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Original Research Article

INCIDENCE OF SECONDARY GLAUCOMA FOLLOWING VITREO-RETINAL SURGERIES

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ABSTRACT

Background: Secondary glaucoma is a known complication following vitreo-retinal surgeries and can adversely affect long-term visual outcomes if not detected early. The reported incidence varies widely, and data on associated risk factors remain limited, particularly in regional populations. The aim is to determine the incidence of secondary glaucoma following vitreo-retinal surgeries and identify associated risk factors influencing its development.

Materials and Methods: This retrospective and prospective observational study including 76 patients who underwent vitreo-retinal surgeries between 2021 and 2023. Medical records from 2021-2022 were reviewed retrospectively, while patients operated in 2023 were followed prospectively for at least six months. Secondary glaucoma was defined as postoperative intraocular pressure >21 mmHg and/or glaucomatous optic disc and visual field changes. Demographic characteristics, surgical variables, visual acuity, intraocular pressure trends, and potential risk factors were analyzed. Independent predictors of secondary glaucoma were identified using multivariate logistic regression.

Results: Secondary glaucoma developed in 14 eyes, yielding an incidence of 18.42%. Open-angle glaucoma was more common (13.16%) than angle-closure glaucoma (5.26%). Most cases (64.3%) occurred within the first postoperative month. Higher preoperative IOP (OR 2.64, p = 0.002), aphakic lens status (OR 5.23, p = 0.022), and vitreous hemorrhage as the indication for surgery (OR 4.78, p = 0.038) were identified as independent risk factors.

Conclusion: Secondary glaucoma is a significant postoperative complication following vitreo-retinal surgery. Early risk stratification and vigilant postoperative monitoring are essential to prevent glaucomatous damage while preserving favorable visual outcomes.

Keywords: Secondary Glaucoma, Vitreo-Retinal Surgery, Pars Plana Vitrectomy, Intraocular Pressure, Risk Factors, Visual Outcomes.

INTRODUCTION

Vitreoretinal surgeries are among the most commonly performed ophthalmic procedures and play a crucial role in the management of posterior segment disorders such as retinal detachment, diabetic retinopathy, macular holes, epiretinal membranes, and vitreous hemorrhage.[1] Advances in surgical techniques, instrumentation, and intraoperative adjuncts have significantly improved anatomical success and visual outcomes.[2] As a result, the frequency of procedures including pars plana vitrectomy, intravitreal silicone oil injection, and intravitreal gas injection has increased substantially. Despite these advances, postoperative complications remain a concern, with secondary glaucoma and elevated intraocular pressure (IOP) being among the most serious long-term sequelae.[3] Secondary glaucoma following vitreoretinal surgery is characterized by an immediate or delayed postoperative rise in IOP exceeding 22 mmHg, with or without associated glaucomatous optic nerve damage. If unrecognized or inadequately treated, it can lead to irreversible visual loss. This condition may occur in the early or late postoperative period and may be influenced by pre-existing ocular

predispositions such as Wagner syndrome, Stickler syndrome, and retinitis pigmentosa, as well as surgical factors including scleral buckling and the use of intraocular tamponade agents such as gases and silicone oil.[4,5] The reported incidence of secondary glaucoma following retinal surgery varies widely, ranging from 19% to 28%, depending on patient characteristics, surgical technique, and duration of follow-up.[3,4]

The pathophysiology of secondary glaucoma after vitreoretinal surgery is multifactorial and includes mechanisms such as tamponade hyperfilling, aqueous misdirection, anterior displacement of the lens–iris diaphragm, ciliary body edema, trabecular meshwork damage, and oxidative stress following vitreous removal.[3] Both open-angle and angle-closure mechanisms may be involved, with onset ranging from acute postoperative IOP elevation to chronic glaucoma developing months or years later. Chronic IOP elevation may result from steroid response, trabecular damage, or ischemia-induced neovascularization, with reported incidence ranging from 8.4% to 14.8% following vitreoretinal procedures.[6-8] Pseudophakic and aphakic eyes appear to be at higher risk than phakic eyes.9 Among vitreoretinal procedures, pars plana vitrectomy is commonly associated with postoperative IOP elevation, with reported incidence ranging from 20% to 60%.6,10 Silicone oil injection has been linked to secondary glaucoma in 2.2% to 56% of cases, due to mechanisms such as pupillary block, inflammation, and trabecular obstruction by emulsified oil droplets.[11-13]

Despite significant advances in vitreoretinal surgical techniques, including small-gauge transconjunctival vitrectomy and preventive measures such as inferior peripheral iridectomy, secondary glaucoma continues to be a notable cause of postoperative morbidity. The reported incidence and associated risk factors of secondary glaucoma following vitreoretinal surgery vary widely across studies, highlighting gaps in existing evidence. Differences in patient demographics, underlying retinal pathology, surgical practices, and accessibility to postoperative follow-up further emphasize the need for region-specific data to accurately assess the burden of this complication. Therefore, the present study was undertaken to evaluate the incidence of secondary glaucoma following vitreoretinal surgeries, analyze the temporal pattern of intraocular pressure changes, and identify potential associated risk factors. Insights from this study may facilitate improved postoperative monitoring, optimized perioperative management, and better visual outcomes in patients undergoing vitreoretinal surgery.

MATERIALS AND METHODS

This retrospective and prospective observational study was conducted in the Postgraduate Department of Ophthalmology, Government Medical College, Srinagar, over a period of 18 months. The study was initiated after obtaining approval from the Institutional Ethical Committee. A total of 76 patients who had undergone vitreo-retinal surgeries during the study period were enrolled.

Data was collected from patients who underwent vitreo-retinal surgeries during the years 2021 and 2022, whose medical records were retrospectively reviewed, as well as from patients who underwent vitreo-retinal surgeries in the year 2023 and were followed prospectively for a minimum duration of six months postoperatively. In this study, patients who had undergone vitrectomy, membrane peeling, silicone oil injection, gas tamponade, or any combination of these procedures were enrolled. Patients with a documented history of pre-existing glaucoma or ocular hypertension prior to vitreo-retinal surgery were excluded. Additionally, patients with a history of steroid use or those on intraocular pressure–lowering medications before surgery, patients with pre-existing uveitis, infectious endophthalmitis, or other ocular inflammatory conditions that could influence glaucoma outcomes, those with a history of recent ocular trauma, and patients with poor follow-up or incomplete medical records were excluded from the study.

Patients satisfying the inclusion criteria were evaluated using a pre-designed proforma that captured relevant demographic, clinical, and surgical details. Patient records were reviewed to collect demographic information, including age and gender, as well as clinical variables such as the indication for vitreo-retinal surgery, history of retinal detachment, number of vitreo-retinal surgeries performed, use of scleral buckle, and use of gas as a vitreous substitute. Details regarding associated ocular and systemic conditions, including high myopia greater than 6.00 dioptres, diabetes mellitus, hypertension, prior panretinal photocoagulation, and history of cataract extraction (performed before, during, or after vitreo-retinal surgery), were also recorded. The duration of postoperative follow-up was documented for each patient.

Secondary glaucoma was defined as a postoperative elevation of intraocular pressure greater than 21 mmHg and/or the presence of glaucomatous optic disc changes with corresponding visual field defects consistent with glaucoma. Preoperative and postoperative ophthalmic examinations included assessment of best corrected visual acuity using Snellen's chart, slit lamp examination of the anterior segment, measurement of intraocular pressure using rebound tonometry and applanation tonometry, evaluation of the anterior chamber angle by gonioscopy, and stereoscopic optic disc examination. Optical coherence tomography was performed for optic disc and retinal nerve fiber layer analysis, and visual field testing was carried out when clinically indicated. Detailed findings from these examinations were recorded preoperatively, at the time of diagnosis, immediately after surgery, and during subsequent follow-up visits. Final postoperative

visual acuity and intraocular pressure values were obtained from the most recent clinical examination.

RESULTS

The mean age of the patients was 54.21 ± 8.52 years with the range from 35 to 68 years. Majority of patients 27 (35.53%) were ≥60 years. 24 (31.58%) patients were between 50-59 years, followed by 21 (27.63%) between 40-49 years and 4 (5.26%) were between 30-39 years. The study population comprised an equal distribution of males and females (38 each; 50%). Preoperatively, the majority of eyes were phakic 46 (60.53%), followed by pseudophakic 27 (35.53%) and aphakic 3 (3.94%) eyes [Table 1].

The most common indications for vitreo-retinal surgery were vitreous hemorrhage (21.05%), rhegmatogenous retinal detachment (19.74%), tractional retinal detachment (19.74%), macular hole (19.74%), and epiretinal membrane (19.74%). Pars plana vitrectomy without tamponade was performed in 60.53% of cases, while 39.47% underwent vitrectomy with tamponade. Among those receiving tamponade, silicone oil was used in 56.67% and SF6 gas in 43.33% of cases [Table 1].

Table 1: Indications and surgical profile of vitreo-retinal procedures (n=76)

Variables	No. of patients	Percentage
Indication		
Vitreous Hemorrhage	16	21.05
Rhegmatogenous Retinal detachment	15	19.74
Tractional retinal detachment	15	19.74
Macular hole	15	19.74
Epiretinal membrane	15	19.74
Type of surgery		
PPV without Tamponade	46	60.53
PPV with Tamponade	30	39.47
Type of tamponade (n=30)		
Silicon Oil	17	56.67
Gas (SF6)	13	43.33

Preoperatively, most patients had poor visual acuity, with 48 (63.2%) having vision ≤6/60 or worse. Postoperatively, progressive improvement in visual acuity was observed across follow-up visits. At one year, 26 (34.2%) of patients achieved a best corrected visual acuity of 6/12, and 22 (28.9%) achieved 6/18. Mean Log MAR visual acuity improved steadily from 1.7 at baseline to 0.5 at one year, indicating a statistically and clinically significant visual recovery following surgery [Figure 1].

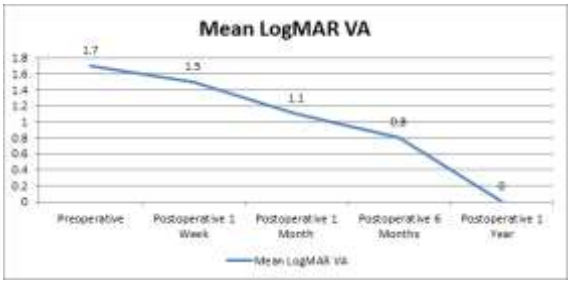

Figure 1: Line showing mean Log MAR VA

All patients had normal preoperative intraocular pressure (IOP <21 mmHg). Postoperatively, transient elevation of IOP was observed, particularly at one week, when 14 (18.4%) of patients recorded IOP >21 mmHg, including 6.6% with IOP >40 mmHg. Mean IOP peaked at one week (18.81 ± 9.01 mmHg) and gradually normalized by six months and one year [Table 2]. Slit lamp examination revealed normal findings in 81.58% of patients, while corneal edema and emulsified silicone oil in the anterior chamber were observed exclusively among glaucoma patients. Gonioscopy showed open angles in 94.74% and angle closure in 5.26% of eyes [Figure 2].

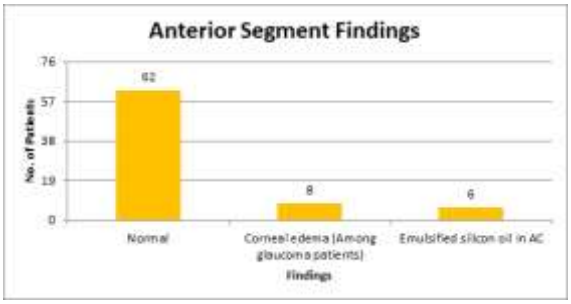

Figure 2: distribution of patients based on slit lamp findings.

Table 2: Intraocular pressure recorded preoperatively and at subsequent follow UPS.

Parameter	Preoperative	1 week	1 month	6 months	1 year
Mean IOP (mmHg)	15.75 ± 2.61	18.81 ± 9.01	16.09 ± 3.34	15.34 ± 2.16	14.96 ± 1.89
IOP <21 mmHg	76	62	68	76	76
IOP >21 mmHg	0	14	8	0	0

Secondary glaucoma developed in 14 out of 76 patients, giving an overall incidence of 18.42%. Open-angle glaucoma was the most common subtype (13.16%), followed by angle-closure glaucoma (5.26%). Acute onset glaucoma (<1 month) was seen in 64.3% of affected patients, while 35.7% developed chronic glaucoma. Stereoscopic disc evaluation demonstrated glaucomatous changes in all glaucoma patients [Table 3]. Optical coherence tomography revealed reduced retinal nerve fiber layer thickness in

patients with secondary glaucoma with the mean of 60.28 ± 2.57 with the range 56 to 65 µm, and visual field testing showed characteristic glaucomatous defects, including arcuate scotomas, nasal steps, and generalized depression.

Table 3: incidence, type and clinical profile of secondary glaucoma

Variables	No. of patients	Percentage
Optic Disc Changes		
Normal	62	81.6
Glaucomatous	14	18.4
Gonioscopy		
Open angle	72	94.7
Angle Closure	4	5.3
Secondary Glaucoma (Overall)	14	18.4
Open-angle glaucoma	10	13.1
Angle-closure glaucoma	4	5.3
Onset of Glaucoma (n=14)		
Acute (<1 Month)	9	64.3
Chronic (> 1 Month)	5	35.7

Tamponade usage was significantly associated with secondary glaucoma ($p < 0.001$), with glaucoma occurring predominantly in eyes receiving silicone oil or gas tamponade. Lens status showed a significant association with glaucoma ($p = 0.006$), with aphakic eyes demonstrating the highest risk. Surgical indication was also significantly associated with glaucoma development ($p = 0.046$), particularly in cases of vitreous hemorrhage. Gender and tamponade type (silicone oil vs gas) did not show statistically significant associations [Table 4].

Table 4: risk factors for secondary glaucoma

Parameters	Variables	Normal	Secondary Glaucoma	P Value
Tamponade Usage	Yes (n=30)	17 (56.7%)	13 (43.3%)	<0.001
	No (n=46)	45 (97.8%)	1 (2.2%)	
Gender	Male (n=38)	31 (81.6%)	7 (18.4%)	1.00
	Female (n=38)	31(81.6%)	7 (18.4%)	
Lens Status	Aphakic (n=3)	2 (66.7%)	1 (33.3%)	0.006
	Phakic (n=46)	37 (80.4%)	9 (19.6%)	
	Pseudophakic (n=27)	23 (85.2%)	4 (14.8%)	
Surgical Indication	Epiretinal membrane (n=15)	12 (80.0%)	3 (20.0%)	0.046
	Macular hole (n=15)	14 (93.33%)	1 (6.7%)	
	Rhegmatogenous Retinal detachment (n=15)	14 (93.33%)	1 (6.7%)	
	Tractional retinal detachment (n=15)	13 (86.7%)	2 (13.3%)	
	Vitreous Hemorrhage (n=16)	9 (56.3%)	7 (43.7%)	
Tamponade Type	Gas Substitute (n=13)	8 (61.5%)	5 (38.5%)	0.460
	Silicon Oil (n=17)	8 (47.1%)	9 (52.9%)	

Pearson correlation analysis demonstrated a strong positive correlation between preoperative IOP and secondary glaucoma ($r = 0.772$, $p < 0.001$), while age showed no significant correlation [Table 5]. Multivariate logistic regression identified higher preoperative IOP (OR 2.64, $p = 0.002$), aphakic lens status (OR 5.23, $p = 0.022$), and vitreous hemorrhage as the surgical indication (OR 4.78, $p = 0.038$) as independent risk factors for secondary glaucoma [Table 6].

Table 5: showing the correlation of age and iop (pre-op) with secondary glaucoma following vitreo-retinal surgeries

Correlation		Glaucoma
Age	Pearson Correlation	-.040
	P value	.734
	n	76
IOP (Pre-op)	Pearson Correlation	.772**
	P value	.000
	n	76

Table 6: multivariate logistic regression analysis of risk factors for secondary glaucoma

Risk Factor	Odds Ratio (OR)	95% Confidence Interval	p-value
Pre-operative IOP	2.64	1.43 – 4.89	0.002
Lens Status			
Pseudophakic	0.68	0.12 – 3.81	0.662
Aphakic	5.23	1.27 – 19.38	0.022
Surgical Indication			
Epiretinal membrane	2.14	0.32 – 14.25	0.432
Vitreous Hemorrhage	4.78	1.09 – 20.96	0.038
Tractional retinal detachment	1.45	0.21 – 9.83	0.706

Statistical Analysis: The collected data was analyzed using IBM SPSS version 20.0 statistical software. The continuous variables were expressed as mean ± standard deviation and categorical variables as frequencies and percentages. The incidence of secondary glaucoma following vitreo-retinal surgery was calculated. Associations between secondary glaucoma and potential risk factors were analyzed using the Chi-square test or Fisher's exact test for categorical variables and Student's t-test for continuous variables, as appropriate. A p-value of less than 0.05 was considered statistically significant.

DISCUSSION

Secondary glaucoma remains a clinically significant complication following vitreo-retinal surgery, with reported incidence varying widely depending on patient characteristics, surgical indications, techniques employed, duration of follow-up, and diagnostic criteria. The development of secondary glaucoma may be related to pre-existing ocular predispositions or may arise as a direct consequence of vitreoretinal interventions and their postoperative sequelae.[5]

In this retrospective and prospective observational study involving 76 patients, the incidence of secondary glaucoma was 18.42%. This finding is consistent with the report by Montanari et al., who documented an incidence of 18.5%.[14] However, the incidence reported in the literature varies considerably, ranging from 11% to nearly 50%. Han et al. reported an incidence of 35.6% within the first 48 hours after pars plana vitrectomy,6 while Nguyen et al. observed glaucoma in 48% of eyes following silicone oil injection, with onset extending up to 51 months postoperatively.[7] Mansoori et al. documented a 28.8% incidence in scieral Buckle surgery for retinal detachment.[15] This wide variability underscores the multifactorial nature of secondary glaucoma and highlights the influence of surgical complexity, tamponade use, and follow-up duration.

In our study, neither age nor gender was significantly associated with the development of secondary glaucoma. The mean age of the cohort was 54.21 ± 8.52 years, and both sexes were equally represented. These findings are consistent with those reported by Kwon et al. (2017), where the mean age was 52 years with a comparable gender distribution (52% males, 48% females).[16] Although Mansukhani et al. identified increasing age as a risk factor for primary open-angle glaucoma after vitreoretinal surgery,[17] the absence of such an association in our study suggests that surgical and anatomical factors may outweigh age-related susceptibility in secondary glaucoma.

Lens status emerged as a significant risk factor for secondary glaucoma in our study ($p = 0.006$), highlighting its important role in postoperative intraocular pressure regulation. The crystalline lens is believed to confer a protective effect by scavenging free radicals generated by surgically induced oxidative stress following vitrectomy, in addition to serving as an anatomical barrier that limits the diffusion of inflammatory mediators from the posterior segment to the anterior chamber. Alterations in lens status may therefore disrupt both biochemical and anatomical homeostasis within the eye. Previous studies have demonstrated inconsistent associations between lens status and the development of secondary glaucoma. Luk et al. reported a higher incidence of secondary glaucoma in pseudophakic eyes (11%) compared with phakic eyes (2%),[9] whereas Kwon et al. observed a higher prevalence in phakic eyes following vitreoretinal surgery, underscoring the complex and multifactorial nature of this relationship.[16] The mechanisms underlying these findings likely vary according to lens status: aphakia may predispose to pupillary block or anterior displacement of vitreous, pseudophakia may be associated with postoperative inflammation, capsular changes, or peripheral anterior synechiae formation, and phakic eyes may be more vulnerable to steroid-induced or inflammation-mediated trabecular meshwork dysfunction. Collectively, these factors suggest that lens status should be carefully considered during preoperative risk stratification and postoperative monitoring for secondary glaucoma.[17]

Preoperative intraocular pressure was the strongest predictor of secondary glaucoma in our cohort. A significant positive correlation was observed between baseline IOP and glaucoma development ($r = 0.772$, $p < 0.001$), and multivariate analysis demonstrated that each unit increase in preoperative IOP increased glaucoma risk by 2.64-fold. Similar observations have been reported by Bhoot et al., who demonstrated that transient or permanent rises in intraocular pressure are common complications following silicone oil injection during pars plana vitrectomy.[18] These findings emphasize the importance of recognizing eyes with IOP at the upper limit of normal as high-risk candidates and supporting the need for closer surveillance and potential prophylactic strategies in such patients.

Surgical indication showed a significant association with secondary glaucoma ($p = 0.046$), with vitreous hemorrhage emerging as an independent risk factor (OR = 4.78). This association likely reflects the role of intraocular blood and its degradation products in impairing trabecular outflow, as supported by Kim WI et al.[19] In contrast, eyes operated for macular hole or rhegmatogenous retinal detachment exhibited a lower incidence of glaucoma. While the type of surgery and tamponade agent did not independently predict glaucoma development, tamponade usage itself was strongly associated with secondary glaucoma ($p < 0.001$). Eyes receiving tamponade demonstrated markedly higher rates of both open-angle and angle-closure glaucoma compared to non-tamponade cases. These findings are consistent with earlier reports implicating tamponade agents,

particularly silicone oil, in postoperative IOP elevation.[7,11,13]

Despite the occurrence of secondary glaucoma, visual outcomes in our cohort improved significantly over time. Mean LogMAR visual acuity improved from 1.7 preoperatively to 0.5 at one year, indicating that effective glaucoma management can preserve the visual benefits of vitreoretinal surgery. Similar improvements have been reported by Bhardwaj et al.[20] However, structural and functional glaucomatous damage was evident on OCT RNFL analysis and visual field testing, highlighting that IOP normalization alone may not prevent progression.

Most glaucoma cases (64.3%) occurred within the first postoperative month, although over one-third presented later, underscoring the need for both early and long-term surveillance. This biphasic pattern is consistent with earlier observations by Henderer et al., who described early and late phases of IOP elevation following vitreoretinal surgery.[21] The early phase, occurring within the first month, may be attributed to inflammation, hemorrhage, or mechanical factors, while the late phase may result from steroid response, angle closure, or progressive trabecular meshwork dysfunction. Multivariate analysis identified preoperative IOP, aphakic lens status, and vitreous hemorrhage as independent predictors of secondary glaucoma. These findings reinforce the multifactorial nature of glaucoma development and highlight the importance of comprehensive risk stratification.

Clinical Implications

Our findings support a risk-stratified approach to postoperative care. Patients with higher baseline IOP, aphakia, or vitreous hemorrhage require closer monitoring, particularly in the early postoperative period. Prophylactic IOP-lowering strategies and mechanism-based management may improve outcomes.

Strengths and Limitations

The strengths of our study are allowing for systematic data collection, reducing recall bias, and ensuring accurate documentation of postoperative outcomes. The study was performed in a tertiary care center, reflecting real-world patient demographics, surgical techniques, and postoperative management strategies. We examined multiple predisposing factors for secondary glaucoma, including patient demographics, ocular parameters, and surgical characteristics, providing a holistic understanding of the condition. Patients were followed for one year, enabling us to assess both early and late-onset secondary glaucoma, as well as the long-term impact on intraocular pressure (IOP) control and visual outcomes.

There are some limitations as: the study was conducted at a single tertiary care institution, limiting the generalizability of findings to broader populations with different surgical practices. Although the study included 76 patients, a larger sample size would provide more robust statistical power, especially for subgroup analyses. Although all cases of secondary glaucoma were managed successfully, this study did not evaluate the long-term efficacy of different treatment modalities (e.g., medical vs. surgical management).

CONCLUSION

In conclusion, our findings underscore the importance of preoperative risk stratification, tailored monitoring protocols, and comprehensive glaucoma evaluation beyond IOP measurement. Future research should focus on developing predictive models for secondary glaucoma risk and evaluating the efficacy of prophylactic measures in high-risk patients.

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