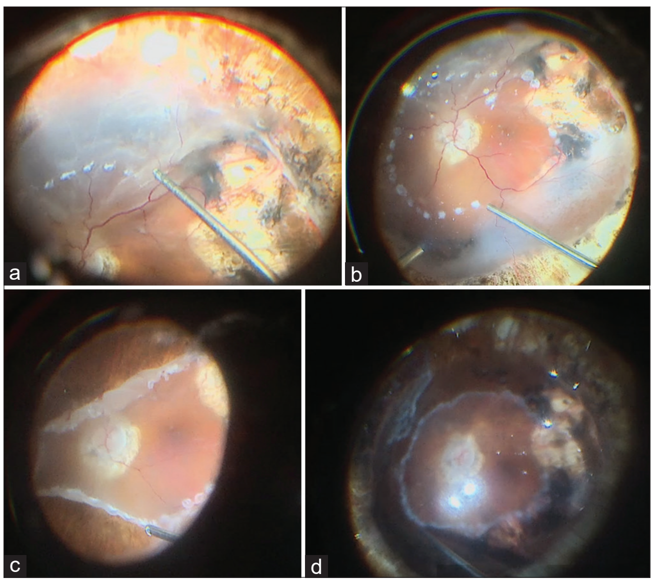

Figure 2: A patient with recurrent RRD undergoing re-pars plana vitrectomy with retinectomy. The retinectomy was initiated by marking the area with endo-diathermy (a and b) to avoid intraoperative bleeding. The retinectomy was completed with the outcome (c), while the posterior pole was flattened with the help of perfluorocarbon liquid. The perfluorocarbon liquid was then exchanged with air, and finally, silicone oil tamponade was performed (d)

corticosteroids were prescribed based on the discretion of the surgeon. The anatomical success of retinal re-attachment was determined based on clinical examination and assessment by the surgeon; optical coherence tomography was optional and left to the discretion of the operating surgeon.

Statistical analysis and outcome measures

The main outcome measure of the study was anatomical success measured in terms of complete retinal re-attachment at 6 months. The secondary outcomes included change in BCVA from the pre-operative visit, change in IOP, development of intra- and post-operative complications, and the need for re-surgery.

All the data were entered in a pre-designed Microsoft® Excel sheet. The continuous demographic and clinical variables such as age, BCVA, and IOP were presented as means with standard deviation, while categorical variables were presented as proportions (n, %). The group differences between continuous variables were assessed using the Mann–Whitney U test for non-parametric distributions, while differences in categorical variables were assessed using the Chi-square or Fischer's exact test. The changes in BCVA and IOP within the group were assessed using the Wilcoxon signed rank test.

Survival analysis was used to determine the cumulative re-attachment rate across various time points and was presented as a cumulative percentage with a 95% confidence interval (CI) and graphically using Kaplan–Meier (KM) curves. The statistical analyses were performed using Stata software, version 12.1 I/c (Stata Corp, Fort Worth, Texas). All P values < 0.05 were statistically significant.

Results

Patient characteristics

We identified 49 patients who could be included in the study based on the inclusion criteria. However, we had to exclude eight patients due to incomplete surgical notes/post-operative data (n = 5 patients) and lack of proper follow-up (n = 3 patients). Forty-one eyes (41 patients; 33 males) were included in the current study. The mean age of the patients included in the study was 44.9 ± 21.4 years (range: 7–85 years). The mean pre-operative logMAR BCVA was 1.9 ± 0.5 (approximately 20/1600 Snellen's equivalent). The mean pre-operative IOP was 12.2 ± 5.4 mm Hg (range 3–35 mm Hg). High myopia ≥6 diopters was noted in nine eyes (21.9%) pre-operatively. Most of the eyes undergoing surgery were pseudophakic (n = 18), 15 were phakic, and five were aphakic, white cataract was present in two eyes, while one eye had an anterior chamber IOL *in situ*. Among the 41 eyes included in the study, 25 eyes (60.9%) were primary surgeries, and 16 eyes (39.1%) underwent re-surgeries. The higher the grade of pre-existent PVR, the more the extent of GPR was done [Fig. 3]. Table 1 presents the pre-operative demographic and clinical features of the patients included in the study. Supplemental Table 1 enlists the study centers, along with the number of years of surgical experience of the surgeons and the number of cases included.

Intra-operative surgical variables

All eyes underwent vitrectomy using a 25-gauge system. The maximum cut rates used during surgery varied from 5000 to 10,000 cuts per min (cpm) (5000 in 5 eyes, 7500 in 8 eyes, and 10,000 in 28 eyes). Epiretinal membrane peeling was performed in nine eyes, while dissection and removal of subretinal bands were performed in one eye. Scleral buckle was not applied in 34 eyes, while 7 eyes (17%) had an already placed buckle (primary scleral buckling surgery was done in 3 eyes, and supplemental 240-band was applied during previous PPV in 4 eyes). Staining of the posterior hyaloid was done in 33 eyes. In nine eyes (21.9%), lensectomy had to be resorted to, while IOL had to be explanted in one eye (2.4%) to dissect the anterior PVR. None of the eyes underwent surgery with combined phacoemulsification. While in most of the eyes (n = 35; 85%), the vitrector was used, in six eyes (15%), the surgeons used intra-ocular scissors to create the retinectomies. AFR was done in all cases (n = 41 eyes; 100%). Table 2 summarizes the extent of the GPR and other intra-operative factors. Direct PFCL-silicone oil exchange was done in 20 eyes (48.7%). In one eye, one of the ports was converted to 23-gauge from 25-gauge at the time of direct PFCL-oil exchange. Thousand centistokes silicone oil was used in 28 eyes (68%), Oxane-1300 in nine eyes (21%), and higher viscosity (5000 centistokes) in three eyes. Surgery was abandoned in one eye due to persistent subretinal air and vitreous hemorrhage, leading to inoperable detachment.

Anatomical outcomes

The mean duration of post-operative follow-up was 15.4 ± 9.6 months (range 6–36 months). Anatomical success was observed in 29 eyes (70.7%). The cumulative re-attachment rate dropped from 92% (95%CI = 78–97%) at 3 months to 66% (48–79%) at 6 months and then remained constant [Fig. 4]. Re-detachment occurred in 12 eyes, of which 3 re-detached by 3 months, another 3 at 4 months, 4 at 5 months, and 2 at 6 months' time point. No re-detachments were noted after 6 months of follow-up. The risk of re-detachment was slightly higher in those who had > 180 GPR (6/16, 37%) compared to those who had smaller GPR (6/25, 24%), though this difference was not statistically significant (log-rank $P = 0.32$). Of the 12 eyes that had re-detachment, 3 eyes underwent re-surgery. The mean duration of silicone oil tamponade was 5 ± 4.4 months. Silicone oil was *in situ* at the time of the last follow-up in 18 eyes (43.9%). Among the 18 eyes that had silicone oil *in situ*, only 2 eyes had retinal detachment under the oil, whereas among the 23 eyes in whom the oil was removed, 11 eyes had recurrent retinal detachment ($P = 0.01$; Chi-square test). The mean post-operative IOP was 14 ± 5.5 mm Hg at the last follow-up ($P = 0.15$).

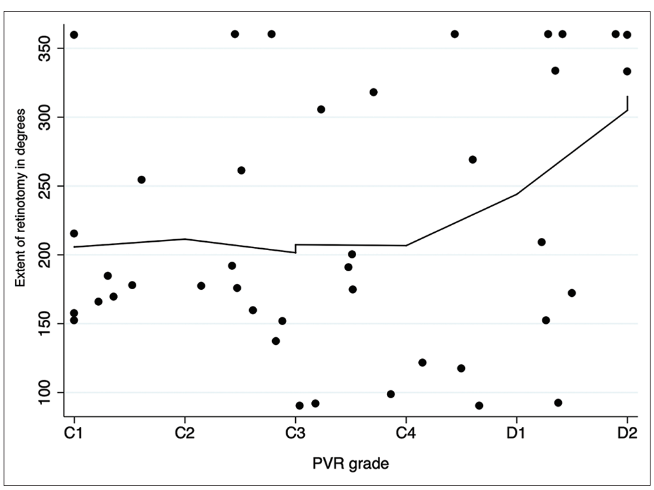

Figure 3: Extent of GPR plotted on the Y-axis along with the grade of the PVR. The graph shows that higher grades of PVR required larger GPR for achieving anatomical success

Visual outcomes

The BCVA improved to 1.4 ± 0.9 (approximately 20/500 Snellen's equivalent) at the last follow-up ($P = 0.05$). Twenty-three eyes (56%) achieved ambulatory vision (5/200) or better, and 17 eyes (41%) had visual acuity of 20/200 or better. One eye in which surgery was abandoned developed no light perception within 2 months from the date of the surgery.

Intra- and post-operative complications

Intra-operative findings/complications included persistent non-resolving macular fold in two eyes (4.8%), vitreous hemorrhage in two eyes (4.8%), large macular scar in four eyes (9.6%), persistent subretinal air in one eye (2.4%), and subretinal hemorrhage in one eye (2.4%); subretinal bands required reflecting the retina in one eye (2.4%), and one patient (2.4%) required combined penetrating

Table 1: Preoperative characteristics of patients included in the study

Parameter	Value
Age (years)	44.9±21.4 (range 7-85)
Sex (M:F)	33:8
Mean preoperative BCVA (LogMAR)	1.9±0.5
Mean preoperative IOP (mm Hg)	12.2±5.4 mm Hg
No. of eyes with previous surgical interventions	16 (39.1%)
GPR and AFR as a primary procedure (eyes)	25 (60.9%)
Previous surgeries performed (eyes)	PPV and gas: 5 (12.1%) PPV and silicone oil: 4 (9.7%) Scleral buckle: 3 (7.3%)
Lens status (eyes)	Pseudophakic – 18 (43.9%) Phakic – 15 (36.5%) Aphakic – 5 (12.1%) White cataract – 2 eyes (4.8%) ACIOL – 1 (2.4%)
High myopia (eyes)	9 (21.9%)
Grade of PVR (eyes)	Grade C1: 8 (19.5%) Grade C2: 10 (24.2%) Grade C3: 11 (26.9%) Grade D1: 6 (14.6%) Grade D2: 5 (12.2%) Grade D3: 1 (2.4%)

ACIOL: anterior chamber intraocular lens; AFR: anterior flap retinectomy; BCVA: best-corrected visual acuity; F: female; GPR: giant peripheral retinotomy; IOP: intraocular pressure; M: male; PPV: pars plana vitrectomy; PVR: proliferative vitreoretinopathy

Table 2: Intraoperative parameters during surgery with giant peripheral retinotomies

Parameter	Value
Extent of peripheral retinotomy (degrees; no. of eyes)	90-180: 9 (22%) 180-270: 16 (39%) 270-360: 16 (39%)
No. of eyes with radial retinotomy (%)	24 (58.5%)
No. of eyes with ERM peeling	9 (22%)
No. of eyes with ILM peeling	6 (14.6%)

ERM: epiretinal membrane; ILM: internal limiting membrane keratoplasty due to poor view secondary to corneal decompensation.

Overall, 22 out of 41 eyes (53.7%) developed post-operative complications during the follow-up. Corneal decompensation/edema was noted in 8 eyes (19.5%) post-operatively. Ocular hypertension (IOP > 25 mm Hg) was documented in 11 eyes (26.8%), of which two eyes required a glaucoma drainage device, while others were managed with anti-glaucoma medications. Four eyes (9.76%) had concomitant corneal decompensation and ocular hypertension. Two eyes developed iris bombe and iris adhesions to the IOL. These required multiple laser peripheral iridotomies to resolve the iris bombe (three sessions in one eye and four in one eye). Hypotony was noted in three eyes. Three eyes developed iris neovascularization, two resolved with aggressive anti-inflammatory therapy (frequent topical and oral corticosteroids), and one eye resolved after receiving anti-VEGF injection.

Eyes with larger retinal breaks ($P = 0.05$), more extensive PVR ($P = 0.02$), and those undergoing re-surgeries ($P = 0.05$) were at significantly higher risk of developing post-operative complications. Table 3 summarizes the post-operative outcomes and complications of all the eyes included in the study.

Sub-group analyses

We also compared patients undergoing primary surgeries with GPR versus patients undergoing re-surgeries to understand differences in the anatomical and functional outcomes with 25-gauge vitrectomy systems. Table 4 summarizes the outcomes between the two groups. No statistically significant differences were noted in the BCVA, IOP, and other post-operative complications between the groups; however, patients undergoing GPR as a primary surgery had significantly higher anatomical success rates ($P = 0.05$). In comparing eyes with silicone oil *in situ* (n = 18) at the final follow-up visit, we did not observe any statistically significant differences in the BCVA or anatomical success. However, eyes with silicone oil *in situ* had higher prevalence of ocular hypertension ($P = 0.02$) [Table 5].

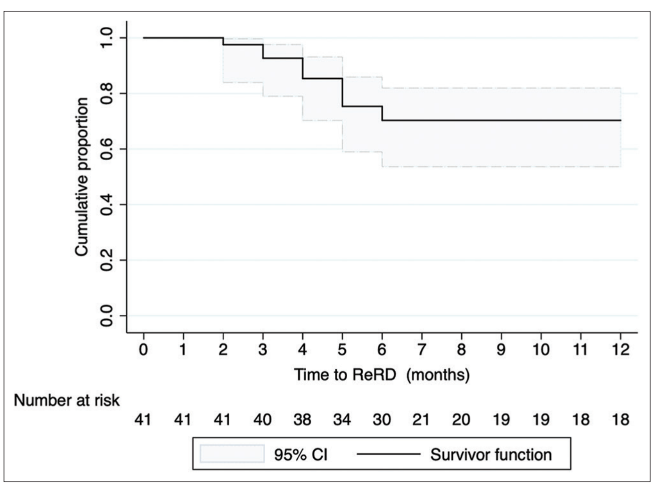

Figure 4: A KM curve which shows the cumulative re-attachment rate across various time points with 95% CI. The cumulative risk of retinal re-attachment dropped from 92% (95%CI = 78–97%) at 3 months to 66% (48–79%) at 6 months. No re-detachments occurred after 6 months

Discussion

In our study, with small gauge vitrectomy systems, anatomical success with an attached retina was achieved in over 73% eyes at the end of 6 months. All re-detachments were seen on or before 6 months of surgery. We observed that 41% eyes gained BCVA of 20/200 or better, and 56% eyes had at least ambulatory vision (5/200 or better) at 6 months follow-up. Overall, complications were noted in 53.7% eyes in the post-operative period, of which ocular hypertension (26.8% eyes) and corneal decompensation/edema (19.5%) were the most common. Re-surgeries could be attempted in 3 eyes of the 12 that showed re-detachment in the follow-up period.

In general, the management of complex RRD with dense fibro-cellular membranes on the surface of the retina, intraretinal, and subretinal bands can be challenging.[4–7,15,16] One of the most important aspects of vitreoretinal surgery in these situations is tackling PVR and relieving the traction.[10,17–19] The dissection of epiretinal and subretinal membranes is of paramount importance; however, retinal shortening secondary to PVR does not allow the retina to flatten or attach intra-operatively despite adequate dissection of the membranes.[16] Performing GPR and AFR have shown good re-attachment rates and visual outcomes in complex detachments [Table 6].[5,9,12,13,16,20–25] There are numerous advantages of small gauge PPV systems which have mostly replaced large gauge PPVs. Previously published literature concerning GPR and AFR deals with 20- and 23-gauge vitrectomy systems.

In our study, we observed that the peak time of re-detachment was between 4 and 5 months when 9 out of 12 eyes (75%) showed retinal detachment. None of the eyes developed re-detachment after 6 months. Therefore, if the eyes developed re-detachment after PPV, it was generally observed before 6 months of follow-up. It may be prudent to keep a close watch on the retinal status for at least 6 months and perhaps consider procedures such as silicone oil removal accordingly. We observed that higher grades of PVR required more extensive GPR during the surgery [Fig. 3]. We also observed that a higher proportion of eyes developed recurrent detachment after removal of silicone oil (11/23 eyes in the silicone oil removal

Table 3: Postoperative outcomes and complications of patients undergoing giant peripheral retinotomies and anterior flap retinectomies in the study

Parameter	Value
Mean follow-up (months)	15.4+9.6 (range: 6–36)
Mean postoperative BCVA (LogMAR)	1.4±0.9
Mean postoperative IOP (mm Hg)	14±5.5
Elevated IOP (≥30 mm Hg) (eyes)	11 (26.8%)
Hypotony (≤6 mm Hg) (eyes)	3 (7.3%)
Corneal decompensation/corneal edema (eyes)	8 (19.5%)
Final anatomic success (attached retina at 6 months) (eyes)	29 (70.7%)
Duration of SO tamponade (months)	5.0 (range: 1–25)
No. of eyes with SO at last follow-up (eyes)	18 (43.9%)

BCVA: best-corrected visual acuity; IOP: intraocular pressure; SO: silicone oil

Table 4: Comparison of anatomical and functional outcomes of patients included in the study based on whether their surgery was a primary event or a re‑surgery

	Eyes with primary surgery (*n*=25)	Eyes with re‑surgery (*n*=16)	*P*
Mean postoperative BCVA (LogMAR)	1.3±0.9	1.5±0.9	0.66
Mean postoperative IOP (mm Hg)	15.8±5.9	13.1±5.2	0.11
Elevated IOP (≥30 mm Hg) (eyes, %)	5, 20%	6, 37.5%	0.21
Hypotony (≤6 mm Hg) (eyes, %)	1, 4%	2, 12.5%	0.31
Corneal decompensation/corneal edema (eyes, %)	3, 12%	5, 31.25%	0.13
Final anatomic success (attached retina at 6 months) (eyes, %)	21, 84%	9, 56.25%	0.05

BCVA: best‑corrected visual acuity; IOP: intraocular pressure

Table 5: Comparison of anatomical and functional outcomes of patients included in the study based on the presence of silicone oil at the final follow‑up

	Eyes with silicone oil at last visit (*n*=18)	Eyes without silicone oil at last visit (*n*=23)	*P*
Mean postoperative BCVA (LogMAR)	1.19±0.6	1.51±1.0	0.25
Mean postoperative IOP (mm Hg)	16.22±5.4	13.6±5.1	0.07
Elevated IOP (≥30 mm Hg) (eyes, %)	8, 44.4%	3, 13.0%	0.02
Corneal decompensation/corneal edema (eyes, %)	5, 27.8%	3, 13.0%	0.24
Final anatomic success (attached retina at 6 months) (eyes, %)	15, 83.3%	15, 65.2%	0.19

BCVA: best‑corrected visual acuity; IOP: intraocular pressure

Table 6: Comparison of postoperative outcomes, anatomical success, and complications following GPRs in eyes with complex retinal detachments

Authors (year)	No. of Eyes	Intervention and gauge of vitrectomy	Anatomical Success[a] eyes (%)	Mean Follow‑up (months)	BCVA at last follow‑up	Types of RD	Retained SO at last follow‑up. eyes (%)	Complications
Faude *et al*.[23] (1999)	30	360‑degree retinotomy 20 G	25 (83%)	10	≥1/50 in 40% eyes	Different types	30 (100%)	RD Recurrence ‑ 15% PVR Recurrence ‑ 39% Hypotony ‑ 20%
Lim *et al*.[12] (2009)	30	≥180‑degree retinectomy, RR 20 G	(28 (93.3%)	6	CF at 2 feet	Different types	NA	Hypotony ‑ 6.7%
Banaee *et al*.[25] (2009)	20	360‑degree retinotomy 20 G	14 (70%)	24.2	5/200 in 40% eyes 20/200 in 15% eyes	Different types	17 (80%)	PVR Recurrence ‑ 25% Hypotony ‑ 40%
Kolomeyer *et al*.[22] (2011)	41	360‑degree retinotomy 20 G	35 (85%)	29	4 out of 35 eyes ‑ ambulatory vision	Different types	NA	RD Recurrence ‑ 32% PVR Recurrence ‑ 39% Hypotony ‑ 15%
Garnier *et al*.[21] (2013)	20	360‑degree retinotomy 20 G	14 (70%)	38	40/200	RRD	15 (75%)	RD Recurrence ‑ 10% PVR Recurrence ‑ 35% INV ‑ 20%
Hocaoglu *et al*.[13] (2016)	40	360‑degree retinotomy, AFR, RR 20 or 23 G	31 (77.5%)	51.5	20/200 in 25% eyes	RRD, traumatic RD	2 (5%)	Hypotony ‑ 32.5% Corneal decompensation ‑ 32.5%
Current Study (2023)	41	GPR (>3 clock hours), AFR 25 G	29 (70.7%)	15.4	5/200 in 56% eyes	RRD	18 (43.9%)	RD Recurrence ‑ 29% Corneal decompensation ‑19.5% Hypotony ‑ 7.3%

[a]Defined as retinal reattachment at the final follow‑up visit. AFR: anterior flap retinectomy; BCVA: best‑corrected visual acuity; CF: counting fingers; GPR: giant peripheral retinotomy; INV: iris neovascularization; IOP: intraocular pressure; PVR: proliferative vitreoretinopathy; RD: retinal detachment; RR: relaxing retinectomy; RRD: rhegmatogenous retinal detachment

group versus 2/18 eyes in which the silicone oil was *in situ*; $P = 0.012$). Therefore, removal of silicone oil may increase the risk of retinal detachment in these eyes, and the surgeon must be cautious and look for any residual traction, sub‑clinical detachment, or other risk factors that could result in recurrent detachments after oil removal. Prior to silicone oil removal, a thorough examination and discussion regarding the risk of re-detachment must be considered.

Using the 23-gauge system, Hocaoglu *et al.*[13] showed that the overall anatomical success of retinal reattachment using combined GPR and AFR with radial retinotomy was 77.5%. Our results show a comparable anatomical success rate of 70.73% with the small gauge system. Kolomeyer *et al.*[22] and Banaee *et al.*[25] have also reported significant re-attachment rates of 85% and 70% in their series, respectively. Faude *et al.*[23] reported a retinal re-attachment rate of 83% in a series of 30 patients. Lim *et al.*[12] reported a significantly higher anatomical success in 93.3% of their cases. In the early 1990s, Iverson *et al.*[26] had noted poor anatomic and functional outcomes in patients undergoing retinectomies with older-generation vitrectomy. However, since then, with the advancement of technology and equipment, later studies have shown favorable outcomes.

In terms of visual success, a higher number of patients in our study showed BCVA of 20/200 or more (41%) and ambulatory vision (5/200 or more) (56%) compared to previous studies [Table 6]. Banaee *et al.*[25] reported BCVA better than 5/200 in 9 out of 20 eyes (45%). Lower visual gains have been reported by Garnier *et al.*[21] (only two eyes had a BCVA of 2/200 or better) and Kolomeyer *et al.*[22] (4 of 35 eyes). BCVA improved in 80% of the eyes in the study by Faude *et al.*,[23] and similar results have been reported by Lim *et al.*[12] (66.7% eyes showed improvement). Various studies have reported differences in the visual gain due to the complex nature of the disease and the variability in the type and morphology of the detachment. In comparison with the most recent study by Hocaoglu *et al.*[13] performed in 2016 using a 23-gauge vitrectomy system, a higher proportion of patients demonstrated a visual outcome of 20/200 or better (41% versus 25%) with smaller gauge vitrectomy systems (25-gauge).

One of the advantages of small gauge PPV is better IOP control during the surgery. However, this may result in challenges faced during important steps such as direct PFCL-silicone oil exchange, during which time a spike in IOP can occur. Thus, smaller gauge systems may require modifications intra-operatively to avoid this complication.[27] Our results showed that steps such as direct PFCL-silicone oil exchange are indeed feasible without an IOP spike. During the surgery, none of the surgeons faced challenges with the smaller gauge instruments because of the improved design and reduced flexibility of the instruments such as the cutter and forceps. Among the major post-operative complications, we experienced raised IOP in 11 eyes (26.8%), persistent hypotony in 3 eyes (7.3%) and corneal decompensation or edema in 8 eyes (19.5%). Apart from IOP control, we observed complications including iris bombe and iris neovascularization, which can be challenging to tackle. Patients with iris bombe develop secondary pupillary block and high IOP, which may be worsened by the iris neovascularization and excessive intra-ocular inflammation. We treated these patients with a course of anti-inflammatory therapy and anti-VEGF injections under extremely close follow-up. None of the surgeons in our series used long-term PFCL or combined tamponade with SO and PFCL.[28]

The major limitations of our study are retrospective nature and a small sample size. We included patients from various international centers who were operated by different surgeons in different settings. These factors can influence the patient outcomes due to variability in the patient prolife, surgeon, and other setup factors. Data collection including records of post-operative findings and intra-operative steps could have suffered from reporting bias. However, our study is one of the first to study the outcomes of GPR and AFR using small gauge (25-gauge) PPV systems by various surgeons from different international centers. Small gauge vitrectomy systems can provide similar anatomical outcomes and possibly better visual gains compared to 20- or 23-gauge systems in otherwise severely compromised eyes which may become permanently blind. However, it must be noted that more than 50% eyes can develop complications in the post-operative period, which may need additional interventions.

Conclusions

In summary, we achieved anatomical success of over 70% and the majority of the patients regained useful ambulatory vision. In the current era, 25-gauge PPV with GPR and AFR can be employed in cases of complex RRD with severe retinal shortening after adequate consideration and discussion with the patient.

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Supplemental Table 1: Number of years of experience for the surgeons included in the study

Study center	Years of surgical experience	Number of patients
Egypt (AMEH)	23	7
Egypt (AMEH)	14	3
India (PGIMER)	11	7
India (PGIMER)	13	7
India (PGIMER)	26	3
Italy (UC)	22	8
Turkey (AU)	16	4
USA (UAMS)	24	2

AMEH: Al Mashreq Eye Hospital; AU: Ankara University; PGIMER: Post Graduate Institute of Medical Education and Research; UAMS: University of Arkansas for Medical Sciences; UC: University of Cagliari