



Risk Factors for Retinal Detachment Repair After Pediatric Cataract Surgery in the United States

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Purpose: To determine the cumulative incidence of retinal detachment (RD) repair following pediatric cataract surgery and identify the associated risk factors.

Design: US population-based insurance claims retrospective cohort study.

Participants: Patients ≤ 18 years old who underwent cataract surgery in 2 large databases: Optum Clinformatics (2003–2021) and IBM MarketScan (2007–2016).

Methods: Individuals with ≥ 6 months of prior enrollment were included, and those with a history of RD, RD repair, traumatic cataract, spherophakia, or ectopia lentis were excluded. The primary outcome was time between initial cataract surgery and RD repair. The risk factors investigated included age, sex, persistent fetal vasculature (PFV), prematurity, intraocular lens (IOL) placement, and pars plana lensectomy approach.

Main Outcome Measures: Kaplan–Meier estimated cumulative incidence of RD repair 5 years after cataract surgery and hazard ratios (HRs) with 95% confidence intervals (CIs) from multivariable Cox proportional hazards regression models.

Results: Retinal detachment repair was performed on 47 of 3289 children included in this study. The cumulative incidence of RD repair within 5 years of cataract surgery was 2.0% (95% CI, 1.3%–2.6%). Children requiring RD repair were more likely to have a history of prematurity or PFV and less likely to have an IOL placed (all $P < 0.001$). Factors associated with RD repair in the multivariable analysis included a history of prematurity (HR, 6.89; 95% CI, 3.26–14.56; $P < 0.001$), PFV diagnosis (HR, 8.20; 95% CI, 4.11–16.37; $P < 0.001$), and IOL placement (HR, 0.44; 95% CI, 0.21–0.91; $P = 0.03$). Age at surgery, sex, and pars plana lensectomy approach were not significantly associated with RD repair after adjusting for all other covariates.

Conclusions: Approximately 2% of patients will undergo RD repair within 5 years of pediatric cataract surgery. Children with a history of PFV and prematurity undergoing cataract surgery without IOL placement are at the greatest risk. *Ophthalmology Science* 2022;2:100203 © 2022 by the American Academy of Ophthalmology. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Retinal detachment (RD) is a rare but vision-threatening complication of cataract surgery. The estimated incidence of RD following cataract surgery in children is up to 5.5%,^{1–6} much greater than the frequently reported $< 1\%$ incidence among adults.^{7–9} Explanations for this difference include the presence of congenital anomalies associated with the development of both cataract and RD, greater proportion of individuals with trauma predisposing to RD, and different surgical approaches in pediatric surgery.¹⁰

Pediatric cataract and vitreoretinal surgeons would benefit from a greater understanding of the demographic and operative risk factors associated with RD following cataract surgery in children. Such information would enable opportunities to provide increased surveillance, modification of surgical approach, or prophylactic treatment for high-risk individuals. Studies thus far have identified several risk factors for RD, including male sex,⁶ intellectual disability,^{3,6} ocular or systemic abnormalities,³ myopic refractive error,^{2,6} and wound dehiscence.² However, the majority of existing literature is derived from single-center studies with limited sample sizes

given the infrequency of pediatric cataract surgery compounded by the low incidence of RD.

We leveraged 2 large commercial insurance claims databases to investigate the nationwide incidence of RD after pediatric cataract surgery in the United States. We hypothesize that a claims-based approach would provide a large enough cohort to evaluate the magnitude of association between RD and various patient and operative risk factors of interest, including age, sex, ocular history, surgical approach, and intraocular lens (IOL) use.

Methods

Study Design and Data Source

This population-based retrospective cohort study was performed using administrative claims data from Optum's deidentified Clinformatics Data Mart (CDM) (2003–2021) and IBM MarketScan Research Database (2007–2016). The CDM Database (OptumInsight) is a deidentified commercial and Medicare Advantage claims database. CDM includes data on approximately 15 to 18 million annual enrollees, for a total of > 63 million individuals from a

geographically diverse population spanning all 50 states of the United States. CDM provides demographic and medical claims data for all inpatient and outpatient services, including ambulatory surgery. The IBM MarketScan Databases include > 240 million individuals insured by 350 unique health carriers. MarketScan data include health insurance claims across the continuum of care (e.g., inpatient, outpatient, outpatient pharmacy, and carve-out behavioral health care) and enrollment data from large employers and health plans across the United States. Both medical claims data sets include the International Classification of Disease, ninth and 10th revisions (ICD-9-CM and ICD-10-CM, respectively) diagnosis codes and Current Procedural Terminology (CPT), version 4, procedural codes. Data access for this project was provided by the Stanford Center for Population Health Science Data Core, which is supported by the National Institutes of Health National Center for the Advancing Translational Science Clinical and Translational Science Award (UL1 TR001085) and internal Stanford funding. The content of this article is solely the responsibility of the authors and does not represent the official views of the National Institutes of Health. The Stanford School of Medicine Institutional Review Board determined that this study involving the use of deidentified data did not require institutional review board approval. The study adhered to the Declaration of Helsinki.

Study Population

Individuals were included in the study if diagnosed with a cataract and treated with cataract surgery at ≤ 18 years of age based on the appropriate CPT and ICD codes (Table 1). We included individuals with continuous enrollment prior to cataract surgery (180 days for children aged ≥ 1 year old and no requirement for children < 1 year old to capture all newborns undergoing cataract surgery) and only individuals for whom the cataract diagnosis code was recorded on or prior to the date of cataract surgery. We excluded individuals with traumatic cataract or coexisting ectopia lentis or spherophakia. To focus our investigation on children undergoing cataract surgery without prior retinal pathology, we excluded any individuals with an ICD code for RD diagnosis, ICD code for stage 4 or 5 retinopathy of prematurity, or CPT code which indicated RD repair on or before the date of cataract surgery.

Data Collection

The variables collected for each individual included age, sex, date of cataract surgery, CPT codes on the day of cataract surgery, date of RD diagnosis, date of RD repair, and CPT codes on the day of RD repair. Patient age in these deidentified data sets was available

as the nearest integer value and treated as a continuous variable. The remaining risk factors of interest were treated as categorical variables and included sex, persistent fetal vasculature (PFV) diagnosis (ICD Q14.0, 743.51), history of prematurity (ICD 362.0-5, H35.10-4x), placement of an IOL (CPT 66982, 66983, and 66984), and pars plana lensectomy approach (CPT 66852, 67036).

Primary Outcome

Our primary outcome was RD diagnosis and repair within 5 years of cataract surgery. For children with bilateral cataracts, we used the date of the first cataract surgery. We intentionally limited our analysis to include cases of RD with concurrent RD repair, given concerns that any potentially miscoded diagnosis claims could overestimate the incidence of RD. Current Procedural Terminology codes for RD repair are more likely to reflect an individual with a true case of RD.

Statistical Analysis

For the univariable analyses, we directly compared the baseline patient demographics and operative factors between children who did and did not undergo RD repair within 5 years of cataract surgery. We reported means and standard deviations for continuous variables and frequency and proportions for categorical variables. We performed *t* tests and chi-square tests. For the time-to-event analysis, we reported the cumulative incidence of RD repair at 5 years after cataract surgery using the Kaplan–Meier estimator. Individuals were censored based on the length of continuous enrollment or administratively 5 years following the initial cataract surgery. For the multivariable analysis, we reported adjusted hazard ratios (HRs) for each risk factor estimated using a multivariable Cox proportional hazards regression model adjusting for all other covariates. Age was treated as a continuous variable in the regression model. We performed an additional stratified analysis of the Kaplan–Meier-estimated probability of RD repair by age category and IOL placement. Statistical significance was defined as a 2-tailed *P* value < 0.05 . We reported 95% confidence intervals (CIs). Statistical analyses were conducted using R, version 4.0.2, (R Core Team, 2021) with the survival package for time-to-event analysis.

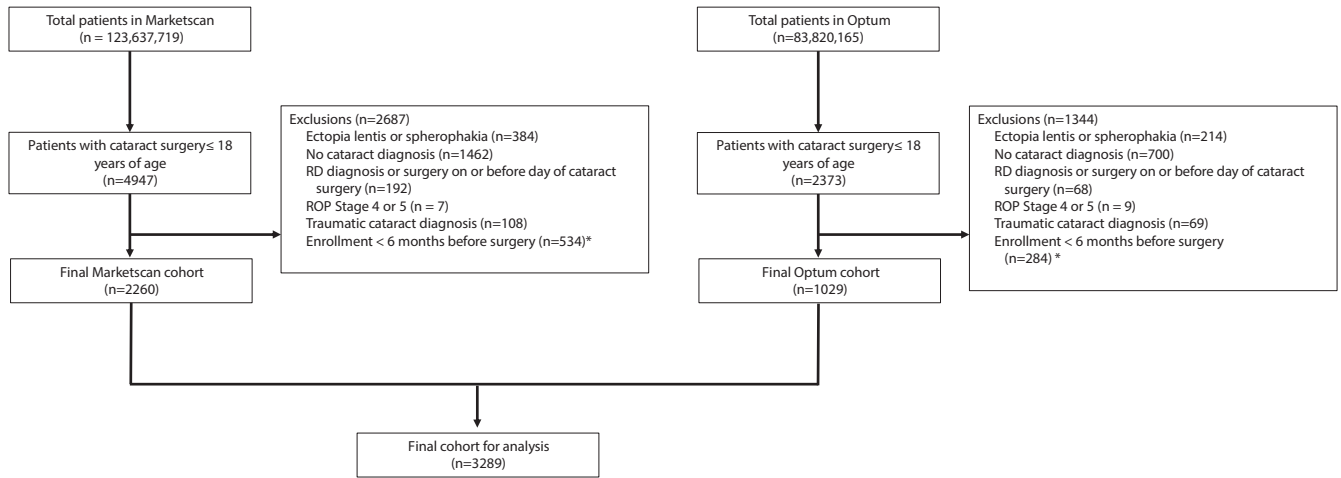
Results

A total of 1029 individuals were identified to have undergone cataract surgery at 18 years of age or younger in the Optum

Table 1. Diagnosis and Procedural Codes Used to Identify Individuals for Inclusion/Exclusion and Potential Risk Factors for RD

Diagnosis/Procedure	Data Type	Codes
Cataract diagnosis	ICD9/10	H26.0, H26.0x, H26.0xx, H26.0xxx, 366.0, 366.0x, Q12.0, 743.30-4
RD diagnosis	ICD 9/10	H33.0, H33.0x, H33.0xx, 361.0, 361.0x, 361.8, 361.8x, 361.9
PFV diagnosis	ICD 9/10	Q14.0, 743.51
Prematurity (ROP diagnosis stage 0–3)	ICD 9/10	362.0-5, H35.10-4x
ROP diagnosis stage 4 and 5	ICD 9/10	362.26, 362.67, H35.15x, H35.16x
Cataract surgery	CPT	66840, 66850, 66852, 66920, 66930, 66940, 66982, 66983, 66984
RD repair	CPT	67101, 67105, 67107, 67108, 67110, 67112, 67113
IOL placement	CPT	66982, 66983, 66984
Pars plana lensectomy approach	CPT	66852, 67036

CPT = Current Procedural Terminology; ICD 9/10 = International Classification of Disease, ninth and 10th revisions; IOL = intraocular lens; PFV = persistent fetal vasculature; RD = retinal detachment; ROP = retinopathy of prematurity.



Notes:

* = only for patients >1 year of age at surgery. No enrollment lookback was used for patients <1 year of age at surgery.

Figure 1. Flowchart illustrating the study inclusion and exclusion criteria. RD = retinal detachment; ROP = retinopathy of prematurity.

CDM database and 2260 in the IBM MarketScan databases. Retinal detachment repair was performed in 47 of the 3289 patients who met the inclusion and exclusion criteria for this study (Figure 1). The cumulative incidence of RD repair within 5 years of cataract surgery was 2.0% (95% CI, 1.3%–2.6%). The median time between initial surgery and RD repair was 47 days (20–232 days) (Figure 2).

Patients requiring RD repair within 5 years of cataract surgery were more likely to be < 1 year of age at time of cataract surgery (51% [24/47] vs. 29% [951/3242], $P = 0.002$), were more likely to have a history of prematurity ($P < 0.001$) or PFV diagnosis (36% [17/47] vs. 6% [188/3242], $P < 0.001$), and were less likely to have an IOL placed during the time of cataract surgery (51% [24/47] vs. 76% [2486/3242], $P < 0.001$) (Table 2). The demographic and operative factors associated with RD repair after pediatric cataract surgery identified using the multivariable

Cox regression model included a history of prematurity (HR, 6.89; 95% CI, 3.26–14.56; $P < 0.001$), PFV diagnosis (HR, 8.20; 95% CI, 4.11–16.37; $P < 0.001$), and IOL placement (HR, 0.44; 95% CI, 0.21–0.91; $P = 0.03$). Age at surgery, sex, and pars plana lensectomy approach were not significantly associated after adjusting for all other covariates (Table 3). The stratified analysis by age category and IOL placement revealed highest probability of RD for children < 1 year of age with IOL placement and children > 1 year of age without IOL placement (Table 4).

Discussion

Approximately 2% of children will develop an RD requiring surgical repair within 5 years of cataract surgery. Our

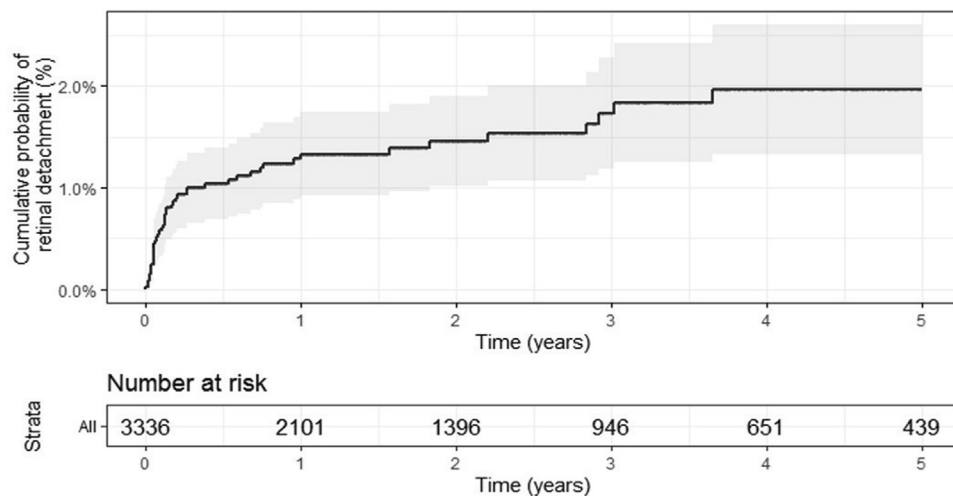


Figure 2. Kaplan–Meier estimate of the cumulative incidence of retinal detachment repair following pediatric cataract surgery.

Table 2. Baseline Demographics and Operative Techniques of Patients Who Underwent Pediatric Cataract Surgery

	Retinal Detachment Repair Within 5 Years of Cataract Surgery		P Value
	No (N = 3242)	Yes (N = 47)	
Age at surgery (continuous)*	5.9 (5.8)	4.4 (5.5)	0.06
Age at surgery (categorical)			0.002
< 1 year	951 (29%)	24 (51%)	
≥ 1 year	2358 (71%)	23 (49%)	
Male sex	1627 (51%)	29 (62%)	0.13
PFV diagnosis	188 (5.7%)	17 (36%)	< 0.001
Prematurity†	102 (3.3%)	< 15	< 0.001
IOL placement	2486 (76%)	24 (51%)	< 0.001
Pars plana lensectomy approach†	475 (14%)	< 15	0.99

IOL = intraocular lens; PFV = persistent fetal vasculature.

*Mean (standard deviation).

†Cell values < 15 are not reported to protect confidentiality.

findings are consistent with prior studies reporting a higher incidence of RD after pediatric cataract surgery than after adult cataract surgery. In addition, we identified a history of prematurity, PFV diagnosis, and no IOL placement as risk factors for RD after adjusting for all covariates, including age at surgery. To our knowledge, our claims-based approach has identified the largest cohort of patients with RD following pediatric cataract surgery described in the literature to date.

The incidence of RD in our study fits well within the range of previously published estimates from smaller case series and population-based studies. Agarkar et al⁶ reported 12 cases of RD among a series of 481 eyes undergoing lensectomy with primary IOL placement at a single tertiary care institution. The 5-year incidence of RD after cataract surgery was 2.5%, and the Kaplan–Meier-estimated cumulative incidence was 5.5% within 10 years. Individuals with intellectual disability and myopia were at increased risk, and all the children who developed RD were male. Similarly, Rabiah et al² identified 33 cases of RD in a single-center series of 1017 eyes that underwent lensectomy without IOL placement. The incidence was 3.2% at a mean follow-up of 6.9 years. RD was associated with myopia in the multivariable analysis and male sex in only the univariate analysis. Finally, in a population-based cohort study, Haargaard et al³ identified 25 cases of RD among 1043 eyes resulting in a 0.8% 5-year risk and 3% 20-year risk among Danish children without ocular or systemic anomalies. Inclusion of children with intellectual disability and ocular or systemic anomalies doubled the risk estimates.

In this study, we did not exclude individuals based on the presence or absence of systemic diagnoses which may predispose to RD, which likely explains the increased incidence we found compared to Haargaard et al. However, we did identify that prematurity was associated with an increased risk of RD following cataract surgery after adjusting for all other covariates, which has not been previously reported. Since prematurity and PFV are independently associated with cataract and RD, further investigation into the additional risk of RD in these patients after cataract surgery is needed. Previous studies have found male sex to be associated with an

increased risk of RD in both children and adults.^{2,6,11–13} Although the increased risk of RD with male sex is not entirely understood, it has been hypothesized that an increased incidence and underreported history of trauma may contribute.¹³ The exclusion of traumatic cataracts may account for the lack of an association between gender and RD in this cohort. Previous studies have shown conflicting relationships between age at cataract surgery and risk of RD. Young age has been associated with an increased risk of RD;¹⁴ however, our multivariable model did not show a significant relationship between age and RD risk, which is consistent with several other published studies.^{3,6} We did not investigate other previously identified risk factors such as intellectual disability and refractive error, given limitations of the claims databases.

Our claims-based analysis of surgical procedure codes identified an overall trend toward IOL placement serving as a protective factor against RD following pediatric cataract surgery. The stratified analysis further demonstrated that IOL placement was associated with a greater risk of RD in children < 1 year of age and a lower risk of RD in children ≥ 1 year of age. Although this relationship has been suspected given increased historical rates of RD prior to the introduction of IOLs in pediatric cataract surgery,¹⁰ the magnitude of

Table 3. The Factors Associated With Risk of Retinal Detachment Repair Following Pediatric Cataract Surgery From the Multivariable Cox Proportional Hazards Regression Model Adjusting for All Covariates

	HR (95% CI)	P Value
Age at surgery*	1.03 (0.97–1.10)	0.37
Male sex	1.61 (0.89–2.90)	0.12
PFV diagnosis	8.20 (4.11–16.37)	< 0.001
Prematurity	6.89 (3.26–14.56)	< 0.001
IOL placement	0.44 (0.21–0.91)	0.03
Pars plana lensectomy approach	0.49 (0.21–1.14)	0.10

CI = confidence interval; HR = hazard ratio; IOL = intraocular lens; PFV = persistent fetal vasculature.

*Per 1-year change.

Table 4. Cases and 5-Year Kaplan–Meier-Estimated Cumulative Probability of Retinal Detachment Repair Stratified by Patient Age at Cataract Surgery and IOL Placement

	IOL Placement	
	No	Yes
Age		
< 1 year	16/659	< 15/316
old	3.1% (95% CI, 1.4%–4.9%)	4.1% (95% CI, 0.5%–7.5%)
≥ 1 year	< 15/167	16/2194
old	4.7% (95% CI, 1.2%–8.2%)	1.1% (95% CI, 0.5%–1.7%)

CI = confidence interval; IOL = intraocular lens.

the association has not been described in a large cohort. Previous studies have also been unable to identify an association between RD and surgical techniques such as posterior capsulotomy and anterior vitrectomy.² We were not able to query this with our claims data as those procedures do not have unique CPT codes and are often bundled with other procedural codes. We were able to look at the individually coded pars plana lensectomy approach; however, there was no significant association with RD.

The strength of our claims-based approach over previous studies is access to a large, nationally representative cohort of patients. Fortunately, although RD is an uncommon complication, the robust sample size of our study provides enough statistical power to identify potential risk factors and their magnitude of association. The claims databases include individuals from across the United States and capture a modern time period involving the use of IOLs in children, in contrast to many of the published series which focus on RD after aphakia.^{4,5,15–17}

There are several limitations inherent to analyzing large claims databases. First, all the data are based on administrative claims and the associated timestamps, which provide relatively few clinically meaningful variables. An investigation of risk factors of RD would benefit from a deeper understanding of patient medical history, type and etiology of cataract, examination findings, refractive error, and biometric measurements, all of which may be associated with risk of RD but cannot be captured through this approach. Second, miscoding of claims data is problematic, especially for diagnostic codes. For this reason, we focused our efforts on identifying children with RD repair after cataract surgery in order to not overestimate the incidence of RD due to miscoding. Agarkar et al⁶ reported that 2 of 12 of the cases of RD they identified were not repaired surgically. Although the majority of RD cases are treated surgically, we acknowledge that our approach likely provides a conservative estimate of the overall incidence of RD. In addition, CPT claims often do not contain information on

laterality, which may result in an overestimate of RD repairs through inclusion of contralateral cases. Since the cohort includes children undergoing unilateral and bilateral cataract surgery, the cumulative incidence of RD should be interpreted at the individual level and not at the eye level. Finally, the length of follow-up in our study is limited to individuals who remain consistently enrolled in the same insurance plan. Although RD after cataract surgery in adults most often occurs between 8 and 40 months postoperatively,^{11,13,18} RD in children has historically been reported to occur as a delayed complication which may be related to differences in vitreous consistency, in the rate of vitreous liquefaction, or in the time to posterior vitreous detachment development.¹⁰ The end point used in this study, 5 years after cataract surgery, was based on the median length of enrollment of the cohort and thus may not capture delayed cases of RD. The 6-month lookback period used in this study for children over the age of 1 year may not be long enough to capture all incident cases of RD prior to cataract surgery. Short lookback periods have been shown to overestimate incident cases of ocular diagnoses¹⁹ and in this study may result in an overestimation of RD repairs. Finally, there is potential for overlap of the patients in the 2 insurance claim databases used in this study. Employers providing data to the MarketScan databases may purchase their insurance from United Healthcare, the supplier of Optum data. Patients who transfer insurance providers during treatment may also be counted twice in this analysis. This potential overlap could bias our results if patient presence in both data sets is associated with the risk of RD.

In conclusion, our claims-based approach to study RD contributes to our understanding of this rare but vision-threatening complication of pediatric cataract surgery. The large nationwide sample provided cumulative incidence estimates consistent with existing single-center studies in the literature. The higher risk of RD after pediatric cataract surgery compared to adult surgery justifies the need for long-term follow-up in this population. In particular, children with a history of prematurity and PFV undergoing cataract surgery without IOL placement are at the greatest risk of developing RD, and future efforts directed toward screening and preventative strategies would be particularly beneficial for individuals with these risk factors.

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Footnotes and Disclosures

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Data analysis and/or interpretation: Isdin Oke, Bryce Hwang, Hwan Heo, Angeline Nguyen, Scott Lambert.

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Abbreviations and Acronyms:

CDM = Optum Clinformatics Data Mart; **CI** = confidence interval; **CPT** = Current Procedural Terminology; **HR** = hazard ratio; **ICD 9/10** = International Classification of Disease, ninth and 10th revisions; **IOL** = intraocular lens; **PFV** = persistent fetal vasculature; **RD** = retinal detachment.

Keywords:

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