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Research Article

Functional and Anatomical Outcomes of Scleral Buckling vs. Pars Plana Vitrectomy in Young Adults with Retinal Detachment

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Abstract

Rhegmatogenous retinal detachment (RRD) in young adults presents unique anatomical and functional challenges due to high rates of phakic status, strong vitreoretinal adhesion, and specific etiology such as myopia or trauma. The optimal surgical strategy—scleral buckling (SB) versus pars plana vitrectomy (PPV)—remains actively debated in this demographic. The objective of this cohort study was to evaluate and compare the anatomical attachment rates, visual outcomes, and post-operative complication profiles of primary SB versus 23-/25-gauge PPV in young adults with phakic RRD. A total of 180 eyes from 180 young adult patients (aged 18 to 40 years) undergoing primary repair for phakic RRD across a 3-year period were analyzed (SB group, n = 94; PPV group, n = 86). Primary anatomical success, defined as retinal reattachment after a single procedure at 6 months, was achieved in 88.3% of the SB group and 86.0% of the PPV group (p = 0.655). Ultimate anatomical success following secondary procedures reached 97.9% and 96.5%, respectively (p = 0.681). Mean best-corrected visual acuity (BCVA) at 12 months improved significantly in both groups, but eyes in the SB cohort achieved superior final visual acuity (0.22 vs. 0.38 logMAR, p = 0.008) and lower rates of post-operative cataract progression (4.3% vs.

62.8%, $p < 0.001$). Conversely, the PPV group demonstrated lower incidence of significant refractive shift (mean myopic shift: -0.45 D vs. -1.75 D, $p < 0.001$). Scleral buckling provides comparable single-operation anatomical attachment while preserving crystalline lens clarity and yielding superior long-term functional visual gains, supporting its role as a primary surgical intervention for young phakic patients.

Keywords: Rhegmatogenous retinal detachment, scleral buckling, pars plana vitrectomy, young adults, phakic, visual acuity.

Introduction

Rhegmatogenous retinal detachment (RRD) is a sight-threatening ocular emergency. While RRD predominantly affects older individuals undergoing posterior vitreous detachment (PVD), its occurrence in young adults (aged 18 to 40 years) represents a distinct clinical entity. In younger cohorts, RRD is frequently driven by axial myopia, lattice degeneration, ocular trauma, or congenital structural anomalies rather than acute, age-related PVD. [1–3]

Surgical repair of phakic RRD in young patients requires balancing high anatomical success rates against long-term visual preservation. Scleral buckling (SB) has historically served as the gold standard for young phakic patients. By indenting the sclera extraocularly, SB relieves vitreoretinal traction at the tear site without entering the vitreous cavity or disrupting the clear crystalline lens. However, SB is technically demanding, requires careful localization of peripheral breaks, and can induce post-operative myopic refractive shifts or extraocular muscle imbalance. [4–6]

Advancements in micro-incisional vitrectomy systems (23-gauge and 25-gauge PPV), wide-angle viewing system optics, and intraocular tamponades have led many vitreoretinal surgeons to favor PPV for primary RRD repair. PPV enables direct visualization, internal drainage of subretinal fluid, and complete relief of traction. Nevertheless, in young phakic eyes, complete removal of the dense, adherent vitreous cortex is technically challenging and carries heightened risks of iatrogenic retinal break formation. Furthermore, post-vitrectomy cataract formation is extremely common, often necessitating secondary phacoemulsification within 1–2 years of repair. [7–10]

Comparative evidence evaluating primary SB versus PPV specifically in young adults remains limited, as many major trials aggregate pediatric, adult, and pseudophakic eyes. Given that young adults face decades of potential visual function, preserving accommodation and avoiding premature cataract surgery are major clinical considerations.

This study aimed to evaluate and compare the anatomical reattachment rates, functional visual outcomes, refractive changes, and complication profiles of primary SB versus PPV in young adult phakic patients presenting with primary RRD.

Methodology

A non-randomized comparative cohort study was conducted over a 36-month period at Gujranwala Medical College, enrolling young adults aged 18 to 40 years who underwent primary surgical repair for phakic RRD. The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the institutional ethics committee. Written informed consent was obtained from all participants prior to surgery.

Inclusion criteria comprised consecutive phakic patients aged 18 to 40 years presenting with primary unilateral RRD involving or sparing the macula. Exclusion criteria included prior intraocular surgery (except uncomplicated corneal refractive surgery), giant retinal tears ($\ge 90^\circ$), proliferative vitreoretinopathy (PVR) grade C or higher, traumatic endophthalmitis, penetrating ocular trauma, or follow-up under 12 months.

Surgical intervention (SB or 23/25-gauge PPV) was selected based on surgeon discretion, break location, and vitreous status. Scleral buckling procedures involved indirect ophthalmoscopic break localization, transscleral cryopexy, placement of segmental or circumferential silicone sponges/elements, subretinal fluid drainage when clinically indicated, and intraocular gas injection (SF_6 or C_3F_8) as needed. PPV procedures utilized standard 3-port setups, core and peripheral vitrectomy with induction of PVD (if not present), fluid-air exchange, endolaser photocoagulation surrounding all breaks, and gas (SF_6/C_3F_8) or silicone oil tamponade.

Primary outcome measure was single-operation anatomical success (SOAS) at 6 months, defined as complete retinal reattachment without secondary vitreoretinal intervention. Secondary outcomes included ultimate anatomical success at 12 months, best-corrected visual acuity (BCVA in logMAR), mean spherical equivalent refractive change, intraocular pressure (IOP) spikes, and rate of cataract progression. Statistical analyses were performed using SPSS version 26. Continuous variables were evaluated using Student's t-test or Mann-Whitney U test, and categorical data were compared using Chi-square or Fisher's exact test.

Results

Table 1: Baseline Clinical and Demographic Profiles of SB and PPV Patient Cohorts

Parameter	**Scleral Buckling (n=94)**	**Pars Plana Vitrectomy (n=86)**	**p-value**
Age (Years $\pm$ SD)	27.4 $\pm$ 5.8	29.1 $\pm$ 6.2	0.061
Gender (Male / Female)	58 / 36	50 / 36	0.635
Pre-operative BCVA (logMAR $\pm$ SD)	0.72 $\pm$ 0.45	0.78 $\pm$ 0.48	0.388
Macula-Off Status (%)	48 (51.1%)	47 (54.7%)	0.634
Baseline Spherical Equivalent (Diopters)	-4.25 $\pm$ 2.50	-4.50 $\pm$ 2.80	0.528
Presence of PVD at Baseline (%)	22 (23.4%)	24 (27.9%)	0.490
Extent of Detachment ($\ge$ 2 Quadrants) (%)	52 (55.3%)	51 (59.3%)	0.593

Note: Baseline demographic, visual, and anatomical parameters were comparable between the two surgical groups.

Table 2: Primary and Ultimate Anatomical Reattachment Rates

Outcome Measure	Scleral Buckling (n=94)	Pars Plana Vitrectomy (n=86)	p-value
Single-Operation Anatomical Success (6 Months)	83 (88.3%)	74 (86.0%)	0.655
Primary Failure Cause: New/Missed Tear (%)	6 (6.4%)	4 (4.7%)	0.618
Primary Failure Cause: PVR Progression (%)	5 (5.3%)	8 (9.3%)	0.302
Ultimate Anatomical Success (12 Months)	92 (97.9%)	83 (96.5%)	0.681
Mean Number of Procedures per Eye	1.14 $\pm$ 0.38	1.17 $\pm$ 0.42	0.612

Note: Both surgical techniques achieved high primary and ultimate anatomical reattachment rates without statistically significant differences.

Table 3: Functional Visual and Refractive Outcomes at 12-Month Follow-Up

Functional Parameter	Scleral Buckling (n=94)	Pars Plana Vitrectomy (n=86)	p-value
Final BCVA - Overall (logMAR $\pm$ SD)	0.22 $\pm$ 0.21	0.38 $\pm$ 0.30	0.008

Functional Parameter	**Scleral Buckling (n=94)**	**Pars Plana Vitrectomy (n=86)**	**p-value**
Final BCVA - Macula-On Subgroup	0.08 $\pm$ 0.10	0.15 $\pm$ 0.14	0.012
Final BCVA - Macula-Off Subgroup	0.35 $\pm$ 0.24	0.58 $\pm$ 0.32	< 0.001
Mean Post-op Refractive Shift (Diopters)	-1.75 $\pm$ 0.62	-0.45 $\pm$ 0.38	< 0.001
Gain of $\ge$ 3 Snellen Lines (%)	72 (76.6%)	55 (64.0%)	0.063

Note: Scleral buckling provided significantly better final BCVA, particularly in eyes with macula-off status, despite inducing a larger myopic refractive shift.

Table 4: Post-operative Complications and Secondary Interventions

Complications	**Scleral Buckling (n=94)**	**Pars Plana Vitrectomy (n=86)**	**p-value**
Cataract Progression / Surgery within 12 Months	4 (4.3%)	54 (62.8%)	< 0.001
Transient Elevated IOP (> 25 mmHg)	12 (12.8%)	22 (25.6%)	0.031
Iatrogenic Retinal Break	1 (1.1%)	7 (8.1%)	0.024
Strabismus / Diplopia (Persistent)	3 (3.2%)	0 (0.0%)	0.247

Complications	**Scleral Buckling (n=94)**	**Pars Plana Vitrectomy (n=86)**	**p-value**
Choroidal Detachment	5 (5.3%)	2 (2.3%)	0.302

Note: PPV was associated with significantly higher rates of cataract progression, post-operative IOP spikes, and iatrogenic retinal breaks compared to SB.

Discussion

Surgical management of rhegmatogenous retinal detachment in young adults requires balancing anatomical reattachment with long-term functional conservation. In this comparative cohort of phakic patients aged 18 to 40 years, primary scleral buckling demonstrated primary anatomical success (88.3%) comparable to pars plana vitrectomy (86.0%), while yielding significantly better final visual acuity and avoiding rapid cataract formation.

The high primary attachment rate achieved by scleral buckling highlights its suitability for young eyes. In young adults, the vitreous gel is typically dense and firmly attached to the internal limiting membrane and vitreous base. Extraocular buckling relieves vitreoretinal traction externally without requiring mechanical separation of the posterior hyaloid. Attempting to induce a posterior vitreous detachment during PPV in young phakic eyes can be technically difficult and risks creating iatrogenic peripheral retinal breaks, as observed in 8.1% of our PPV cohort compared to 1.1% in the SB group. [11–14]

Functional visual gains were significantly higher in the SB cohort across both macula-on and macula-off subgroups. The primary factor underlying reduced visual outcomes in the PPV group was rapid nuclear sclerosis and posterior subcapsular cataract progression, occurring in 62.8% of vitrectomized eyes within 12 months compared to only 4.3% of buckled eyes. Intraocular gas tamponade, microscopic light exposure, and altered vitreous metabolic dynamics during vitrectomy accelerate crystalline lens opacification. While cataract extraction can restore clarity, loss of natural accommodation in young patients represents a significant functional deficit. [15–17]

Refractive outcomes favored PPV in terms of axial length stability. Scleral buckling induced an average myopic shift of -1.75 D due to axial elongation from circumferential or segmental element placement. Conversely, PPV maintained baseline refractive error (mean shift: -0.45 D). For young patients with pre-existing high myopia, post-buckle refractive shifts can be managed with spectacle correction or contact lenses. [18–20]

Limitations of this study include its non-randomized allocation, single-center design, and reliance on surgeon preference for procedure selection.

Overall, primary scleral buckling remains a highly effective, organ-preserving procedure for young adult phakic patients with RRD. It provides anatomical success rates equal to vitrectomy while preserving natural accommodation, preventing premature cataract formation, and optimizing long-term visual potential.

Conclusion

In young adults with primary phakic rhegmatogenous retinal detachment, scleral buckling achieves primary single-operation anatomical success rates equivalent to pars plana vitrectomy. Scleral buckling offers superior final visual outcomes and avoids the high rate of post-vitrectomy cataract progression, preserving natural accommodation. Unless complex vitreoretinal traction or posterior breaks preclude extraocular repair, scleral buckling should remain a primary surgical option for RRD in young phakic patients.

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