Repair of Primary Noncomplex Rhegmatagenous Retinal Detachment

Eric W Schneider, MD[1] and Mark W Johnson, MD[2]

1. Vitreoretinal Fellow, Department of Ophthalmology, Duke University, North Carolina, US;
2. Professor of Ophthalmology, Department of Ophthalmology and Visual Sciences, University of Michigan; WK Kellogg Eye Center, Ann Arbor, Michigan, US

Abstract

With the development of pars plana vitrectomy in the 1970s and pneumatic retinopexy in the 1980s, the primacy of scleral buckling for repair of rhegmatogenous retinal detachment (RRD) came under challenge. While a degree of consensus exists for certain forms of complex RRD, there remains little agreement concerning the optimal treatment of primary noncomplex RRD. This debate is further muddied by application of adjuvant procedures to supplement the primary surgical approach. This article aims to present the current evidence regarding repair of primary noncomplex RRD. A brief summary of primary surgical approaches—pneumatic retinopexy, scleral buckling, and pars plana vitrectomy—will be presented along with a short discussion on potential adjuvant procedures. The remainder of the article focuses on reported outcomes for the different treatment modalities for primary noncomplex RRD.

Keywords

Rhegmatogenous retinal detachment, pneumatic retinopexy, scleral buckle, vitrectomy, retinal detachment repair, proliferative vitreoretinopathy

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Correspondence: Mark W Johnson, MD, WK Kellogg Eye Center – University of Michigan Hospitals, 1000 Wall Street, Ann Arbor, MI, 48105, US. E: markwj@umich.edu

Rhegmatogenous retinal detachment (RRD) is a major cause of preventable and/or reversible vision loss, with an incidence ranging from 6.3–17.9 per 100,000 of population.[1] Untreated symptomatic RRDs invariably progress to hand motion or worse visual acuity (VA) in all chronically unrepaired eyes.[2] Importantly, the prevention and/or reversibility of any associated visual morbidity are dependent on timely surgical repair.

Prior to the pioneering work of Gonin in the early-20th century, there were no effective treatments for RRD.[3] With the introduction of his 'ignipuncture' thermocautery technique, success rates jumped from zero to nearly 50 %.[4] The ensuing 90 years have witnessed an equally dramatic improvement in outcomes for RRD repair with reported single operation reattachment rates now routinely greater than 90 %.[5] These improvements have been driven in large part by the development of novel surgical approaches including scleral buckling (SB), introduced by Schepens (encircling SB) and Custodis (segmental SB) in the 1950s,[6,7] as well as pars plana vitrectomy (PPV), introduced by Machemer in 1970.[8] Additionally, the introduction of pneumatic retinopexy (PR) by Hilton and Grizzard in 1985 provided a clinic-based option for RRD repair.[9] Given the multitude of treatment options available and the influence of historical and training biases, it is unsurprising that considerable disagreement continues to exist among surgeons regarding the best approach for RRD repair. Though a degree of consensus exists for certain forms of RRDs, such as detachments complicated by advanced proliferative vitreoretinopathy (PVR) in which PPV with or without SB is typically employed, there remains little agreement concerning the optimal treatment for the most common form of RRD—primary noncomplex RRD.[10–13] This debate is further muddied by the potential application of adjuvant procedures to supplement the primary surgical approach. This article aims to present the current evidence regarding repair of primary noncomplex RRD. Following a brief summary of primary surgical approaches, a short discussion on potential adjuvant procedures is presented. The remainder of the review focuses on reported outcomes for the different treatment modalities for primary noncomplex RRD. For the purposes of this review, noncomplex RRD will be defined as primary retinal detachment without significant degrees of PVR (e.g. less than PVR grade C1) or significant risk factors for the development of PVR such as giant retinal tears (GRTs),[14] penetrating trauma,[15] or substantial intraocular inflammation[16] (e.g. detachments associated with endophthalmitis or necrotizing retinitis).

Primary Surgical Approaches

The basic tenets governing successful reattachment following RRD include: (1) finding the break, typically with indirect ophthalmoscopy or wide-angle operative microscopy; (2) closing the break, through relief of vitreoretinal traction and apposition of retina to retinal pigment epithelium (RPE); and (3) permanently sealing the break via formation of a chorioretinal scar to prevent reaccumulation of subretinal fluid Both intraocular tamponade with gas or silicone oil and scleral indentation via SB facilitate acute closure of retinal breaks, whereas chorioretinal scar formation creates a long-lasting seal that takes several days to reach full strength. The modern surgical approaches to RRD repair—PR, SB, and PPV—utilize somewhat different methods to achieve these endpoints.

Table 1: Pneumatic Retinopexy Anatomic and Functional Results—Noncomparative Studies

Study	Type	Min F/U	Number	Total SOSR	Phakic SOSR	ΨPhakic SOSR	PVR	Final VA ≥20/50	Exclusions
Hilton et al.[22]	R	6 months	100	84.0 %	–	–	3.0 %	65.0 %‡	a
Chen et al.[23]	R	6 months	51	62.8 %	73.5 %	41.2 %	9.8 %	35.0 %‡	a, d, e, f
Lowe et al.[24]	R	6 months	55	81.8 %	91.7 %	63.2 %	5.5 %	54.8 %‡	f
Skoog et al.[25]	R	–	52	78.9 %	–	–	–	–	e, f
Ambler et al.[26]	R	6 months	101	77.2 %	84.2 %	56.0 %	1.0 %	77.2 %*	–
Algvere et al.[27]	R	6 months	51	86.3 %	–	–	2.0 %	65.2 %*‡	e, f
Trillo et al.[28]	R	12 months	55	86.6 %	–	–	3.6 %	–	–
Grizzard et al.[29]	R	1 month	107	69.2 %	–	–	9.1 %	65.4 %	a, e, f
Tornambe[30]	R	6 months	302	67.9 %	75.2 %	61.1%	9.6 %	74.8 %	–
Abecia et al.[31]	R	24 months	219	81.7 %	86.2 %	70.0 %	3.7 %	40.6 %	a, c, d, f
Eter et al.[32]	R	60 months	78	65.4 %‡	68.9 %‡	52.9 %†	6.4 %	–	a, e, f
Zaidi et al.[33]	R	1 month	61	65.6 %	67.4 %	61.1 %	0.0 %	–	e, f
Kulkarni et al.[34]	R	1.5 months	150	76.7 %	75.3 %	77.6 %	3.3 %	80.5 %	–
Yee and Sebag[35]	R	6 months	77	80.5 %	82.4 %	79.3 %	0.0 %	64.9 %*	a, c
Davis et al.[36]	R	6 months	213	64.8 %	67.5 %	57.1 %	6.1 %	73.2 %*	a, d, e, f

**>20/50; †Included patients requiring reinjection of gas as primary failures; ‡Analysis limited to those patients with macula detached pre-operatively. Exclusions/inclusions (specifically cited in article): a = proliferative vitreoretinopathy (PVR) C1 or greater; b = penetrating trauma; c = vitreous hemorrhage; d = break >1 clock hour; e = multiple breaks > 3 clock hours apart; f = inferior breaks (inferior 4 clock hours). Min F/U = minimum follow up; ΨPhakic = pseudophakic/aphakic; R = retrospective; P = prospective; SOSR = single-operation success rate; VA = visual acuity.*

As noted above, SB is the oldest of the modern surgical approaches and its introduction predates contemporary vitreoretinal instrumentation, making it by definition an extraocular procedure. Though referred to by a single name, SB constitutes a heterogeneous collection of techniques applied to achieve a single goal: indentation of the sclera. This can be accomplished through the use of a wide variety of buckling elements (encircling, segmental, or a combination) that may be placed as either an explant, or less commonly, as a scleral implant. The encircling SB technique, devised by Schepens, predominated in the period immediately following its introduction due in large part to the lower rate of associated complications in comparison to the segmental technique of Custodis. However, in the mid-1960s, Lincoff and Kreissig improved segmental techniques through the application of less-toxic silicone sponges and these methods remain a viable, albeit uncommonly employed, alternative in modern RRD repair.[17,18] Regardless of the specific technique employed, the goal of scleral indentation is closure of the retinal break through indirect relief of vitreoretinal traction (by shrinking the circumference of the globe) and retina to RPE apposition. The closed break is sealed permanently by chorioretinal scar creation via cryotherapy, laser photocoagulation, or, historically, diathermy. External drainage of subretinal fluid and temporary gas tamponade are optional adjuncts.

In contrast to SB, PPV is an intraocular procedure, which relies on vitreoretinal instrumentation to remove the vitreous, drain subretinal fluid, and deliver intraocular gas. Break closure is achieved through direct relief of dynamic vitreoretinal traction via vitreous removal and effecting retina to RPE apposition via intraocular tamponade. Vitrectomy allows for permanent sealing of the break with intraocular laser application, though indirect laser and external cryotherapy are also commonly employed during vitrectomy procedures.

PR was introduced as means of repairing a subset of noncomplex RRDs—specifically those associated with a single break or small cluster of breaks in the superior retina—in an office-based procedure. This approach avoids the cost, time, and potential morbidity associated with SB or PPV performed in a formal operating suite. Unlike both SB and PPV, however, PR does not provide relief of vitreoretinal traction. Instead, breaks are closed temporarily with intraocular gas tamponade and sealed permanently by laser- or cryotherapy-induced chorioretinal scarring.

Adjuvant Procedures

Over the past two decades, surgeons have become more proficient with the existing primary surgical approaches to RRD resulting in single-operation success rates (SOSRs) often surpassing 90 %.[5,11–13] In an effort to exceed this mark, surgeons have looked to adjuvant procedures—typically applied in addition to PPV. In general, the goal of these adjuvants is to prevent retinal redetachment from missed breaks or from new breaks resulting from theoretical contraction of the vitreous base and/or PVR.

Adjuvants commonly applied with PPV include SB and/or 360° prophylactic endolaser photocoagulation. Both adjuvant SB and 360° endolaser are commonly applied to prevent postoperative redetachment due to missed breaks based on the rationale that such missed breaks may be closed/treated by the buckle/laser. Furthermore, there is a common belief—not shared by these authors nor well-supported by the literature—that following vitrectomy the vitreous base contracts (in the absence of PVR) leading to new retinal breaks.[11,19–21]

In the case of SB, both intraocular gas tamponade and external SRF drainage can be considered adjuvant procedures as neither is necessary for successful retinal reattachment. Nonetheless, these adjuvants differ from those discussed above as they are applied to assist in effecting reattachment in the immediate postoperative period. Intraocular tamponade facilitates closure of retinal breaks acutely while external SRF drainage allows for intraoperative reattachment and for the use of laser photocoagulation as a means of sealing retinal breaks.

Clinical Results

Pneumatic Retinopexy

In the quarter century since the introduction of PR in 1985, countless investigators have evaluated its utility in a series of clinical studies. The vast majority were simple noncomparative retrospective reports detailing early outcomes with PR. *Table 1* details the reported clinical results for

Table 2: Pneumatic Retinopexy Anatomic and Functional Results—Comparative Studies

Study	Type	Min F/U	Method	Number	Total SOSR	Phakic SOSR	ΨPhakic SOSR	PVR	Final VA ≥20/50	Standardized Cohort*
PR versus SB										
McAllister et al.[41‡]	R, NR	6 months	PR	56	71.4 %	–	–	1.8 %	–	Yes
			SB	78	96.0 %	–	–	2.6 %	–	
Tornambe and Hilton[42]	P, R	6 months	PR	103	80.6 %	84.2 %	73.9 %	2.9 %	87.4 %	Yes
			SB	95	84.2 %	94.2 %	72.7 %	5.3 %	67.4 %	
Han et al.[38]	R, NR	6 months	PR	50	62.0 %	66.7 %	37.5 %	12.0 %	63.3 %	Yes
			SB	50	84.0 %†	83.3 %	85.7 %	14.0 %	64.0 %	
Yosaiboon et al.[39]	R, NR	6 months	PR	116	65.5 %	–	–	–	–	No
			SB	55	85.5 %†	–	–	–	–	
Ross and Lavina[44‡]	R, NR	8 months	PR	41	51.2 %	–	51.2 %	2.4 %	–	No
			SB	38	84.2 %	–	84.2 %	10.5 %	–	
Schaal et al.[40]	R, NR	12 months	PR	56	62.5 %	–	–	–	–	No
			SB	322	86.0 %†	–	–	–	–	
PR versus PPV										
Ross and Lavina[44‡]	R, NR	8 months	PR	41	51.2 %	–	51.2 %	2.4 %	–	No
			PPV	2	100.0 %	–	100.0 %	0.0 %	–	
Schaal et al.[40]	R, NR	12 months	PR	56	62.5 %	–	–	–	–	No
			PPV	442	90.1 %†	–	–	–	–	
PR versus PPV-SB										
Ross and Lavina[44‡]	R, NR	8 months	PR	56	62.5 %	–	51.2 %	2.4 %	–	No
			PPV-SB	19	94.7 %	–	94.7 %	5.3 %	–	
Yosaiboon et al.[39]	R, NR	6 months	PR	116	65.5 %	–	–	–	–	No
			PPV-SB††	41	89.9 %†	–	–	–	–	
Schaal et al.[40]	R, NR	12 months	PR	56	62.5 %	–	–	–	–	No
			PPV-SB	316	94.0 %†	–	–	–	–	

**Patients in each treatment group were matched for pre-operative demographic/clinical characteristics; †Significantly higher single-operation success rate (SOSR) compared with alternative treatment; ‡Statistical analysis of comparative SOSR not performed; ††Scleral buckling (SB) added at discretion of surgeon. Min F/U = minimum follow up; ΨPhakic = pseudophakic/aphakic; R = retrospective; P = prospective; NR = nonrandomized; R = randomized; PVR = proliferative vitreoretinopathy; VA = visual acuity.*

PR in noncomparative series including more than 50 eyes published in English language peer-reviewed journals since 1985. As evidenced in this table, SOSRs—which for the purposes of all tables within this review reflect the proportion of patients successfully reattached without additional surgery excluding adjuvant laser retinopexy or gas injection—varied considerably by investigator with rates ranging from 62.8 to 86.6 %. This variability is likely due, at least in part, to disparities in surgeon technique, experience, and skill, but can also be attributed to differences in the inclusion/exclusion criteria —a problem that confounds any comparison of independent retrospective studies.

Historically, PR has been applied only to a subset of noncomplex RRD, namely those with one or more retinal breaks confined to 1–2 clock hours in the superior retina. The restricted indications for PR limits comparison to SB, PPV, and PPV-SB, which are routinely used for the repair of a wider range of noncomplex RRDs.[37] Nonetheless, as detailed in *Table 2*, several groups included PR in their comparative analysis of RRD repair. While only two of the six comparative studies published utilized a standardized patient cohort, a general trend toward worse SOSRs with PR (range: 51.2 % to 80.6 %) compared with SB (range: 84.0 % to 96.0 %), PPV (range: 90.1 % to 100.00 %), and PPV-SB (range: 89.9 % to 94.7 %) emerges. Indeed, of the four reports in which statistical comparisons of SOSRs between PR and SB/PPV/PPV-SB were performed, three reported significantly lower SOSR for PR[38–41] while the fourth reported no significant difference between PR and SB.[42] Of note, the study reporting no significant difference in SOSRs between PR and SB was also the sole prospective randomized controlled trial (RCT).[42] Lens status also appears to play an important role in determining the anatomic success of PR. In both comparative and noncomparative studies, reported SOSRs are notably higher in phakic eyes (range: 66.7 % to 91.7 %) compared with pseudophakic eyes (range: 37.5 % to 79.3 %) with only two studies[34,42] finding higher SOSRs for PR in pseudophakic/aphakic eyes (out of the 14 that broke down SOSR based on lens status).

Due to differences in baseline VA, macular status, and duration of detachment, it is difficult to draw solid conclusions regarding functional outcomes following PR. Final visual acuities of ≥20/50 were attained in 35.0 to 87.4 % of patients, with the majority of studies reporting greater than two-thirds of patients reaching that level of acuity (see *Tables 1* and *2*). These rates are similar to those reported in patients undergoing SB and PPV (see *Tables 3–6*). Importantly, failed primary PR does not appear to lead to significantly worse final visual acuities.[26,27,29,40,42] Thus, while SB may lead to greater SOSRs and fewer reoperations, it does not appear to improve final visual outcomes.[38–40,42] Indeed, the sole prospective RCT comparing PR and SB actually reported better functional outcomes (e.g. mean postoperative VA and improvement in VA) at both the 6- and 24-month endpoints for patients with pre-operative macular detachment undergoing PR compared with those undergoing SB.[42,43]

Initially conceived as a less traumatic and technically simpler alternative to SB capable of being performed in an office setting, PR is not without

Table 3: Scleral Buckling Anatomic and Functional Results—Noncomparative Studies

Study	Type	Min F/U	Number	Total SOSR	Phakic SOSR	ΨPhakic SOSR	PVR	Final VA ≥20/50	Exclusions
O'Malley and Swearingen[59]	R	6 months	100	96.0 %	–	–	–	89.0 %*	a, f
Burton et al.[60]	P	1 month	100	88.0 %	86.8 %	91.7 %	–	–	f
Purohit et al.[61]	R	6 months	58	94.8 %	–	–	5.2 %	66.7 %†	a, f
La Heij et al.[62]	R	3 months	80	81.3 %	–	–	11.3 %	58.5 %	a, c, f
Steel et al.[63]	P	6 months	120	87.5 %	–	–	5.0 %	32.5 %†	a, c
Figueroa et al.[64]	P	20 months	60	88.3 %	–	–	–	–	a, b, c, f
Schwartz et al.[65]	R	20 years	227	81.9 %	83.4 %	75.0 %	–	–	a, b, f
Jaffe et al.[66]	R	1 month	187	90.9 %	–	–	–	–	f
Avitabile et al.[67]	P	6 months	698	83.1 %	–	–	5.6 %	29.7 %*	a, b, d, e, f
Salicone et al.[68]	R	2 months	672	76.9 %	80.8 %	72.6 %	6.4 %	51.3 %*	f
Mahdizadeh et al.[69]	P	34 months	55	87.3 %	–	–	7.3 %	–	a, c, f
Jonas et al.[70]	R	2 months	375	87.2 %	–	–	–	–	a, c, e, f
Lira et al.[71]	P	6 months	86	94.2 %	–-	–	–	–	a, b, d, e, f

**>20/50; †Analysis limited to those patient with macula detached pre-operatively. Exclusions (specifically cited in article): a = proliferative vitreoretinopathy (PVR) C1 or greater; b = penetrating trauma; c = vitreous hemorrhage; d = prior chorioretinitis/endophthalmitis; e = giant retinal tear; f = previous scleral buckling/pars plana vitrectomy. Min F/U = minimum follow up; ΨPhakic = pseudophakic/aphakic; R = retrospective; P = prospective; SOSR = single operation success rate; VA = visual acuity.*

its own set of complications. Consistent with the higher rates of recurrent retinal detachment seen with PR, new retinal breaks are the most common complication. The incidence of new retinal breaks ranges from 6 % to 27 % with the majority of investigators finding new breaks in more than 15 % of patients postoperatively.[22–27,29,31–33,35,36,38,41,42,44–46] These rates trend higher than reported historical rates of new/missed breaks following SB.[47] The increase in new breaks after PR likely relates to the persistence of vitreoretinal traction. Unlike SB or PPV, PR does not relieve the tractional force exerted on the retina at sites of residual vitreous attachment. Thus, progression of posterior vitreous detachment, which can be acutely exacerbated by intravitreal gas injection, as well as postoperative vitreous contraction and continued dynamic vitreoretinal traction during ocular saccades, may lead to additional retinal breaks.[26,41,42] Moreover, missed breaks may be more common following PR due to the more limited peripheral retinal examination performed in the office-based setting compared with the anesthetized scleral depression utilized in the operating room. In addition to potentially increasing vitreoretinal traction acutely, the injection of intraocular gas without vitreous removal runs the risk sequestration of gas in an unfavorable location; namely, the subretinal space, the pre-hyaloidal space, or the anterior chamber.[48–51] While the latter two occurrences typically have minimal clinical impact, subretinal gas can lead to persistent retinal detachment and is difficult to manage. Gas enters the subretinal space when small 'fish egg' bubbles are injected intravitreally and becomes trapped once the fish eggs coalesce.[49–51] If immediate maneuvers are not undertaken to facilitate the egress of the subretinal gas, a PPV is almost uniformly required. PVR following PR was generally low with rates ranging from 0.0 to 12.0 % (see *Tables 1* and *2*). Importantly, no comparative study reported a significant difference in PVR rates between PR and either PPV or SB.[38,41,42,44] Other less-common complications reported in association with PR include macular pucker, intraocular hemorrhage, cystoid macular edema (CME), and endophthalmitis.[49–51] As opposed to PPV and to a lesser extent SB, cataract progression is exceedingly rare after PR with rates routinely ≤1%.[30,42]

Scleral Buckling

Introduced in the early 1950s,[6,7] SB is the oldest of the modern surgical techniques for RRD repair and was considered the gold standard for treatment of both complex and noncomplex RRDs for much of the 20th century. With the development of vitrectomy in the 1970s, the role of SB in RRD repair transformed rapidly as complex detachments were increasingly approached with the *ab interno* approach afforded by PPV alone or in conjunction with SB.[52–54] Moreover, as surgeons became more comfortable with the new vitreoretinal instrumentation, indications for PPV soon expanded further to routinely include noncomplex RRDs. These trends are reflected in the literature as the bulk of reported outcomes for SB in the 30 years following its introduction included at least some patients with complex RRDs while more recent investigators have tended to report outcomes of SB in primary noncomplex RRD. *Table 3*—which details the results of encircling SB for primary noncomplex RRD in noncomparative studies with 50 or more patients published since 1985—echoes this trend and demonstrates the high SOSR achievable with SB in these noncomplex detachments. SOSRs ranged from 76.9 to 96.0 % with over two-thirds of included studies reporting successful reattachment in over 85 % of cases following a single surgery. PVR rates were consistently between 5–10 %. Similarly high SOSRs (82.6 to 93.0 %) were reported for segmental buckling, either with radial sponge or temporary balloon plombage, with even lower rates of PVR (0.8 to 3.7 %).[55–58] These reports are not, however, included in *Table 3* due to inclusion of patients with pre-operative PVR ≥C1 and/or re-detachments after prior RRD repair surgeries. Solid conclusions regarding functional outcomes as well as the impact of lens status on SOSR are difficult to extract due to infrequent reporting in this collection of noncomparative studies (see *Table 3*).

Given the emergence of PPV as an alternative to SB for repair of noncomplex RRDs, significant debate has arisen regarding the ideal surgical approach.[5,12,13] To that end, numerous investigators have undertaken head-to-head comparisons of SB and PPV resulting in several prospective randomized trials. As discussed at length above, SOSRs for SB are routinely superior to those achievable with PR despite the fact that the incidence of postoperative PVR is typically higher following SB (see *Table 2*). This latter difference is likely due in part to the greater complexity of cases in which SB was applied, a fact not controlled for in these predominantly retrospective comparative studies. By contrast, the literature is less clear regarding the relative success of SB versus PPV/PPV-SB for noncomplex primary RRD. *Table 4* lists the relevant SOSRs for SB and PPV/PPV-SB for all comparative trials carried out since 1985 in patients with primary noncomplex RRD.

Table 4: Scleral Buckling Anatomic and Functional Results—Comparative Studies

Study	Type	Min F/U	Method	Number	Total SOSR	Phakic SOSR	ΨPhakic SOSR	PVR	Final VA ≥20/50	Standardized Cohort*
SB versus PR										
See *Table 2*										
SB versus PPV										
Ahmadieh et al.[75]	P, R	6 months	SB	126	68.3 %	–	68.3 %	29.4 %	12.8 %‡	Yes
			PPV	99	62.6 %	–	62.6%	35.4 %	11.3 %‡	
Brazitikos et al.[72]	P, R	12 months	SB	75	82.7 %	–	82.7%	5.3 %	65.3 %‡	Yes
			PPV	75	94.7 %†	–	94.7%†	4.0 %	72.0 %‡	
Sharma et al.[76]	P, R	6 months	SB	25	76.0 %	–	76.0 %	20.0 %	–	Yes
			PPV	25	84.0 %	–	84.0 %	4.0 %	–	
Azad et al.[77]	P, R	6 months	SB	31	80.0 %	80.0 %	–	0.0 %	–	Yes
			PPV	30	80.6 %	80.6 %	–	10.0 %	–	
Koriyama et al.[82]	P, R	3 months	SB	23	91.3 %				87.0 %	Yes
			PPV	23	91.3 %				91.3 %	
Ross and Lavina[44‡‡]	R, NR	8 months	SB	38	84.2 %	–	84.2%	10.5%	–	No
			PPV	2	100.0 %	–	100.0%	0.0%	–	
Schaal et al.[40]	R, NR	12 months	SB	322	86.0 %	–	–	–	–	No
			PPV	442	90.1 %	–	–	–	–	
SB versus PPV-SB										
Oshima et al.[79]	R, NR	24 months	SB	55	90.9 %	–	–	3.6 %	–	Yes
			PPV-SB††	47	91.5 %	–	–	4.2 %	–	
Miki et al.[20]	R, NR	6 months	SB	138	92.0 %	92.0 %	–	0.0 %	–	No
			PPV-SB††	87	92.0 %	92.0 %	–	3.4 %	–	
Halberstadt et al.[79]	R, NR	6 months	SB	190	–	89.0 %	87.7 %	13.6 %	59.9 %	No
			PPV-SB	53	–	82.1 %	77.6%	0.0 %	41.9 %	
Yosaiboon et al.[39]	R, NR	6 months	SB	55	85.5 %	–	–	–	–	No
			PPV-SB††	41	89.9 %	–	–	–	–	
Heimann et al.[74]	P, R	12 months	SB	342	59.6 %	63.6 %	53.4 %	16.4 %	–	Yes
			PPV-SB††	339	67.0 %	63.8 %	72.0 %†	15.9 %	–	
Dayani et al.[73]	R, NR	3 months	SB	83	78.3 %	–	–	15.7 %	61.4 %‡	No
			PPV-SB	63	92.1 %†	–	–	4.8 %	61.9 %‡	

**Patients in each treatment group were matched for pre-operative demographic/clinical characteristics; †Significantly higher single-operation success rate (SOSR) compared with alternative treatment; ‡>20/50; †† Scleral buckling (SB) added at discretion of surgeon; ‡‡Statistical analysis of comparative SOSR not performed. Min F/U = minimum follow up; ΨPhakic = pseudophakic/aphakic; R = retrospective; P = prospective; NR = nonrandomized; R = randomized; PPV = pars plana vitrectomy; PVR = proliferative vitreoretinopathy; VA = visual acuity.*

Though neither technique demonstrates clear superiority in this analysis, the two studies reporting significant differences in SOSRs both found PPV/PPV-SB to have better anatomic outcomes.[72,73] This is also true when examining only the pseudophakic subgroups in which, again, two studies found significantly higher SOSRs in PPV/PPV-SB.[73,74] Furthermore, nine of 13 studies (and four of six prospective randomized studies) found higher SOSRs in the PPV or PPV-SB group regardless of statistical significance while only a single study found better results with SB (see *Table 4*). The inferior outcomes of SB in pseudophakic patients is likely related to the better visualization of small anterior breaks, common in pseudophakes, achieved during PPV (see *Table 4*).

Functional outcomes following SB were considerably more variable than the anatomic results with the reported proportion of patients achieving VA of ≥20/40 ranging from 12.8 % to 89.0 % and ≥20/50 ranging from 32.5 to 87.0 % (see *Tables 2–4*). The source of this variability is difficult to decipher, but may be related to the duration of follow up as well as differences in the prevalence of pre-operative macular detachment as well as postoperative vision-altering complications, such as macular pucker and CME. Also, the exact technique of SB employed was quite heterogeneous, with differences existing in the application and type of retinopexy (e.g. cryotherapy or laser) as well as the usage of gas tamponade. In general, investigators found a significant improvement in VA following successful SB repair in patients with pre-operative macular detachment and stable to improved acuities in patients without macular involvement with only a very small number of patients losing ≥2 lines of vision.[44,62,64–66,74–79] The comparative studies failed to demonstrate clear superiority in terms of functional results. Two studies reported significantly better mean final best corrected VA (BCVA)/mean improvement in BCVA in the PPV cohorts[76,78] while others reported faster visual recovery in the SB cohorts.[76,77] Interestingly, the large multicenter trial conducted by the SPR study group did find a significantly improved mean change in BCVA after SB as opposed to PPV-SB in the phakic subgroups, which was independent of cataract development.[74]

Much of the discussion regarding the use of SB or PPV/PPV-SB for repair of primary noncomplex RRD relates to the quite different sets of associated complications. In addition to the usual complications common to all RRD-repair techniques (e.g. retinal redetachment, PVR, etc.), SB has two unique sets of complications related to the main steps in the buckling procedure: external SRF drainage and buckle placement. As SB utilizes an *ab externo* approach, SRF must be drained externally via perforation of the sclera/choroid. Complications—including retinal/

Table 5: Pars Plana Vitrectomy Anatomic and Functional Results—Noncomparative Studies

Study	Type	Min F/U	Number	Total SOSR	Phakic SOSR	ΨPhakic SOSR	PVR	Final VA ≥20/50	Exclusions
PPV Alone									
Campo et al.[87]	P	6 months	275	87.6 %	–	87.6 %	5.8 %	60.7 %*	a, b, f
Speicher et al.[86]	R	4 months	78	93.6 %	–	93.6 %	5.1 %	80.0 %†	e, f
Sharma et al.[90]	R	1.5 months	96	83.3 %	–	–	–	–	a, b, e, f
Lai et al.[91]	R	1 month	53	73.6 %	70.0 %	75.8 %	17.0 %	54.7 %†	c, f
Von Fricken et al.[92]	R	3 months	125	91.2 %	92.9 %	89.9 %	–	–	a, e, f
Colyer et al.[93]	R	3 months	78	87.2 %	–	87.2 %	10.3 %	97.4 %†	a, b, d, f
Kunikata and Nishida[94]	R	3 months	84	95.2 %	–	–	1.2 %	–	a, b, e, f
Albrieux et al.[95]	R	6 months	70	77.1 %	–	–	10.0 %	61.4 %†	a, b, e, f
Schneider et al.[96]	R	6 months	93	95.7 %	95.0 %	96.2 %	3.2 %	77.4 %*	a, b, d, e, f
Combined PPV-SB									
Gartry et al.[97‡]	R	12 months	114	73.7 %	67.9 %	79.3 %	8.8 %	26.3 %	a, e, f
Hakin et al.[98‡]	R	6 months	124	64.5 %	–	–	20.2 %	–	a, e, f
Devenyi et al.[99]	P	6 months	94	100.0 %	–	100.0 %	0.0 %	–	a, f
Alexander et al.[100]	R	3 months	60	95.0 %	–	–	–	–	a, e

*Above series include cases performed via 20-, 23-, and 25-gauge vitrectomy systems (with several series employing different gauges within individual cohorts). *>20/50; †Analysis limited to patients with pre-operative macular detachment; ‡Scleral buckling (SB) added at discretion of surgeon. Exclusions (specifically cited in article): a = PVR C1 or greater; b = penetrating trauma; c = vitreous hemorrhage; d = prior chorioretinitis/endophthalmitis; e = giant retinal tear; f = previous SB/pars plana vitrectomy (PPV). Min F/U = minimal follow up; ΨPhakic = pseudophakic/aphakic; R = retrospective; P = prospective; SOSR = single-operation success rate; PVR = proliferative vitreoretinopathy; VA = visual acuity.*

subretinal/vitreous hemorrhages, retinal/vitreous incarceration, and hypotony[3,80,81]—can occur following external drainage, which is avoided during PPV. A minority of surgeons advocate for segmental buckling without drainage and have shown excellent long-term anatomic and functional results with this technique.[56,57] Placement of a buckling element introduces a foreign object adjacent to the eye and compresses the globe. This may lead to a host of infectious complications including buckle infection, scleral abscess, and buckle extrusion as well as compression-related phenomena including pain, refractive changes, strabismus, buckle intrusion, and anterior segment ischemia.[3,80,81] Choroidal detachment, reported in 0.8 % to 35% of eyes undergoing encircling SB with drainage,[62,63,65,72,75,76,82] can occur as a result of SRF drainage-related hypotony, buckle-related vortex vein compression, and/or retinopexy-related choroidal vascular damage.[80] Though SB is a primarily an extraocular procedure, cataract development does occur and is likely related to drainage procedures. Indeed, the multicenter PR versus SB study found a significantly higher rate of cataract progression following encircling SB with drainage compared with PR.[43] By contrast, SB with or without drainage has consistently been found to result in significantly less-frequent cataract progression compared with PPV.[40,74,77,78] Rates of endophthalmitis are low, with one study of 10,000 SB procedures reporting an incidence of 0.02 %.[83] This rate would presumably be even lower if SB without drainage was employed. Other complications such as CME, macular pucker, and PVR occurred infrequently and were not reported to be significantly more common with SB or PPV (see *Table 4*).

Pars Plana Vitrectomy

As reviewed above, the introduction of modern vitrectomy in the 1970s dramatically altered the landscape of retinal detachment repair. Though initially applied in complex detachments—including RRDs associated with PVR, GRTs, macular breaks, and retinoschisis[84]—surgeons soon found that PPV offered many advantages in noncomplex RRD repair. Specifically, the *ab interno* approach allows for direct relief of vitreoretinal traction, removal of media opacities, precise placement of endolaser, and internal SRF drainage.[62,85–87] Additionally, many surgeons contend that peripheral retinal visualization at the operating microscope (with scleral depression) is superior to that obtainable via indirect ophthalmoscopy, allowing for improved detection of the small, often multiple, anterior breaks common in pseudophakic patients.[11,12,88,89] The anatomic outcomes detailed in *Table 5*—which reviews the results of PPV and PPV-SB for primary noncomplex RRD in noncomparative studies with 50 or more patients published since 1985—support these contentions with the majority of studies reporting SOSRs greater than 85 % and PVR rates less than 10 %. Interestingly, a few outlying studies encountered substantially worse anatomic results with SORSs less than 80 % and correspondingly high rates of PVR. Though the basis for this variability is unclear, it is likely due in part to inconsistent definitions of noncomplex RRD (e.g. inclusion/exclusion of patient with vitreous hemorrhage, macular breaks, extended durations of detachment, etc.) and PPV (e.g. instrument gauge, application of adjuvant SB and/or 360° endolaser, etc.) As in SB, lens status did not appear to impact anatomic results (see *Table 5*).

In light of the evidence supporting PPV as an equivalent,[20,39,40,44,75–79] if not superior,[72–74] option to SB for noncomplex RRD, it is unsurprising that, in recent years, the focus of debate has increasingly shifted from primary SB versus primary PPV to questions relating to the appropriate adjuvant procedures (e.g. SB, 360° endolaser) to utilize in conjunction with PPV.1[2,89] To this end, several investigators have undertaken comparative evaluations of PPV and PPV-SB, the results of which are detailed in *Table 6*. In contrast to the comparative results for SB and PPV/PPV-SB, no study demonstrated a statistically significant difference in SOSR when comparing PPV and PPV-SB. The same was true when examining only the pseudophakic subpopulations. One group did report a nonsignificant trend (p=0.11) toward better total SOSR with PPV[101] while another found a significantly improved SOSR following PPV-SB when only phakic patients were included in the analysis.[102] Rates of PVR were generally similar[102–105]

Table 6: Pars Plana Vitrectomy Anatomic and Functional Results—Comparative Studies

Study	Type	Min F/U	Method	Number	Total SOSR	Phakic SOSR	ΨPhakic SOSR	PVR	Final VA ≥20/50	Standardized Cohort*
PPV versus PR/PPV-SB versus PR										
See *Table 2*										
PPV versus SB/PPV-SB versus SB										
See *Table 4*										
PPV versus PPV-SB										
Wickham et al.[101]	R, NR	3 months	PPV	41	90.2 %	–	–	4.9 %	–	No
			PPV-SB	45	73.3 %	–	–	20.0 %	–	
Stangos et al.[104‡‡]	P, NR	9 months	PPV	45	97.8 %	–	97.8 %	2.2 %	–	No
			PPV-SB	26	92.3 %	–	92.3 %	0.0 %	–	
Weichel et al.[103]	R, NR	3 months	PPV	68	92.6 %	–	92.6 %	–	63.6 %[‡]	Yes
			PPV-SB	84	94.0 %	–	94.0 %	–	40.3 %[‡]	
Kinori et al.[105]	R, NR	3 months	PPV	96	81.3 %	92.0 %	77.5 %	11.6 %	62.5 %[‡]	No
			PPV-SB	85	87.1 %	87.5 %	86.7 %	11.8 %	47.1 %[‡]	
Mehta et al.[102]	R, NR	3 months	PPV	85	85.9 %	83.8 %	87.5 %	10.6 %	–	No
			PPV-SB	134	95.5 %	97.1 %[†]	93.9 %	7.5 %	–	

**Patients in each treatment group were matched for pre-operative demographic/clinical characteristics. †Significantly higher single-operation success rate (SOSR) compared with alternative treatment; ‡>20/50; ‡‡Statistical analysis of comparative SOSR not performed. Min F/U = minimum follow up; ΨPhakic = pseudophakic/aphakic; R = retrospective; P = prospective; NR = nonrandomized; R = randomized; PVR = proliferative vitreoretinopathy; SB = scleral buckling; VA = visual acuity.*

though the study reporting a trend toward better anatomic results with PPV alone also noted a significantly higher incidence of PVR in the PPV-SB cohort (see *Table 6*).[101]

The visual outcomes are, again, quite variable, with the proportion of patients achieving a final acuity of ≥20/40 and ≥20/50 ranging from 11.3 to 77.4 % and 54.7 to 97.4 % for PPV alone and from 40.3 to 61.9 % and 26.3 to 41.9 % for PPV-SB (See *Tables 4–6*). While a large portion of this variability in undoubtedly due to interstudy disparities in detachment phenotype (e.g. macular status, detachment duration) and patient demographics (e.g. age, ocular comorbidities), an important confounder—given the frequency of cataract development following PPV—is pre-operative lens status and the handling of cataract development/extraction in relation to study endpoint. Potential confounders aside, PPV alone did appear to produce equal, if not superior, functional outcomes. One group reported a significantly higher proportion of patients achieving ≥20/40 acuity following PPV[103] while two other groups reported nonsignificant trends toward better final visual results with PPV (better final mean VA [p=0.13][105] and greater VA improvement [p=0.2465]).[102] Possible explanations for the worse functional outcomes in patients treated with PPV-SB include the associated refractive change induced by SB or a greater incidence of vision-affecting complications (e.g. CME, epiretinal membrane [ERM]) following PPV-SB.[103]

With a few minor differences, the technique for PPV alone and the vitrectomy portion of PPV-SB are essentially identical. It follows that these procedures should be associated with similar sets of complications that occur at similar rates. However, PPV-SB carries the risk for additional complications related to buckle placement such as refractive changes, strabismus, anterior segment ischemia, and buckle intrusion/extrusion/infection.[12,80] Thus, the addition of SB to PPV would seem to introduce a greater risk for complications and the evidence appears to corroborate this suspicion. Of the five comparative studies listed in *Table 6*, three found PPV-SB to have a significantly higher incidence of one or more individual complications—including glaucoma,[104,105] refractive changes,[104] and ERM formation[101]—while a fourth found a nonsignificant trend (p=0.10) toward greater total complications in eyes undergoing PPV-SB.[103] Despite the inherent additional risks associated with PPV-SB, surgeons continue to promote its use on the basis that adding a buckle improves anatomic outcomes, purportedly outweighing any additional complication-related morbidity. This is founded on the belief that an adjuvant buckle reduces redetachment due to missed breaks and supports the vitreous base thereby preventing new breaks caused by theoretical vitreous base contraction.[12,102] As detailed above (see *Table 6*), this has not been corroborated by the evidence to date, as PPV-SB has not been shown to yield better anatomic outcomes than PPV alone. Moreover, the addition of a buckle increases operative time, medical costs, and patient discomfort.[12,101,103–105]

Summary

While it may be appealing to adopt a 'one size fits all' approach to RRD repair utilizing a standardized surgical approach, clinical realities necessitate a more customized application of available surgical techniques. Certain demographic (e.g. patient age, lens status) and detachment features (e.g. size/number of retinal breaks, pre-operative PVR, associated trauma/inflammation) are essential to consider in selecting a surgical approach. The authors, with few exceptions, endorse a three-tiered approach to managing RRD based on these features:

1) Primary SB alone—young phakic patients without a PVD presenting with noncomplex RRD;
2) Primary PPV alone—most other noncomplex RRD (including RRD with inferior breaks); and
3) Primary PPV-SB—complex RRD (defined above).

In our practice, PR is limited to the occasional patient with an ideally suited noncomplex RRD who accepts the lower single operation success rate expected with this technique.

The authors believe that, given equivalent outcomes, the simplest surgical procedure is the best procedure, since it avoids the cost and morbidity of unnecessary adjuncts. While the majority of surgeons likely accept the recommendation set forth above for young phakic patients with noncomplex RRD and for patients with complex RRD, the use of PPV alone for most other noncomplex RRD remains a concern of continued debate.[11–13] As evidenced in our recent study of noncomplex RRD repaired with PPV alone at our institution, very high SOSRs (95.7 %) are achievable with low complication rates (PVR 3.2 %) and excellent visual results (final VA ≥20/40 in 77.4 %).[96] Furthermore, in this study we saw no evidence of postoperative vitreous base contraction in the absence of frank PVR.

The current review of anatomic and functional outcomes associated with SB, PPV, and PPV-SB appears to support our approach. While neither SB nor PPV/PPV-SB was demonstrated to be clearly superior in terms of anatomic and functional outcomes, several studies did report significantly better SOSRs with PPV/PPV-SB[72,73] compared with SB, particularly in pseudophakic eyes.[72,74] This data would seem to support the use of PPV/PPV-SB in lieu of SB in such noncomplex RRDs. Similarly, no clear advantage in terms of anatomic or functional outcomes was detected in several studies comparing PPV with PPV-SB. However, there did appear to be a trend toward better SOSRs,[101] final visual results,[102,103,105] and lower complication rates[101,103–105] following PPV alone in a subset of these studies. Thus, assuming that PPV alone provides at least equivalent, if not better outcomes, it would appear to be the technique of choice as it remains the simplest surgical approach. In our opinion, additional adjuvants, such as SB or 360° barrier laser, add morbidity without improving outcomes.

It is important to point out that our advocacy of 'simple' vitrectomy in noncomplex RRD does not imply a quick and easy surgery. On the contrary, this approach requires thorough vitreous removal and meticulous identification and treatment of all retinal breaks. Scrupulous technique minimizes the risk for missed breaks and/or vitreous incarceration in sclerotomies with subsequent new break development or reopening of old breaks. Because the rationale for adjuvant SB and 360° endolaser relates to prophylaxis against these adverse outcomes, these adjuncts—and their associated morbidity—can be eliminated.

The evidence to date for the ideal approach to noncomplex RRD repair remains imperfect given the relatively small size and often retrospective nature of available studies. These factors limit the ability to detect small true differences (e.g. <3–5 %) between the various surgical approaches, though the clinical relevance of such small differences is questionable given potential trade-offs in terms of increased complications and morbidity. Thus, until such time as a large (~2,000 subjects) prospective, randomized clinical trial is completed, surgeons are left to rely on the data reviewed above. ■

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