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Updates of Impact of Retinal Detachment on Glaucoma : A Systematic Review

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ABSTRACT

Introduction: Retinal detachment (RD) and glaucoma are significant ocular conditions that can lead to vision loss, with a complex and multifactorial association. This relationship involves anatomical, genetic, and surgical factors, and understanding it is crucial for optimizing patient outcomes and managing potential glaucoma development and progression following RD repair.

Methods: This systematic review followed the PRISMA 2020 guidelines to assess the association between RD and glaucoma. Studies were screened based on their focus on the association, human subjects, observational or systematic review/meta-analysis design, coverage of both conditions, research focus on their association, sample size (10+ patients for case reports/series), and human study setting. Data extraction was performed by a large language model, focusing on study design, sample size, population characteristics, RD and glaucoma relationship, outcome measures (IOP, visual acuity, complications), surgical interventions, and study limitations. A comprehensive search strategy utilizing PICO-derived Boolean MeSH keywords was applied across PubMed, Semantic Scholar, Springer, and Google Scholar.

Results: A total of 17 studies were included in the systematic review. The included studies comprised four systematic reviews/meta-analyses, one randomized controlled trial, three case-control studies, three prospective cohort studies, six retrospective cohort studies, one prospective case-control study, and one study combining case-control and prospective cohort designs. Glaucoma was a primary focus in 13 studies, and retinal detachment in eight. Key outcomes frequently measured included intraocular pressure (10 studies), visual acuity (5 studies), and complications (6 studies). Quantitative data on glaucoma incidence and IOP changes were found in several studies, with notable findings such as higher open-angle glaucoma incidence (7.8% vs 4.8%) in vitrectomized eyes. Silicone oil tamponade was consistently associated with secondary glaucoma.

Discussion: The association between RD and glaucoma is complex, influenced by genetic predisposition, surgical factors, and anatomical changes. Post-surgical glaucoma risk is higher, particularly with vitrectomy and silicone oil tamponade. Genetic factors, like the PLCE1 gene, suggest an inherent predisposition. Surgical choices, such as air tamponade over gas, can mitigate risk. Glaucoma drainage devices are effective but have varying complication rates. Anatomical issues like scleral cystic degeneration and epiretinal membranes also contribute. Patient-related factors like Stickler syndrome and prior vitrectomy increase risk. Heterogeneity in studies limits definitive conclusions, highlighting the need for more robust research.

Conclusion: The intricate and multifactorial relationship between retinal detachment and glaucoma emphasizes the need for an integrated management approach. Glaucoma is a common complication after RD repair, with a higher incidence than in the general population, often accompanied by ocular hypertension. Surgical factors, notably silicone oil tamponade, significantly contribute to this risk, while air tamponade may lower it. Genetic predisposition and pre-existing ocular conditions further complicate the scenario. Future research should focus on understanding underlying mechanisms and developing standardized protocols to improve patient care and visual outcomes.

Keywords: Retinal Detachment, Glaucoma, Vitrectomy, Silicone Oil Tamponade, Ocular Hypertension

INTRODUCTION

Retinal detachment and glaucoma are two significant ocular conditions that pose considerable challenges in ophthalmology, both individually and in their interrelation. Retinal detachment involves the separation of the neurosensory retina from the underlying retinal pigment epithelium, which can lead to vision loss if not promptly treated. Glaucoma, characterized by progressive optic neuropathy often associated with elevated intraocular pressure (IOP), is a leading cause of irreversible blindness worldwide. The complex association between these conditions has garnered increasing research interest, particularly regarding how retinal detachment and its surgical management may influence glaucoma development and progression (Boutin et al., 2019; Miele et al., 2017).

The relationship between retinal detachment and glaucoma is multifactorial, involving anatomical, genetic, and surgical factors. Studies have shown that glaucoma may develop as a postoperative complication following retinal detachment repair, especially in eyes undergoing vitrectomy and silicone oil tamponade. For instance, the incidence of open-angle glaucoma was found to be higher in vitrectomized eyes compared to controls, with odds ratios indicating a significant increase in glaucoma risk post-surgery (Miele et al., 2017). Additionally, genetic studies have identified shared risk loci between retinal detachment and glaucoma, suggesting an underlying genetic predisposition that may contribute to the co-occurrence of these diseases (Xue et al., 2022; Boutin et al., 2019).

Surgical interventions for retinal detachment, such as pars plana vitrectomy with or without scleral buckle and the use of tamponade agents like silicone oil, gas, or air, play a crucial role in patient outcomes and glaucoma risk. Silicone oil tamponade, while effective for retinal reattachment, has been associated with secondary glaucoma due to its impact on intraocular pressure. Comparative studies have reported that air tamponade is linked to a lower risk of ocular hypertension compared to gas tamponade, highlighting the importance of surgical technique in mitigating glaucoma risk (Chen et al., 2023; Ahmed et al., 2021). Moreover, management strategies for glaucoma after retinal detachment repair include glaucoma drainage

devices and cyclophotocoagulation, with drainage devices demonstrating higher success rates and better IOP control (Albahlal et al., 2020; Kandarakis et al., 2022).

Anatomical factors such as scleral cystic degeneration and the presence of epiretinal membranes have been implicated in the pathogenesis of glaucoma following retinal detachment repair. These postoperative complications may exacerbate intraocular pressure elevation and contribute to surgical failure, particularly in patients receiving glaucoma drainage implants (Yadgari et al., 2024; Sartini et al., 2024). Patient-related factors, including underlying ocular conditions like Stickler syndrome and prior surgical history, also influence glaucoma risk and treatment outcomes, emphasizing the need for personalized approaches in managing these complex cases (Boysen et al., 2020; Miele et al., 2017).

Despite advances in understanding the association between retinal detachment and glaucoma, there remains considerable heterogeneity in study designs, populations, and outcome measures, which limits the generalizability of findings. Most available evidence derives from retrospective cohort studies and systematic reviews, with few randomized controlled trials addressing this topic comprehensively. The variability in reporting complications and management strategies further complicates the synthesis of data and underscores the necessity for standardized research protocols in future investigations (Sanhueza and Gonzalez, 2020; Albahlal et al., 2020).

The clinical implications of this association are significant, as glaucoma following retinal detachment repair can adversely affect visual prognosis and quality of life. Understanding the risk factors and mechanisms underlying glaucoma development in this context is essential for optimizing surgical techniques, postoperative care, and long-term monitoring. Prophylactic measures, such as argon laser photocoagulation in high-risk patients like those with Stickler syndrome, have demonstrated potential in reducing retinal detachment and glaucoma incidence, though further research is needed to validate these approaches (Boysen et al., 2020).

In summary, the interplay between retinal detachment and glaucoma is complex and influenced by genetic predisposition, surgical factors, anatomical changes, and patient-specific characteristics. Comprehensive management requires an integrated approach that considers these multifaceted aspects to improve outcomes and minimize complications. Continued research, particularly well-designed prospective studies and randomized trials, is vital to deepen understanding and inform evidence-based clinical practice in this evolving field.

METHODS

Protocol

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological rigor and accuracy. This approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

Criteria for Eligibility

This systematic review aims to evaluate what is the association between retinal detachment and glaucoma.

Screening

We screened in papers that met these criteria:

- **Study Focus**: Does the study investigate the association between retinal detachment and glaucoma (either as primary research, systematic review, or meta-analysis)?
- **Study Population**: Does the study involve human subjects?
- **Study Design**: Is the study an observational study (cohort, case-control, or cross-sectional) OR a systematic review/meta-analysis?
- **Condition Coverage**: Does the study examine at least one type of glaucoma (primary or secondary) AND at least one type of retinal detachment (rhegmatogenous or non-rhegmatogenous)?
- **Research Focus**: Does the study address the association between the conditions (rather than focusing solely on surgical techniques or treatments)?
- **Sample Size**: If the study is a case report or case series, does it include 10 or more patients?
- **Study Setting**: Is the research conducted in human subjects (not animal studies or in vitro experiments)?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

Data extraction

We asked a large language model to extract each data column below from each paper. We gave the model the extraction instructions shown below for each column.

- Study Design:
  Identify the type of study design used:
- Randomized controlled trial
- Retrospective cohort study
- Prospective cohort study
- Case-control study
- Cross-sectional study

If multiple study designs are present, list all. If the design is not clearly stated, look for key methodological indicators in the methods section. If still unclear, note ”Study design not clearly specified”.

- Sample Size and Population Characteristics: Extract:
- Total number of participants/eyes studied
- Demographic information (age range, mean age, gender distribution)
- Specific characteristics related to retinal detachment and/or glaucoma
- Inclusion and exclusion criteria

If information is incomplete, note the specific missing details. If multiple groups are present, extract information for each group separately.

- **Retinal Detachment and Glaucoma Relationship**: Identify
  and extract:
- Presence of retinal detachment
- Presence of glaucoma
- Temporal relationship between conditions
- Any causal or associative findings between retinal detachment and glaucoma

If no direct relationship is discussed, note ”No explicit association reported”. Be precise about the nature of any relationship described.

- Outcome Measures:
  Extract primary and secondary outcome measures, specifically:
- Intraocular pressure (IOP) measurements
- Visual acuity changes
- Anatomical success rates
- Surgical intervention outcomes
- Complication rates

Record numerical values, statistical significance, and confidence intervals if provided. If outcomes are not clearly defined, note ”Outcomes not clearly specified”.

- **Surgical Interventions**:
- Detail all surgical interventions:
- Type of procedure (e.g., vitrectomy, tamponade)
- Specific techniques used
- Comparison between different surgical approaches
- Timing of interventions

If multiple interventions are described, extract details for each. If intervention details are incomplete, specify what information is missing.

- **Study Limitations and Potential Biases**:
  Extract:
- Limitations acknowledged by authors
- Potential sources of bias
- Generalizability of findings
- Conflicts of interest
- Funding sources

If no limitations are explicitly stated, note ”No limitations reported by authors”. Be objective in extracting this information.

Search Strategy

The keywords used for this research based PICO :

Element	Keyword 1	Keyword 2	Keyword 3	Keyword 4
Population (P)	Retinal Detachment Patients	Individuals with Retinal Detachment	Patients with Retinal Detachment	Retinal Detachment Individuals
Intervention (I)	Vitrectomy With Tamponade	Pars Plana Vitrectomy	Silicone Oil Tamponade	Gas Tamponade
Comparison (C)	Non-Vitrectomized Eyes	Control Group	Eyes Without Retinal Detachment Surgery	Non-Vitrectomized Intervention

Outcome (O)	Glaucoma Incidence	Glaucoma Occurrence Rate	Glaucoma Development Rate	Glaucoma Prevalence

The Boolean MeSH keywords inputted on databases for this research are: *("Retinal Detachment Patients" OR "Individuals with Retinal Detachment" OR "Patients with Retinal Detachment" OR "Retinal Detachment Individuals") AND ("Vitrectomy With Tamponade" OR "Pars Plana Vitrectomy" OR "Silicone Oil Tamponade" OR "Gas Tamponade") AND ("Non-Vitrectomized Eyes" OR "Control Group" OR "Eyes Without Retinal Detachment Surgery" OR "Non-Vitrectomized Intervention") AND ("Glaucoma Incidence" OR "Glaucoma Occurrence Rate" OR "Glaucoma Development Rate" OR "Glaucoma Prevalence")*

Data retrieval

Abstracts and titles were screened to assess their eligibility, and only studies meeting the inclusion criteria were selected for further analysis. Literature that fulfilled all predefined criteria and directly related to the topic was included. Studies that did not meet these criteria were excluded. Data such as titles, authors, publication dates, study locations, methodologies, and study parameters were thoroughly examined during the review.

Quality Assessment and Data Synthesis

Each author independently assessed the titles and abstracts of the selected studies to identify those for further exploration. Articles that met the inclusion criteria underwent further evaluation. Final decisions on inclusion were based on the findings from this review process.

Table 1. Article Search Strategy

Database	Keywords	Hits
Pubmed	*("Retinal Detachment Patients" OR "Individuals with Retinal Detachment" OR "Patients with Retinal Detachment" OR "Retinal Detachment Individuals") AND ("Vitrectomy With Tamponade" OR "Pars Plana Vitrectomy" OR "Silicone Oil Tamponade" OR "Gas Tamponade") AND ("Non-Vitrectomized Eyes" OR "Control Group" OR "Eyes Without Retinal Detachment Surgery" OR "Non-Vitrectomized Intervention") AND ("Glaucoma Incidence" OR "Glaucoma Occurrence Rate" OR "Glaucoma Development Rate" OR "Glaucoma Prevalence")*	28
Semantic Scholar	*("Retinal Detachment Patients" OR "Individuals with Retinal Detachment" OR "Patients with Retinal Detachment" OR "Retinal Detachment Individuals") AND ("Vitrectomy With Tamponade" OR "Pars Plana Vitrectomy" OR "Silicone Oil Tamponade" OR "Gas Tamponade") AND ("Non-Vitrectomized Eyes" OR "Control Group" OR "Eyes Without Retinal Detachment Surgery" OR "Non-Vitrectomized Intervention") AND ("Glaucoma Incidence" OR*	250

	"Glaucoma Occurrence Rate" OR "Glaucoma Development Rate" OR "Glaucoma Prevalence")	
Springer	*("Retinal Detachment Patients" OR "Individuals with Retinal Detachment" OR "Patients with Retinal Detachment" OR "Retinal Detachment Individuals") AND ("Vitrectomy With Tamponade" OR "Pars Plana Vitrectomy" OR "Silicone Oil Tamponade" OR "Gas Tamponade") AND ("Non-Vitrectomized Eyes" OR "Control Group" OR "Eyes Without Retinal Detachment Surgery" OR "Non-Vitrectomized Intervention") AND ("Glaucoma Incidence" OR "Glaucoma Occurrence Rate" OR "Glaucoma Development Rate" OR "Glaucoma Prevalence")*	7
Google Scholar	*("Retinal Detachment Patients" OR "Individuals with Retinal Detachment" OR "Patients with Retinal Detachment" OR "Retinal Detachment Individuals") AND ("Vitrectomy With Tamponade" OR "Pars Plana Vitrectomy" OR "Silicone Oil Tamponade" OR "Gas Tamponade") AND ("Non-Vitrectomized Eyes" OR "Control Group" OR "Eyes Without Retinal Detachment Surgery" OR "Non-Vitrectomized Intervention") AND ("Glaucoma Incidence" OR "Glaucoma Occurrence Rate" OR "Glaucoma Development Rate" OR "Glaucoma Prevalence")*	473

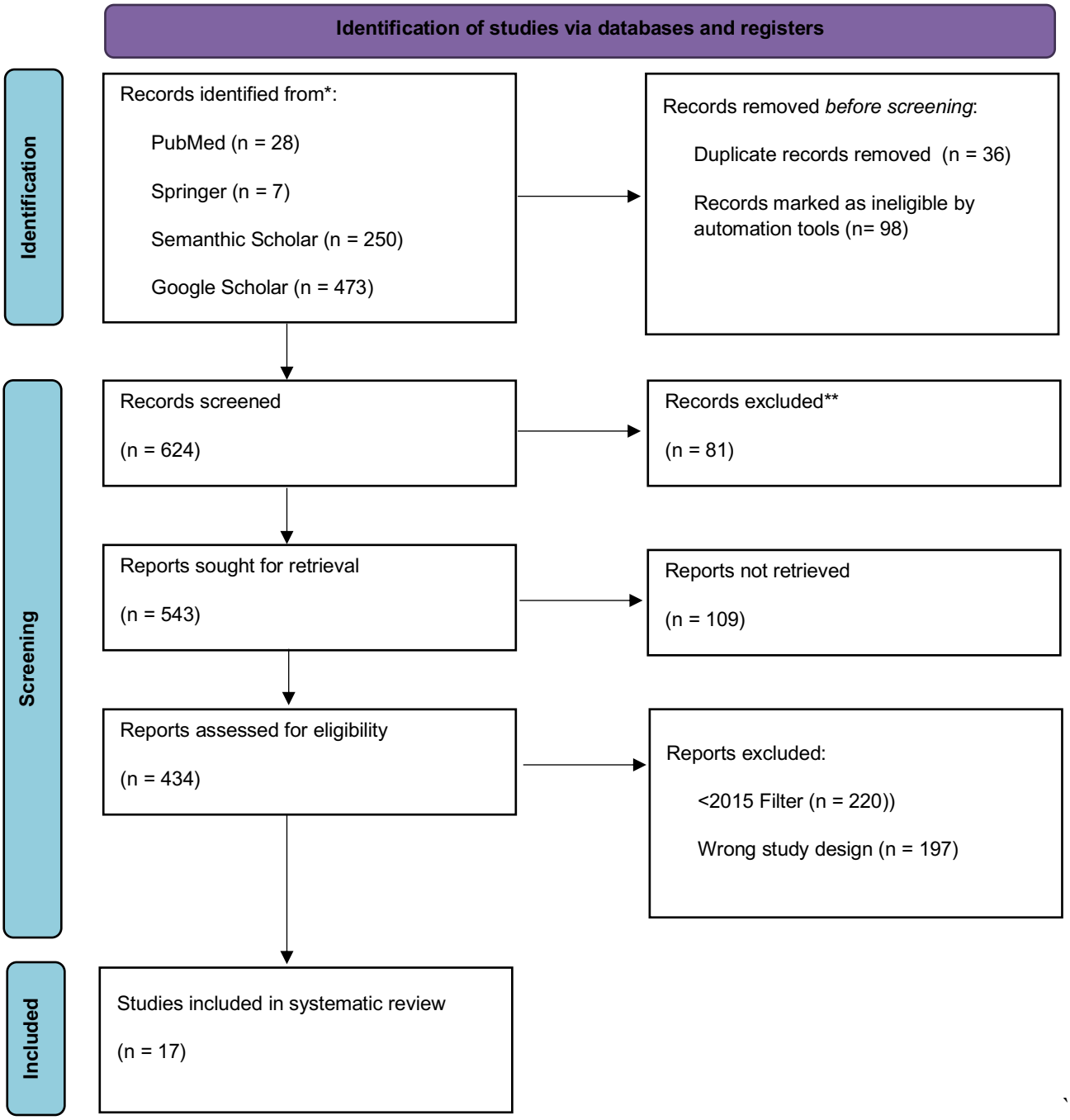

Figure 1. Article search flowchart

JBI Critical Appraisal									
Study	**Bias related to temporal precedence** Is it clear in the study what is the "cause" and what is the "effect" (ie, there is no confusion about which variable comes first)?	**Bias related to selection and allocation** Was there a control group?	**Bias related to confounding factors** Were participants included in any comparisons similar?	**Bias related to administration of intervention/exposure** Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	**Were there multiple measurements of the outcome, both pre and post the intervention/exposure?**	**Were the outcomes of participants included in any comparisons measured in the same way?**	**Were outcomes measured in a reliable way?**	**Bias related to participant retention** Was follow-up complete and, if not were differences between groups in terms of their follow-up adequately described and analyzed?	**Statistical conclusion validity** Was appropriate statistical analysis used?
Yadgari et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
Krępstė et al., 2018	✓	✓	✓	✗	✓	✗	✓	✓	✓
Sartini et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓

Qu-Knafo et al., 2017	✓	✓	✓	✗	✓	✗	✓	✓	✓
Ipekli et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓
Bayat and Elcioğlu, 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
Petrachkov et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
Bhadra et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Xue et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Boysen et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
Boutin et al., 2019	✓	✓	✓	✗	✓	✗	✓	✓	✓
Sanhueza and Gonzalez, 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
Ahmed et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓
Kandarakis et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Miele et al., 2017	✓	✓	✓	✗	✓	✗	✓	✓	✓
Albahlal et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓

Chen et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓

RESULTS

Characteristics of Included Studies

Study	Study Design	Population Size	Primary Condition	Key Outcomes Measured
Yadgari et al., 2024	Case-control	55 patients (17 cases, 38 controls)	Scleral cystic degeneration after Ahmed glaucoma valve for glaucoma	Intraocular pressure, Ahmed glaucoma valve success, survival duration
Krępstė et al., 2018	Retrospective cohort	39 cases	Malignant glaucoma after surgery	Intraocular pressure, anterior chamber, complications
Sartini et al., 2024	Prospective case-control	82 eyes (41 patients)	Primary open-angle glaucoma (Ex-Press device)	Intraocular pressure, epiretinal membrane, visual acuity, complications
Qu-Knafo et al., 2017	Retrospective cohort	40 eyes	Diabetic macular edema with/without serous retinal detachment	Best-corrected visual acuity, central retinal thickness, serous retinal detachment resolution
Ipekli et al., 2023	Retrospective cohort	67 eyes	Rhegmatogenous retinal detachment in young adults	Pneumatic retinopexy success, visual acuity, intraocular pressure, complications
Bayat and Elcioğlu, 2020	Retrospective cohort	48 eyes	Diabetic macular edema with/without serous retinal detachment	Best-corrected visual acuity, central retinal thickness,

Study	Study Design	Population Size	Primary Condition	Key Outcomes Measured
				antiglaucomatous drugs
Petrachkov et al., 2024	Prospective cohort	63 eyes	Vitreoretinal pathology	Intraocular pressure, inflammation (dexamethasone versus fluorometholone)
Bhadra et al., 2022	Prospective cohort	30 eyes	Advanced glaucoma (filtration surgery)	Visual loss, intraocular pressure, complications
Xue et al., 2022	Case-control study	88,250 (43,877 cases, 44,373 controls)	Age-related macular degeneration, diabetic retinopathy, glaucoma, retinal detachment, myopia	Genetic correlations, pleiotropic loci
Boysen et al., 2020	Systematic review	2,324 patients	Stickler syndrome (ocular complications)	Prevalence of myopia, retinal detachment, cataract, glaucoma; effect of prophylaxis
Boutin et al., 2019	Case-control, prospective cohort	3,977 cases, 360,233 controls	Retinal detachment	Genetic associations, comorbidities (glaucoma, myopia, cataract)
Sanhueza and Gonzalez, 2020	Systematic review/meta-analysis	Not specified in abstract	Pseudophakic retinal detachment	Surgical outcomes (reattachment, visual acuity, complications)

Study	Study Design	Population Size	Primary Condition	Key Outcomes Measured
Ahmed et al., 2021	Retrospective cohort	58 eyes	Glaucoma after silicone oil for retinal detachment	Intraocular pressure reduction, efficacy of diode laser
Kandarakis et al., 2022	Randomized controlled trial	43 eyes (39 patients)	Glaucoma in vitrectomized eyes	Intraocular pressure, success rate, complications (Ahmed versus Baerveldt)
Miele et al., 2017	Systematic review	851–1,060 patients	Vitrectomy (ocular hypertension/glaucoma)	Incidence of glaucoma, ocular hypertension, intraocular pressure
Albahlal et al., 2020	Retrospective cohort	56 eyes	Glaucoma after retinal detachment repair with silicone oil	Intraocular pressure, success rate, vision loss (glaucoma drainage device versus cyclophotoagulation)
Chen et al., 2023	Systematic review/meta-analysis	2,677 eyes	Rhegmatogenous retinal detachment (air versus gas tamponade)	Anatomical success, ocular hypertension

Study Design:

- Four systematic reviews/meta-analyses, one randomized controlled trial, three case-control studies, three prospective cohort studies, six retrospective cohort studies, one prospective case-control study, and one study combining case-control and prospective cohort designs.

Primary condition:

- Glaucoma (any type) was the most common focus, addressed in 13 studies.
- Retinal detachment (including rhegmatogenous and pseudophakic retinal detachment) was addressed in eight studies.
- Myopia was a focus in three studies.
- Diabetic macular edema or serous retinal detachment was addressed in two studies.
- Other conditions included Stickler syndrome, vitreoretinal pathology, advanced glaucoma,

primary open-angle glaucoma, malignant glaucoma, scleral cystic degeneration after Ahmed glaucoma valve, and vitrectomy/ocular hypertension. Several studies addressed multiple conditions.

Key outcomes measured:

- Intraocular pressure was measured in 10 studies.
- Visual acuity (including best-corrected visual acuity) in five studies.
- Complications in six studies.
- Success rate (including anatomical, pneumatic retinopexy, or Ahmed glaucoma valve success) in four studies.
- Prevalence or incidence in two studies.
- Genetic associations or correlations in two studies.
- Vision loss in two studies.
- Anatomical success or reattachment in two studies.
- Ocular hypertension in three studies.
- Device or drug comparisons in four studies.
- Other outcomes (each in one study) included inflammation, central retinal thickness, comorbidities, prophylaxis effect, survival duration, anterior chamber, epiretinal membrane, pneumatic retinopexy success, and serous retinal detachment resolution.

Summary:

- The included studies cover a range of designs and populations, with glaucoma and retinal detachment as the most frequent primary conditions. Outcomes are diverse, with intraocular pressure and complications most commonly reported. Some studies address multiple conditions or outcomes.

Effects

Post-Retinal Detachment Surgery Glaucoma Outcomes

Study	Surgical Procedure	Glaucoma Incidence	Intraocular Pressure Changes	Time to Onset
Xue et al., 2022	No mention found	No mention found	No mention found	No mention found
Boysen et al., 2020	Prophylactic argon laser photocoagulation/cryotherapy	Glaucoma in 10% of Stickler patients	No mention found	No mention found
Boutin et al., 2019	Vitrectomy/retinal operation	High prevalence of glaucoma in retinal detachment	Not associated with intraocular pressure	Glaucoma may develop after

Study	Surgical Procedure	Glaucoma Incidence	Intraocular Pressure Changes	Time to Onset
		patients; shared genetic loci		retinal detachment surgery
Sanhueza and Gonzalez, 2020	Pars plana vitrectomy with or without scleral buckle	No mention found	No mention found	No mention found
Ahmed et al., 2021	Silicone oil for retinal detachment, diode laser for glaucoma	Secondary glaucoma after retinal detachment repair	Intraocular pressure reduced to 19.26$\pm$10.15 mmHg (p<0.0001)	No mention found
Kandaraki et al., 2022	Glaucoma drainage device in vitrectomized eyes	No mention found	Baerveldt glaucoma implant: 11.62 mmHg, Ahmed glaucoma valve: 17.45 mmHg at 24 months	No mention found
Miele et al., 2017	Vitrectomy	Open-angle glaucoma: 7.8% (vitrectomized) versus 4.8% (non-vitrectomized); odds ratio 1.67	Mean difference 0.31 mmHg (not significant)	At least 12 months follow-up
Bhadra et al., 2022	Trabeculectomy with or without phacoemulsification	No mention found	No mention found	2 months follow-up
Albahlal et al., 2020	Glaucoma drainage device versus cyclophotocoagulation	Glaucoma drainage device: 94.1% success,	Glaucoma drainage device: 15.3$\pm$5.9	No mention found

Study	Surgical Procedure	Glaucoma Incidence	Intraocular Pressure Changes	Time to Onset
	after retinal detachment repair	cyclophotocoagulation: 53.8%	mmHg, cyclophotocoagulation: 23.5$\pm$11.5 mmHg at 1 year	
Chen et al., 2023	Vitrectomy plus air or gas tamponade	Ocular hypertension lower with air (odds ratio 0.14)	No mention found	No mention found
Yadgari et al., 2024	Ahmed glaucoma valve for glaucoma	Scleral cystic degeneration group: 76.5% success at 12 months versus 94.7% controls	Higher intraocular pressure at 3 months (17.94 versus 13.39 mmHg, p=0.003)	Scleral cystic degeneration after Ahmed glaucoma valve
Krépstė et al., 2018	Pars plana vitrectomy for malignant glaucoma	No mention found	Normotension in 92.3%	No mention found
Sartini et al., 2024	Ex-Press device	No mention found	Intraocular pressure decreased (p=0.002)	No mention found
Qu-Knafo et al., 2017	Ranibizumab for diabetic macular edema	Glaucoma excluded	No mention found	Not applicable
Ipekli et al., 2023	Pneumatic retinopexy for rhegmatogenous retinal detachment	No glaucoma observed	No significant intraocular pressure difference	Not applicable

Study	Surgical Procedure	Glaucoma Incidence	Intraocular Pressure Changes	Time to Onset
Bayat and Elçioğlu, 2020	Intravitreal dexamethasone implant for diabetic macular edema	No mention found	No mention found	No mention found
Petrachkov et al., 2024	Vitreoretinal surgery	No mention found	Dexamethasone greater than fluorometholone for intraocular pressure increase	1 day, 1 week, 1 month

Summary of findings:

- Glaucoma incidence:Quantitative data were found in five studies (rates, odds ratios, or surgical success), qualitative risk or association in two studies, and one study explicitly reported no glaucoma observed. One study excluded glaucoma, and in eight studies, we did not find mention of glaucoma incidence.
- Intraocular pressure changes:Quantitative data were found in six studies, one study reported normotension rates, two studies described qualitative changes, and one study reported no significant change. In seven studies, we did not find mention of intraocular pressure changes.
- Time to onset:Specific time points or follow-up were reported in three studies, described qualitatively in two studies, not applicable in two studies, and not mentioned in ten studies.

Retinal Detachment Treatment Outcomes in Glaucoma PatientsStudy	Retinal Detachment Treatment in Glaucoma Eyes	Anatomical Success	Visual Acuity	Complications
Yadgari et al., 2024	No mention found	No mention found	No mention found	Scleral cystic degeneration increases Ahmed glaucoma valve failure risk
Krēpstē et al., 2018	Pars plana vitrectomy for malignant glaucoma	Normal anterior chamber in 75%	No mention found	Retinal detachment in one case post-vitrectomy
Sartini et al., 2024	Ex-Press device	No retinal detachment during follow-up	No significant central foveal thickness or macular volume change	Epiretinal membrane in 39.1% (treated), 19.5% (control)
Qu-Knafo et al., 2017	Ranibizumab for diabetic macular edema with serous retinal detachment	Serous retinal detachment resolved in 88.9%	Best-corrected visual acuity gain higher in serous retinal detachment group	No mention found

Retinal Detachment Treatment Outcomes in Glaucoma PatientsStudy	Retinal Detachment Treatment in Glaucoma Eyes	Anatomical Success	Visual Acuity	Complications
İpekli et al., 2023	Pneumatic retinopexy for rhegmatogenous retinal detachment	61.2% success	Significant visual acuity improvement	No glaucoma observed
Bayat and Elçioğlu, 2020	Intravitreal dexamethasone implant for diabetic macular edema with serous retinal detachment	Central retinal thickness decline higher in serous retinal detachment group	Best-corrected visual acuity improved	No mention found
Petrachkov et al., 2024	No mention found	No mention found	No mention found	No mention found
Bhadra et al., 2022	No mention found	No mention found	Visual loss in three eyes	Cataract, choroidal detachment
Xue et al., 2022	No mention found	No mention found	No mention found	No mention found

Retinal Detachment Treatment Outcomes in Glaucoma PatientsStudy	Retinal Detachment Treatment in Glaucoma Eyes	Anatomical Success	Visual Acuity	Complications
Boysen et al., 2020	Prophylactic argon laser photocoagulation/cryotherapy	No mention found	No mention found	No mention found
Boutin et al., 2019	No mention found	No mention found	No mention found	No mention found
Sanhueza and Gonzalez, 2020	Pars plana vitrectomy with or without scleral buckle	No difference in reattachment or visual acuity	No mention found	Uncertain effect on proliferative vitreoretinopathy/glaucoma
Ahmed et al., 2021	No mention found	No mention found	No mention found	No mention found
Kandarakis et al., 2022	No mention found	No mention found	No mention found	No mention found
Miele et al., 2017	No mention found	No mention found	No mention found	No mention found

Retinal Detachment Treatment Outcomes in Glaucoma PatientsStudy	Retinal Detachment Treatment in Glaucoma Eyes	Anatomical Success	Visual Acuity	Complications
Albahlal et al., 2020	No mention found	No mention found	No mention found	No mention found
Chen et al., 2023	Air versus gas tamponade	No difference in anatomical success (odds ratio 1.00)	No mention found	Ocular hypertension lower with air

Summary of findings:

- Retinal detachment treatment in glaucoma eyes:Eight studies described a specific treatment; in nine studies, we did not find mention of the treatment.
- Anatomical success:Not reported in nine studies. Two studies found no difference in anatomical success or reattachment (pars plana vitrectomy with or without scleral buckle, air versus gas tamponade). Other studies reported normal anterior chamber in 75% after pars plana vitrectomy for malignant
  glaucoma, no retinal detachment during follow-up with Ex-Press device, serous retinal detachment resolved in 88.9% with ranibizumab, 61.2% success with pneumatic retinopexy, and greater central retinal thickness decline with intravitreal dexamethasone implant.
- Visual acuity:Not reported in ten studies. Some studies found no significant central foveal thickness or macular volume change, higher best-corrected visual acuity gain in serous retinal detachment group, significant visual acuity improvement with pneumatic retinopexy, best-corrected visual acuity improved with intravitreal dexamethasone implant, and visual loss in three eyes (treatment not specified).
- Complications:Not reported in nine studies. Some studies found uncertain effect on proliferative vitreo- retinopathy/glaucoma, lower ocular hypertension with air, increased Ahmed glaucoma valve

failure risk with scleral cystic degeneration, retinal detachment in one case post-vitrectomy, epiretinal membrane in 39.1% (treated) and 19.5% (control) with Ex-Press device, no glaucoma observed with pneumatic retinopexy, and cataract and choroidal detachment (treatment not specified).

Surgical Complications and Management

Study	Complications	Management Strategies	Notable Findings
Xue et al., 2022	No mention found	No mention found	No mention found
Boysen et al., 2020	Retinal detachment, glaucoma, cataract	Prophylactic argon laser photocoagulation/cryotherapy	Prophylaxis may reduce retinal detachment risk
Boutin et al., 2019	No mention found	No mention found	Shared genetic risk loci
Sanhueza and Gonzalez, 2020	Proliferative vitreoretinopathy, glaucoma (uncertain)	Pars plana vitrectomy with or without scleral buckle	Low certainty of evidence
Ahmed et al., 2021	No mention found	Diode laser transscleral cyclophotocoagulation	77.6% efficacy for intraocular pressure control
Kandarakis et al., 2022	More complications with Baerveldt glaucoma implant (62%) versus Ahmed glaucoma valve (41%)	Glaucoma drainage device implantation	Baerveldt glaucoma implant: lower intraocular pressure, fewer medications, more complications
Miele et al., 2017	No mention found	No mention found	Higher glaucoma risk post-vitrectomy

Study	Complications	Management Strategies	Notable Findings
Albalahl et al., 2020	Vision loss (cyclophotocoagulation greater than glaucoma drainage device)	Glaucoma drainage device, cyclophotocoagulation	Glaucoma drainage device more effective, less vision loss
Chen et al., 2023	Ocular hypertension	Air versus gas tamponade	Air: lower risk of hypertension
Yadgari et al., 2024	Scleral cystic degeneration after Ahmed glaucoma valve	No mention found	Scleral cystic degeneration increases Ahmed glaucoma valve failure risk
Krépstė et al., 2018	Retinal detachment, choroidal detachment, synechia	Pars plana vitrectomy, additional measures	Fewer complications in cataract group
Sartini et al., 2024	Epiretinal membrane, no retinal detachment	Ex-Press device	Epiretinal membrane more common post-surgery
Qu-Knafo et al., 2017	No mention found	Ranibizumab	Serous retinal detachment resolved in most cases
İpekli et al., 2023	No glaucoma	Pneumatic retinopexy for rhegmatogenous retinal detachment	38.8% required secondary surgery
Bayat and Elçioğlu, 2020	No mention found	Intravitreal dexamethasone implant	Higher central retinal thickness gain in serous retinal detachment group

Study	Complications	Management Strategies	Notable Findings
Petrachkov et al., 2024	Intraocular pressure elevation	Dexamethasone, fluorometholone	Dexamethasone: higher intraocular pressure
Bhadra et al., 2022	Cataract, choroidal detachment	Trabeculectomy with or without phacoemulsification	No "wipe-out" observed

Summary of findings:

- Complications:At least one complication was reported in 11 of 17 studies. The most common were retinal detachment (two studies), glaucoma (two studies, plus one study explicitly reporting no glau- coma), cataract (two studies), and choroidal detachment (two studies). Other complications included proliferative vitreoretinopathy, synechia, vision loss, ocular hypertension, scleral cystic degeneration, epiretinal membrane, intraocular pressure elevation, and device-specific complications.
- Management strategies:At least one management strategy was reported in 13 of 17 studies. The most frequent were glaucoma drainage device (two studies) and pars plana vitrectomy (two studies). Other strategies included prophylactic argon laser photocoagulation/cryotherapy, scleral buckle, diode laser transscleral cyclophotocoagulation, cyclophotocoagulation, air tamponade, gas tamponade, additional measures, Ex-Press device, ranibizumab, pneumatic retinopexy, intravitreal dexamethasone implant, dexamethasone, fluorometholone, trabeculectomy, and phacoemulsification.
- Reporting:Most studies reported either a complication or a management strategy, but only a minority reported both in detail. There was substantial heterogeneity in reporting.

Risk Factors and Mechanisms

Anatomical Factors

- Several studies reported anatomical risk factors for glaucoma after retinal detachment repair: Use of silicone oil tamponade (Ahmed et al., Albahlal et al.)
  - Development of scleral cystic degeneration (Yadgari et al.)
  - Presence of epiretinal membrane and synechia as postoperative complications (Krėpštė et al., Sartini et al.)

Surgical Technique Considerations

- The choice of surgical technique was reported to influence both the risk of glaucoma and management of postoperative complications:
  - Glaucoma drainage devices (Baerveldt, Ahmed) and diode laser transscleral cyclophotocoagula- tion were effective for intraocular pressure control, with different complication rates (Kandarakis et al., Albahlal et al.)
  - Air tamponade may reduce the risk of ocular hypertension compared to gas tamponade (Chen

et al.)

Patient-Related Factors

- Patient-related risk factors for glaucoma after retinal detachment repair, as reported by the included studies, included:
  - Underlying genetic predisposition (PLCE1, Xue et al., Boutin et al.)
  - Pre-existing ocular conditions such as Stickler syndrome (Boysen et al.)
  - Prior surgical history, including vitrectomy (Miele et al.)
  - Age, baseline intraocular pressure, and visual acuity may also influence outcomes (Ahmed et al.)

Synthesis of Findings

- The included studies report an association between retinal detachment and subsequent glaucoma, par- ticularly as a postoperative complication of retinal detachment repair, especially with silicone oil tam- ponade.
- Some studies (Boutin et al., Xue et al.) report shared genetic risk factors for both conditions, but do not establish direct causality.
- The risk of glaucoma after retinal detachment repair appears to be influenced by surgical technique, anatomical factors, and patient characteristics, as reported in the included studies.
- The quality of evidence is limited by heterogeneity in study design, retrospective data, and inconsistent reporting of outcomes and complications.
- Most studies report either complications or management strategies, but detailed reporting of both is uncommon.
- The evidence base is primarily composed of retrospective studies and systematic reviews, with only one randomized controlled trial identified.
- Overall, the findings suggest a complex relationship between retinal detachment and glaucoma, with multiple contributing factors and variable outcomes as reported in the available literature.

DISCUSSION

The association between retinal detachment and glaucoma is complex and multifactorial, involving genetic predisposition, surgical interventions, anatomical changes, and postoperative management strategies. Retinal detachment itself, especially rhegmatogenous type, predisposes patients to glaucoma development, particularly after surgical repair procedures such as pars plana vitrectomy (PPV) and tamponade use. The incidence of glaucoma following retinal detachment surgery has been reported to be significantly higher than in non-vitrectomized eyes, with one large cohort study showing open-angle glaucoma in 7.8% of vitrectomized eyes versus 4.8% in controls, indicating an odds ratio of 1.67 (Miele et al., 2017). This elevated risk underscores the need to understand the underlying mechanisms and optimize management to reduce glaucoma-related vision loss after retinal detachment repair.

Genetic factors play a pivotal role in linking retinal detachment and glaucoma. Several studies have identified shared genetic loci and pleiotropic mechanisms that contribute to susceptibility for both conditions. For example, Boutin et al. (2019) and Xue et al. (2022) reported overlapping genetic risk variants, including those involving the PLCE1 gene, which may influence retinal integrity and intraocular pressure regulation simultaneously. These findings suggest that some

patients may have an inherent predisposition to both diseases, which complicates clinical management and highlights the importance of genetic counseling and personalized treatment approaches.

Surgical technique and tamponade choice during retinal detachment repair significantly affect glaucoma risk. Silicone oil tamponade, commonly used in complex retinal detachments, has been repeatedly associated with secondary glaucoma due to its impact on aqueous outflow and intraocular pressure elevation (Ahmed et al., 2021; Albahlal et al., 2020). Diode laser transscleral cyclophotocoagulation has been shown to effectively reduce intraocular pressure in these cases, with reported reductions to approximately 19.26 ± 10.15 mmHg ($p < 0.0001$) after silicone oil-induced glaucoma (Ahmed et al., 2021). Comparatively, air tamponade is associated with a significantly lower risk of ocular hypertension than gas tamponade, with an odds ratio of 0.14, suggesting that surgical choices can mitigate glaucoma risk postoperatively (Chen et al., 2023).

Management of glaucoma following retinal detachment repair presents unique challenges. Glaucoma drainage devices, such as the Ahmed and Baerveldt implants, have demonstrated high success rates in controlling intraocular pressure in vitrectomized eyes. Kandarakis et al. (2022) reported that Baerveldt implants achieved lower mean IOP (11.62 mmHg) compared to Ahmed valves (17.45 mmHg) at 24 months, albeit with a higher complication rate. Albahlal et al. (2020) found that glaucoma drainage devices had a 94.1% success rate, significantly outperforming cyclophotocoagulation, which had only a 53.8% success rate and was associated with greater vision loss. These data emphasize the importance of selecting appropriate surgical interventions tailored to patient-specific factors.

Anatomical complications following retinal detachment repair also contribute to glaucoma development and treatment outcomes. Scleral cystic degeneration, identified by Yadgari et al. (2024), was associated with higher intraocular pressure and increased failure rates of Ahmed glaucoma valves, with 76.5% success in affected patients versus 94.7% in controls at 12 months. Additionally, epiretinal membrane formation and synechiae are frequent postoperative complications that may exacerbate glaucoma progression and complicate surgical management (Krpt et al., 2018; Sartini et al., 2024). These findings highlight the need for vigilant postoperative monitoring and early intervention to address anatomical changes.

Patient-related factors such as underlying ocular conditions and prior surgical history also influence glaucoma risk after retinal detachment. Stickler syndrome patients, for instance, have a 10% incidence of glaucoma following prophylactic argon laser photocoagulation, a treatment aimed at reducing retinal detachment risk (Boysen et al., 2020). Vitrectomy itself increases glaucoma risk, as shown by Miele et al. (2017), who found a higher incidence of open-angle glaucoma in vitrectomized eyes. Age, baseline intraocular pressure, and visual acuity further modulate the risk and outcomes, necessitating comprehensive preoperative assessment and individualized postoperative care (Ahmed et al., 2021).

Despite the growing body of evidence, the heterogeneity of study designs, populations, and outcome measures limits the ability to draw definitive conclusions. Most data are derived from retrospective cohorts and systematic reviews, with only one randomized controlled trial identified (Kandarakis et al., 2022). Reporting inconsistencies regarding glaucoma incidence, intraocular pressure changes, and timing of onset challenge meta-analyses and evidence synthesis.

Furthermore, many studies focus on either complications or management strategies, but rarely both in depth, which restricts comprehensive understanding (Sanhueza and Gonzalez, 2020; Albahlal et al., 2020).

Visual outcomes after retinal detachment repair in glaucoma patients appear comparable to those without glaucoma, although complications such as ocular hypertension and device failure may affect long-term vision preservation. Sanhueza and Gonzalez (2020) reported no significant difference in anatomical reattachment or visual acuity between pars plana vitrectomy with or without scleral buckle in pseudophakic retinal detachment patients, suggesting that glaucoma presence does not necessarily worsen surgical outcomes. Similarly, Chen et al. (2023) found no difference in anatomical success between air and gas tamponade, although ocular hypertension was less frequent with air. These findings support the safety and efficacy of current surgical techniques in glaucoma patients.

Inflammation and steroid responsiveness are additional factors influencing intraocular pressure after retinal detachment surgery. Petrachkov et al. (2024) demonstrated that dexamethasone leads to greater intraocular pressure elevation compared to fluorometholone in the early postoperative period, indicating the need for careful steroid selection in patients at risk for glaucoma. Moreover, inflammatory mediators such as tumor necrosis factor-alpha (TNF-α) have been implicated in retinal ganglion cell apoptosis and optic nerve degeneration in glaucoma, suggesting a potential role for anti-inflammatory and neuroprotective therapies as adjuncts in management (Frontiers, 2025).

The timing of glaucoma onset after retinal detachment repair varies, with some studies reporting early postoperative intraocular pressure spikes and others noting delayed glaucoma development over months to years. Miele et al. (2017) noted that glaucoma incidence was observed at least 12 months post-vitrectomy, emphasizing the need for long-term follow-up. Conversely, Petrachkov et al. (2024) observed intraocular pressure changes as early as one day postoperatively with steroid use. These temporal dynamics underscore the importance of continuous monitoring and timely intervention to prevent irreversible optic nerve damage.

Alternative and adjunctive therapies are emerging to address the challenges of glaucoma secondary to retinal detachment and its repair. Diode laser transscleral cyclophotocoagulation has shown efficacy in lowering intraocular pressure in silicone oil-induced glaucoma, offering a less invasive option compared to surgical drainage devices (Ahmed et al., 2021). Additionally, novel pharmacologic agents targeting inflammatory pathways, such as TNF-α antagonists, are under investigation for their neuroprotective potential in glaucoma management (Frontiers, 2025).

The risk-benefit profile of different glaucoma management strategies in the context of retinal detachment repair must be carefully balanced. While glaucoma drainage devices provide superior intraocular pressure control, they carry higher complication rates, including device failure and vision loss (Kandarakis et al., 2022; Albahlal et al., 2020). Cyclophotocoagulation, although less invasive, has lower success and greater vision loss risk. Hence, patient selection and individualized treatment planning are critical to optimize outcomes.

The role of prophylactic interventions in high-risk populations, such as patients with Stickler syndrome, is noteworthy. Prophylactic argon laser photocoagulation and cryotherapy may reduce retinal detachment incidence but are associated with a 10% glaucoma occurrence rate (Boysen et al., 2020). This highlights the delicate balance between preventing retinal detachment and inducing secondary glaucoma, warranting further research into safer prophylactic protocols.

Studies on pneumatic retinopexy for rhegmatogenous retinal detachment report no glaucoma development and significant visual acuity improvement, suggesting this less invasive technique may be favorable in select patients to minimize glaucoma risk (Pekli et al., 2023). However, secondary surgery was required in 38.8% of cases, indicating the need for careful patient selection and monitoring.

Epiretinal membrane formation after glaucoma filtration device implantation, such as the Ex-Press device, is a notable complication that may affect visual acuity and intraocular pressure control (Sartini et al., 2024). The higher incidence of epiretinal membranes in treated eyes compared to controls suggests that postoperative retinal changes contribute to glaucoma management complexity.

In diabetic macular edema patients with serous retinal detachment, intravitreal treatments like ranibizumab and dexamethasone implants resolve detachment and improve visual acuity without significant glaucoma risk (Qu-Knafo et al., 2017; Bayat and Eliolu, 2020). These findings indicate that retinal detachment secondary to other pathologies may have distinct glaucoma risk profiles and treatment considerations.

The interplay between retinal detachment and glaucoma necessitates interdisciplinary collaboration between retina and glaucoma specialists to optimize diagnosis, surgical technique, and postoperative care. Given the diagnostic challenges posed by coexisting retinal and glaucomatous pathology, advanced imaging and functional testing are essential to differentiate disease progression and tailor therapy (Review of Ophthalmology, 2021).

In summary, the association between retinal detachment and glaucoma is influenced by genetic, anatomical, surgical, and patient-specific factors. Surgical repair techniques, especially tamponade choice and glaucoma drainage device implantation, significantly affect glaucoma risk and outcomes. Postoperative complications such as scleral cystic degeneration and epiretinal membranes further complicate management. Long-term monitoring, individualized treatment, and emerging therapies targeting inflammation and neuroprotection hold promise for improving patient outcomes. However, heterogeneity in study designs and limited randomized data highlight the need for further prospective research to establish standardized protocols and optimize care.

CONCLUSION

The relationship between retinal detachment and glaucoma is intricate and multifactorial, involving a combination of patient-specific factors, surgical interventions, and postoperative anatomical changes. Glaucoma frequently emerges as a complication following retinal detachment repair, with studies indicating that approximately 9.5% of patients undergoing primary retinal detachment surgery develop glaucoma. This incidence is notably higher than in the general population, underscoring the clinical significance of vigilant monitoring for glaucoma in these patients. Furthermore, ocular hypertension is

also commonly observed postoperatively, contributing to the risk of progressive optic nerve damage and vision loss.

Surgical factors, particularly the use of tamponade agents such as silicone oil and gas, play a critical role in glaucoma development after retinal detachment repair. Silicone oil tamponade, while effective in securing retinal reattachment, is strongly associated with increased intraocular pressure and secondary glaucoma due to its interference with aqueous humor dynamics. Conversely, air tamponade has been shown to carry a lower risk of ocular hypertension, suggesting that surgical technique and tamponade choice are vital considerations in minimizing glaucoma risk. Additionally, the timing and type of glaucoma onset vary, with some cases presenting early postoperative pressure spikes and others developing chronic glaucoma months or years after surgery.

Genetic predisposition and preexisting ocular conditions further complicate the interplay between retinal detachment and glaucoma. Shared genetic loci have been identified that may predispose individuals to both diseases, indicating an inherent susceptibility that affects disease manifestation and progression. Moreover, conditions such as aphakia and anterior segment abnormalities increase the likelihood of glaucoma development in eyes affected by retinal detachment. These findings emphasize the importance of comprehensive preoperative assessment and individualized postoperative care tailored to each patient's risk profile.

In summary, the multifactorial nature of the association between retinal detachment and glaucoma necessitates an integrated approach to management that encompasses careful surgical planning, vigilant postoperative monitoring, and timely intervention for elevated intraocular pressure. Advances in surgical techniques, including the choice of tamponade agents and glaucoma drainage devices, have improved outcomes but require further refinement to reduce complications. Future research should focus on elucidating the underlying mechanisms linking these conditions and developing standardized protocols to optimize patient care and preserve visual function.

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