Original Article

Pneumatic retinopexy outcomes as primary or secondary surgical option for treating rhegmatogenous retinal detachment

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Purpose: To report the outcomes of pneumatic retinopexy (PR) performed as a primary surgical procedure for rhegmatogenous retinal detachment (RRD) or as a secondary procedure for recurrent RRD. **Methods:** We retrospectively analyzed case records of 54 patients (54 eyes) who underwent PR for RRD by injecting 0.3 ml of perfluoropropane (C3F8) in the vitreous cavity and cryopexy to break in the same sitting, followed by positioning. **Results:** A total 54 eyes of 54 patients aged between 17 and 84 years (mean - 51.3, median - 53 years) were included in the study. Except five eyes, all had breaks in the superior quadrants. The RRD ranged from 1 quadrant to 4 quadrants. Twenty-eight eyes (51.8%) were phakic and 26 (48.1%) were pseudophakic. The follow-up ranged from 6 to 144 months. In 25 eyes (46.2%), PR was the primary intervention and was successful in 15 (60%) eyes with a significant visual improvement (P = 0.023). Twenty-nine eyes (52.7%) with failed scleral buckle or failed pars plana vitrectomy underwent PR with a success rate of 65.5% and significant visual improvement (P = 0.0017). Progression of proliferative vitreoretinopathy changes (40%) was the most common cause of failure. The success rate was higher in phakic eyes, eyes with attached macula, superior breaks, superior RRD, and RRD limited to 3 quadrants or less. **Conclusion:** PR remains a minimally invasive procedure which can be used primarily or as a salvage procedure in failed surgery with moderately good success rate and minimal complications. One-step procedure reduces patient visits and ensures adequate treatment of the break.

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The last two decades have seen great advances in the field of vitreoretinal surgery. Innovations in surgical machines and refinements in surgical techniques have led to expanding surgical indications beyond the traditional ways. This has paved the way for changing practice patterns over time. For rhegmatogenous retinal detachment (RRD) repair, the surgeons have the options of performing scleral buckle (SB), pneumatic retinopexy (PR), or vitrectomy. SB was the preferred option until recently. However, now, with the advances in surgical techniques, the minimally invasive vitreous surgery is increasingly being preferred. McLaughlin and Hwang analyzed the trends in vitreoretinal surgeries in Medicare beneficiaries from 2000 to 2014 and found that there was a sharp decline in SBs with 83% undergoing vitrectomy, 5% scleral buckling, and 12% PR.[1] PR is a simple and cost-effective treatment for uncomplicated RRDs. The reported success rates range from 60% to 93%.[2-4] PR is most suitable for RRDs with small tears within 1'o clock hour or a single tear smaller than 1'o clock hour located in the superior 8'o clock hours of the fundus, with clear media, and no proliferative vitreoretinopathy (PVR). PR can also be used as a rescue procedure in cases after failed SB or pars plana vitrectomy (PPV).[5]

This study aims at evaluating the surgical outcomes including the surgical success rates of PR after primary intervention and after secondary intervention as a rescue procedure after failed SB or PPV.

Methods

We did a retrospective analysis of medical records of all the patients, who underwent PR as a primary or secondary surgical intervention. The patient data were obtained from a tertiary eye care hospital in South India. The study was approved by the institutional review board and adhered to the tenets of the Declaration of Helsinki with appropriate safeguards for patient confidentiality.

Details of patients who underwent the intervention at our center between January 1998 and December 2014 were analyzed. We grouped the patients in two groups: group 1 included data of patients who underwent PR as a primary procedure for simple, uncomplicated RRD, and Group 2 consisted of patients who had a recurrent retinal detachment (RD) following a failed SB or failed vitrectomy who then underwent PR as a secondary procedure. We excluded patients with complicated RDs namely those with media opacities, proliferative retinopathy more than Grade C, nonrhegmatogenous, or combined RDs. We

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also excluded patients with recent trauma and glaucoma and patients unable to comprehend the instructions or maintain specific head position after the procedure. Patients with a follow-up of at least 6 months were included and all others with inadequate follow-up were excluded. In this study, we did not include patients who underwent PR in combination with either an SB or encirclage.

We noted the side of the eye affected, main complaints, duration of complaints, medical and surgical history, and associated systemic illnesses. Details of all ocular examinations done were analyzed. Readings for best-corrected visual acuity (BCVA) by Snellen chart test were noted and converted to logMAR. Details from slit lamp test, intraocular pressure (IOP) measurement using applanation tonometry, and fundus examination were noted for each eye. Details regarding the lens status, type, number and extent of break (s), number of quadrants involved in RD, and the status of macula – whether attached or detached – were specifically noted for all. In case of a secondary PR, details regarding the failed primary surgery were noted.

Procedure of pneumatic retinopexy

PR was performed as a one-step procedure under local anesthesia in the operation theater under aseptic conditions. Retrobulbar anesthesia was given using 2% lignocaine. The eye and surrounding area were cleaned and draped. The pupil was dilated preoperatively using a mixture of tropicamide and phenylephrine eye drops. The breaks were localized with indirect ophthalmoscopy, and transconjunctival cryopexy was performed to seal the breaks, before gas injection. The anterior chamber paracentesis was performed using a 30-gauge needle mounted on a 1 cc tuberculin syringe without the plunger, draining around 0.1–0.3 mL of aqueous humor to obtain a hypotonic eyeball. Pure form of expansile concentration of perfluoropropane (C3F8) gas was withdrawn through a micropore filter and 0.3 ml was loaded in another 1cc syringe. This gas was then injected with a 30-gauge needle, 3.5–4 mm posterior to the limbus in the superior quadrant in a rapid motion, taking care to form one single bubble of gas, avoiding multiple small bubbles resembling fish eggs. The fundus was inspected immediately to ascertain central retinal artery perfusion and location and size of the gas bubble. If necessary, a paracentesis was repeated to reduce IOP. The eye was patched for 2 h with 1 drop of prednisolone acetate and povidone iodine each. Patients were instructed to maintain appropriate position for 2 weeks and were reviewed periodically.

Single operation success rate (SOSR) was defined as completely attached retina with one procedure. BCVA, IOP, and retinal status were noted at each follow-up.

Statistical analysis

Descriptive statistics was computed for continuous variables and frequency distribution was constructed for qualitative variables. All statistical analysis was performed using SPSS V14.0 (SPSS Inc, Chicago). Any statistical test with $P < 0.05$ was considered as statistically significant.

Results

Patient demographics

Fifty-four eyes of 54 patients were included in the study. The mean age of the patients was 52.1 ± 17.19 years (range 17–90 years, median 54 years). The mean refractive error was −2.86 ± 4.28 (range −11 to +7 diopters). The mean preoperative BCVA was 1.302 ± 0.91 logMAR units. There were 44 (81.5%) males and 10 (18.5%) females. The mean follow-up was 24.8 ± 35.8 months (range 6–144 months, median 28.8 months). The mean BCVA at the last follow-up was 0.84 ± 0.74 logMAR units.

There were 25 patients (46.2%) in Group 1 who underwent PR as a primary surgical procedure to correct RRD and Group 2 consisted of 29 patients (53.7%) for whom PR was used as a rescue secondary procedure following failed SB (28 eyes, 96.5%) or PPV (1 eye, 3.5%).

Of the 54 eyes, 28 (51.8%) were phakic and 26 (48.1%) were pseudophakic. Among these, 14 (50%) phakic eyes each underwent primary PR and secondary PR, whereas among the pseudophakic eyes, 11 (42.3%) underwent primary PR and 15 (57.7%) underwent secondary PR. All the pseudophakic eyes had a posterior chamber intraocular lens (IOL). We did not have any eyes with an anterior chamber or iris-fixated IOL in our series. In 22 (40.7%) eyes, the macula was attached at presentation, whereas it was detached in the remaining 32 (59.3%) eyes. Major proportion of eyes, i.e. 49 eyes (90.7%), had breaks located in the superior 8’o clock hours. However, five eyes (9.26%) had break in the inferior 4’o clock hours. All these five eyes had failed primary procedure and had a peripheral buckle element in place. Only the superior quadrants were involved in RRD in 26 eyes (48.1%). In 28 eyes (51.8%), the RRD extended in the inferior quadrants also. Mean 5.2 ± 2.881 (median 4.5 and range 2–12) clock hours was involved in RD and the most common retinal break was a horseshoe tear in 39 eyes (72.2%). The mean 1.5 ± 0.869 (range 1–3) number of breaks was present in an eye. The mean time interval for performing PR after the onset of RD in primary surgical intervention was 18.06 ± 14.3 days (1–60 days) and for secondary intervention was 15.8 ± 18.4 days (2–70 days) after the failed primary procedure.

Treatment outcomes

The SOSR for primary intervention with PR was 60% (15 out of 25 eyes) and for secondary intervention was 65.5% (19 out of 29 eyes). Table 1 gives details about the SOSR in various categories. The success rate was higher in phakic eyes, eyes with preoperatively attached macula, superior breaks, superior RRD, and RRD limited to 3 quadrants or less. We could not demonstrate statistical significance of these factors probably owing to small sample size. We also analyzed various factors responsible for success or failure of PR and compared them among different groups. Table 2 gives data about comparison among the phakic versus pseudophakic eyes. Age ($P < 0.001$), preoperative vision ($P = 0.008$), postoperative vision ($P = 0.031$), and vision change ($P = 0.04$) were significantly associated with SOSR. The comparison of factors among macula on and macula-off eyes is shown in Table 3 and between primary and secondary PR is shown in Table 4. Preoperative vision was significantly related to PR outcome among all the groups.

There were five eyes with inferior RD which had undergone SB as primary surgery and had recurrent detachment due to an open break below the horizontal meridian. Secondary PR was done for these eyes and prone position with head hanging down was given. Three eyes showed reattachment and two eyes had a recurrent RD requiring PPV.

Table 1: Single operation success rates of pneumatic retinopexy

Variables	No. of eyes(%)	P
Procedure		
Primary (*n*=25)	15 (60)	
Secondary (*n*=29)	19 (65.5)	
Lens status		
Phakic (*n*=28)	23 (82.1)	0.16
Pseudophakic (*n*=26)	17 (65.4)	
Macula status		
Attached (*n*=22)	18 (81.8)	0.282
Detached (*n*=32)	22 (68.7)	
Location of breaks		
Superior (*n*=49)	37 (75.5)	0.451
Inferior (*n*=5)	3 (60)	
Location of RD		
Superior quadrants (*n*=26)	21 (80.8)	0.279
Inferior quadrants (*n*=28)	21 (75)	
Extent of RD		
≤3 quadrants (*n*=17)	15 (88.2)	0.1075
All 4 quadrants (*n*=36)	25 (69.4)	

RD: Retinal detachment

Table 2: Pneumatic retinopexy outcomes for phakic versus pseudophakic eyes

Parameters	Phakic eyes (*n*=28)	Pseudophakic eyes (*n*=26)	P
Refractive error (D)	−3.76±4.857	−1.433±2.749	0.102
Preoperative VA (logMAR)	0.99±0.788	1.638±0.929	0.008
Postoperative VA (logMAR)	0.677±0.643	1.034±0.821	0.031
VA change (logMAR)	0.342±0.466	0.622±1.01	0.04
Age (years)	39.393±12.203	65.731±9.586	<0.001

logMAR: Logarithm of the minimum angle of resolution, VA: Visual acuity

One eye in this series, which had undergone phakic intraocular lens implantation (ICL) for the correction of myopia, developed superior RRD which was managed with PR without the need for removal of ICL or change in refractive error, with significant anatomical and functional outcomes.

The mean postoperative visual acuity (VA) was 0.84 ± 0.74 logMAR units. There was a significant correlation between preoperative vision and success rate ($P < 0.001$). The Kaplan–Meier analysis [Fig. 1] showed that for primary intervention through months 1–12, the survival rate was 61%–52%, which was maintained at 52% till 72 months, and from months 72 to 120, the survival rate was maintained at 34%. The survival rate for secondary intervention from 1 to 12 months varied between 87% and 81%. From 24th to 36th month, the survival rate was 67%. From the 48th to 132nd month, the survival rate was 37%. The survival rate was not statistically significant ($P = 0.317$, using Mantel-Cox test).

Table 3: Pneumatic retinopexy outcomes for macula attached preoperatively versus macula detached eyes

Parameters	Macula attached (*n*=22)	Macula detached (*n*=32)	P
Refractive error (D)	−3.047±4.339	−2.739±4.344	0.875
Preoperative VA (logMAR)	0.759±0.772	1.675±0.814	<0.001
Postoperative VA (logMAR)	0.629±0.503	0.985±0.85	0.192
VA change (logMAR)	0.079±0.725	0.74±0.683	0.001
Age (years)	47.636±19.34	55.125±15.116	0.046
Clock hours of RD	4.4±1.698	5.75±3.341	0.347
Clock hours break	5.955±4.825	7.063±4.464	0.367
Number of breaks	1.524±0.928	1.469±0.842	0.702

RD: Retinal detachment, logMAR: Logarithm of the minimum angle of resolution, VA: Visual acuity

Table 4: Primary versus secondary intervention with pneumatic retinopexy

Parameters	Primary	Secondary	P
Refractive error (D)	−3.778±4.268	−2.083±4.247	0.337
Preoperative VA (logMAR)	1.178±0.755	1.409±1.028	0.469
Postoperative VA (logMAR)	0.898±0.793	0.775±0.696	0.521
VA change (logMAR)	0.226±0.675	0.736±0.786	0.026
Age (years)	55.08±17.888	49.483±16.442	0.318
Clock hours RD	4.44±2.2	5.963±3.264	0.082
Number of breaks	1.48±1.005	1.5±0.745	0.467
Success rate (%)	60	65.5	

RD: Retinal detachment, logMAR: Logarithm of the minimum angle of resolution, VA: Visual acuity

PR failed to attach the retina in 10 eyes in each group, failure rate being 40% in Group 1 and 34.5% in Group 2. Of the 20 eyes which required additional procedures, the causes of failure were lifting up of the original break in 5 eyes (25%), PVR in 8 eyes (40%), nonresolving subretinal fluid in 5 eyes (25%), and formation of a new break in 2 eyes (10%). At the final follow-up, all eyes maintained successful anatomical outcome after additional SB or PPV with final vision of 0.84 ± 0.74 logMaR units.

Discussion

Hilton and Grizzard[6] originally reported a high success rate of 90% for PR. Later, authors have found it to vary between 60% and 82%.[7-12] Table 5 lists the major studies and their results of PR. Our SOSR of 60% is toward the lower side due to the inherent biases in a retrospective study and uncontrolled parameters. Further, our selection criteria were expanded to include pseudophakic patients, inferior breaks, and inferiorly extending detachments. RDs with breaks >1’o clock hour in size, multiple breaks further

Table 5: Comparison of published studies of pneumatic retinopexy

Author	Study type	Number of cases	Classic versus expanded indications	1 versus 2 step	SOSR (%)	Final success rate (%)	Complications	Mean final BCVA
Zaidi AA *et al.* (2006)	Retrospective	61	Classic	1	54	66	NB 21%, GRT 1 eye	20/25
Fabian *et al.* (2013)	Retrospective	258	Expanded	1 and 2	61.2	99.2	ERM 11.3%, CME 2.4%, cataract 24.6%, MH 1.8%, PVR 0.6%	20/32
Modi YS *et al.* (2014)	Prospective	63	Classic+VH	1 and 2	63	97	NB/MB 22.2%, ERM 16%, PVR 2%	20/25
Davis MJ *et al.* (2011)	Retrospective	213	Classic	2	64.8	99.53		20/40
Gilca *et al* (2014)	Retrospective	422	Classic	1 and 2	60.7	99.5	NB/MB 16.3%, DSFR 12.1%, ERM 10.2%, PVR 4%	20/30
Ellakwa AF *et al.* (2012)	Prospective	40	Classic	1 and 2	75	100	Raised IOP 20%, cataract 32.5%	20/50
Ling J *et al.* (2016)	Retrospective	44	Expanded (pseudophakic)	2	45.5	52.3	NB/MB 47.6%	25/35
Rahat F *et al.* (2015)	Retrospective	97	Classic	2	82.5	93.8	AC leak 4.1% raised IOP 1 eye	20/44
Rootman D *et al.* (2013)	Prospective	113	Expanded	2	61.9	69.6	-	-
Our study	Retrospective	54	Expanded	1	60	100	PVR 40%	20/30

VH: Vitreous hemorrhage, NB: New break, MB: Missed break, GRT: Giant retinal tear, MH: Macular hole, PVR: Proliferative vitreoretinopathy, ERM: Epiretinal membrane, DSFR: Delayed subretinal fluid reabsorption, IOP: Intraocular pressure, CME: Cystoid macular edema, SOSR: Single operation success rate, BCVA: Best-corrected visual acuity, AC: Anterior chamber

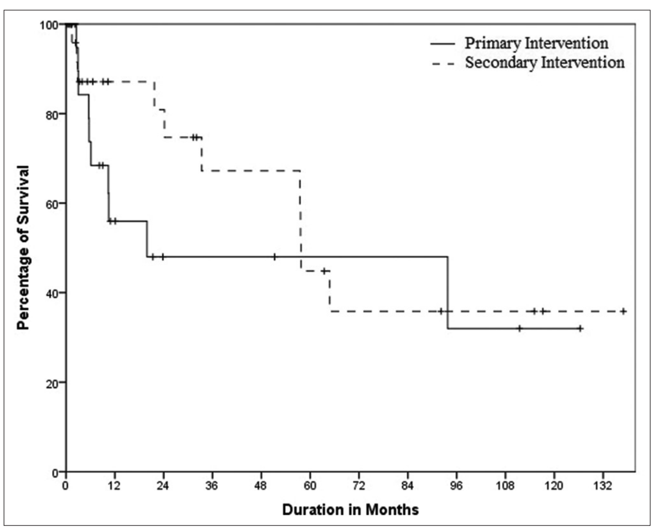

Figure 1: Kaplan–Meier survival plots for primary and secondary pneumatic retinopexy

than 1'o clock hour apart, and PVR not exceeding Grade C2 have also shown favorable results with PR compared with scleral buckling.[13] We found slightly higher SOSR of 65.5% in the secondary PR group compared to the 60% SOSR of the primary group. However, it was not statistically significant. There are previous reports of successful rescue PR done for failed SBs as well as vitrectomies by Petrushkin *et al*.[5] and Friberg and Eller.[14] Both reported 90%–100% success rate with a secondary PR after failed RD surgery. Our SOSR is more comparable with that of 69.4%, reported by Sharma *et al*.[15] Progression of PVR was the reason for failure of PR in our series. This perceived fear of PVR formation and failure of PR, coupled with easy availability of minimally invasive vitreous surgery, deters young retinal surgeons from choosing PR. However, PR offers a highly cost-effective, simple method to rescue the situation. The major advantage is the elimination of a second major surgery which obviates a major expenditure.

Several previous reports have shown a lower success rate of PR in pseudophakic or aphakic eyes as compared to phakic eyes.[4,8,13,16] Davis *et al*. reported a success rate of 57.1% in pseudophakic eyes while success rate in phakic eyes was 67.5%.[4] Rootman *et al*., on multivariate analysis, found pseudophakic status to be significantly related with PR failure.[17] Our results showed SOSR of 82.4% in phakic eyes versus 65.4% in pseudophakic eyes ($P = 0.16$). Pseudophakic eyes have a lower success rate due to poor/incorrect localization of breaks, missed breaks, migration of gas bubble anteriorly.[18] The "classic" aphakic/pseudophakic retinal tears tend to be smaller in size. These challenges are further compounded by optical aberrations from the IOL implant and posterior capsule opacity. Eyes with anterior chamber IOL and iris-fixated IOLs have the worst success rate.[18]

The eyes with attached macula had higher SOSR of 81.8% in our study in comparison to 68.7% in macula-detached eyes. Superior breaks with RD in superior quadrants had a better SOSR than RD involving the inferior quadrants as well. Interestingly, a few patients in our series had breaks located below the horizontal meridian, but all these patients had a previous buckle/encirclage supporting the inferior periphery which would have made the closure of the break slightly easier. Similar to other studies, in our study too, the SOSR was better for RRD of ≤3 quadrants.[4,8] Tornambe reviewed 302 consecutive cases of PR with a follow-up of 6 months to 10 years and concluded that SOSR of 97% can be achieved with the following criteria: phakic eyes; only one quadrant of RD; only one retinal break located in the upper two-thirds of the fundus; postoperatively 360° prophylactic laser.[16]

Among the causes of failure of PR, we found progression of PVR to be the most common in 40% eyes followed by reopening of the original break, nonresloving subretinal fluid, and formation of new breaks. Vitreous condensation can occur around the gas bubble leading to formation of vitreous membranes which can cause traction on the retina in the opposite quadrant precipitating breaks and PVR. Our choice of a long-acting gas was dependent on the availability of gas. Sulfur hexafluoride would be preferable to perfluorooctane due to its shorter retaining capacity. In a study by Rootman *et al*.,[17] morphologic criteria including the position and number of breaks, position and extent of lattice degeneration, size of the detached area, and macular status were all found not to be significantly related to failure. On multivariate analysis, they found only three predictors: pseudophakic status, presence of retinal break > 1'o clock hours, and presence of Grade C or D PVR to be statistically significant. After a failed PR, on an average, 1.4 procedures were required for reattachment and no difference was seen in visual outcome in a study by Anaya *et al*.[19]

The original description of PR by Hilton and Grizzard[6] involved a two-step procedure wherein gas was injected in the first step followed by laser photocoagulation after the retina around the break was attached. Many authors reported the same procedure. We however, in our institution, follow the one-step procedure of cryopexy to the break followed by gas injection. There is a small concern of release of pigments leading to PVR, but advantages are reduced visits to the clinic and easy visualization of the break.[20] It is difficult to visualize the break through the gas bubble once the retina is attached. Preoperatively, marking the meridian of the break with laser has been suggested to overcome this difficulty.[21]

Our study was retrospective in nature and we could not assess the quality of life. However, Gauthier and Adelman compared the quality of life after PR versus after SB and noted no difference in general health, general vision, ocular pain, discomfort, near activities, distance activities, social functioning, mental health, role difficulties, dependency driving, color vision, and peripheral vision.[22] However, more patients in the PR group preferred to have a similar procedure in the fellow eye.

The limitations of this study include its retrospective nature. The procedure and recording were performed by multiple surgeons, and the small number of patients in some groups may have limited the statistical analysis. We also did not examine the relative efficacy of primary PPV and/or SB relative to primary PR for RRDs. This was beyond the scope of this article but would be important to determine. Finally, all patients were treated at a tertiary academic hospital, and it is possible that these patients may be subject to referral bias.

Conclusion

Despite these limitations, our study confirms that PR is a viable option for selective patients with RRD. PR causes minimal discomfort to the patient and carries minimal surgical risk, yet the patient has a 60% chance of achieving permanent reattachment of the retina. Visual improvement is seen, regardless of presenting VA or macular status, with successful reattachment with a single procedure.

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Conflicts of interest

There are no conflicts of interest.

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