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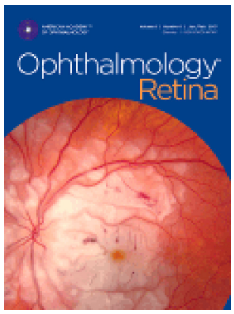

Epidemiology, clinical features, and visual outcomes after intraocular foreign body removal: an IRIS® Registry (Intelligent Research in Sight) Analysis

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Epidemiology, clinical features, and visual outcomes after intraocular foreign body removal: an IRIS® Registry (Intelligent Research in Sight) Analysis

Running head: IRIS Analysis of IOFB visual outcomes

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Key Words: Intraocular foreign body, Outcomes, IRIS Registry, Pars plana vitrectomy, Retinal detachment

Supplemental material available at https://www.ophthalmologyretina.org/.

Abstract

Purpose: To describe the epidemiology, clinical features, and visual outcomes following intraocular foreign body (IOFB) removal.

Design: Retrospective multicenter cohort study utilizing data from the American Academy of Ophthalmology IRIS® Registry (Intelligent Research in Sight).

Subjects: Eyes that underwent IOFB removal between January 2016 and October 2024.

Methods: Sociodemographic information, clinical features at presentation, primary surgical procedures and postoperative complications were summarized. Multivariable linear mixed-effects regression models were employed to investigate predictors of visual outcomes up to 18 months post-IOFB removal.

Main outcome measure: Epidemiology (including annual incidence rates and associated factors) and clinical characteristics; predictors of visual acuity (VA) up to 18 months post-IOFB removal.

Results: A total of 4784 eyes (4684 patients, 70.3% male) with a median age of 55 years at presentation (interquartile range 36-70) were identified over the study period. Mean annual incidence was estimated at 2.32 per 100,000 patient-years (95% CI 2.12-2.52) and was independently associated with male sex, race, and rural residence. The most common complications at presentation were retinal detachment (12.5%), cataract (10.5%), vitreous hemorrhage (7.9%), and endophthalmitis (3.9%). Median VA at presentation was 1.24 logMAR (IQR 0.30-2.30). A significant improvement in VA was seen only from month two post-IOFB removal (-0.38 logMAR, 95%CI -0.41 to -0.34), with further minor improvements up to month 18 (-0.59 logMAR, 95%CI -0.69 to -0.48). After adjusting for relevant covariates, Black or African American race and presence of endophthalmitis, retinal detachment or hyphema at baseline were associated with worse visual outcomes. Subgroup analysis of patients with pre-IOFB VA found that improvement was attenuated for people with pre-IOFB VA worse than 1.0 logMAR.

Conclusions: These findings offer a real-world benchmark for post-IOFB visual trajectories and outcomes, and may support clinicians in prognostication and patient counselling. Further research is needed to investigate the underlying drivers of observed racial disparities to inform equitable care.

Open globe injuries (OGI) involving intraocular foreign bodies (IOFB) are ophthalmic emergencies with the potential for severe and lasting visual impairment. Despite their clinical significance, there remains a lack of contemporary, population-level data on the sociodemographic profiles, clinical presentation, and long-term visual outcomes associated with these injuries.

Existing literature on the topic is limited in scope. Most published studies to date predominantly focus on OGI. A smaller number of reports on IOFBs mostly comprise small sample sizes and single-center settings, with a dearth of longitudinal follow-up.[1–9] The available literature includes data largely collected from previous decades, which may not fully capture the impact of modern surgical techniques and treatment protocols (including antimicrobial prophylaxis practices), thus limiting their utility for guiding prognosis and clinical management. In addition, while these studies were conducted across a diverse range of countries, robust data from high-income countries are lacking.

While sociodemographic factors such as race and ethnicity, income, education, or geographic disparities are increasingly recognized to be associated with health outcomes across surgical and trauma care,[10] how these factors intersect with treatment outcomes has not been as well characterized. Better understanding of these dimensions may be helpful in guiding clinical decision-making and patient counselling, while informing the design of targeted public health initiatives aimed at prevention and management of IOFB-related injuries and improving health equity.

This study aimed to address these research gaps using a large multicenter clinical registry to provide a better understanding of contemporary presentation, management and factors influencing visual prognosis in routine clinical practice. In particular, we assessed the 1) epidemiological and sociodemographic characteristics of patients presenting with IOFB injuries requiring surgery in the American Academy of Ophthalmology IRIS® Registry (Intelligent Research in Sight), a large United States (US)-based dataset of over 80 million patients, 2) clinical presentation and procedures performed around the time of presentation, and 3) the long-term visual outcomes following IOFB removal and their predictors.

Methods

Study design and data source

This was a multicenter retrospective observational cohort study of eyes with IOFBs treated in the US. The study period spanned January 2016 to October 2024. The study utilized data from the IRIS Registry, one of the largest specialty-specific clinical data registries in the world. The IRIS Registry captures structured electronic health record (EHR) data from a broad network of ophthalmology practices encompassing diverse geographic regions, subspecialties, and practice settings across the US. Details of the EHR data extraction process, data fields, and distribution of practices contributing data has been published previously.[11] This version of the database was frozen on October 31, 2024.

The IRIS Registry is a centralized data repository and reporting tool that can be used for research purposes. This does not constitute human subject research because data in the IRIS Registry is de-identified, and the investigator does not have access to study identifiers. The study was exempted from review by the Massachusetts Eye and Ear Institutional Review Board and did not require informed consent due to its retrospective nature and de-identified data source (protocol number 2020P000080). This study adheres to the Declaration of Helsinki.

Study population

Clinical diagnoses were identified using International Classification of Diseases (ICD) 10th Edition and Systematized Nomenclature of Medicine Clinical Terms (SNOMED-CT) codes, while procedures were identified using Current Procedural Terminology (CPT) codes, allowing for consistent classification across institutions and time.

Inclusion criteria: Eyes with CPT codes for IOFB removal (65235, 65260, 65265) were identified, and the first-ever instance of this code was assigned as the baseline date.

Exclusion criteria: Eyes with CPT codes for retained lens fragments following cataract surgery, glaucoma procedures (e.g., goniotomy, insertion of aqueous shunt), removal of implanted foreign materials (e.g., removal of aqueous shunt), or revision thereof (e.g., intraocular lens (IOL) repositioning, aqueous shunt revision) within 3 days of IOFB removal were excluded. This was a conservative approach designed to minimize potential errors from miscoding. The full list of codes used is provided in Supplementary S1 (available at https://www.ophthalmologyretina.org/).

Variables of interest and data handling

Sociodemographic information including age, sex, race and ethnicity, median income, high school graduation percentage, operating practice geographic location, and urban/rural status were extracted. The terminology used for race and ethnicity (e.g., "Black or African American") followed the IRIS Registry's data collection and reporting conventions, in accordance with best practice.[12] Operating practice geographic location was converted from state to region based on US Census classifications. Median income and high school graduation percentage are based off the 2021 American Community Survey results for the patient's recorded zip code.

Clinical characteristics of interest included IOFB extraction method (magnetic, non-magnetic, or not recorded (NR)), whether they had an IOFB in one or both eyes, IOFB location, and contemporaneous ophthalmic procedures recorded at baseline or up to 3 days prior to this, to account for the possibility of delayed primary repair and/or sequential IOFB removal. These data fields were extracted and summarized from a list of CPT codes performed at baseline. Complications at presentation were recorded up to 3 days prior to IOFB removal for the same reasons and were detailed separately for 'early complications' (1-6 days) and 'later complications' (7 days onwards). The list of complications was informed by a comprehensive literature search, and were extracted using pre-specified ICD-10 codes listed in Supplementary Table 2 (available at https://www.ophthalmologyretina.org/).

Logarithm of the minimum angle of resolution (logMAR) visual acuity (VA) was used for analysis. Any VA recorded in Snellen fractions was converted to the appropriate logMAR equivalent using a standard conversion table for the IRIS Registry (-log(Snellen fraction), log base 10). All VA measures reported utilize best documented distance visual acuity (BDVA) for a given date and eye. Presenting VA was similarly defined as being the mean of BDVA recorded at baseline or up to 3 days prior to this. VA analyses were restricted to the first 18 months post-IOFB removal for maximal robustness. For the small subset of patients with pre-IOFB VA measurements between 1-12 months prior to baseline, eyes were categorized into one of 3 categories based on their mean pre-IOFB BDVA : -0.3 to 0.5 logMAR, 0.5 to 1.0 logMAR, and >1.0 logMAR.

Statistical analysis

Categorical data were described with number and proportion, and continuous data with the median and interquartile range (IQR) after confirming a non-normal distribution with the Shapiro-Wilk test and Q-Q plots.

Annual incidence rates (per 100,000 patients) were calculated as the number of patients undergoing IOFB removal in that year divided by the number of patients recorded in the IRIS Registry over that same period with 95% confidence intervals (CI) estimated via the Poisson distribution. Incidence calculations were performed at the patient level, with bilateral same day cases counted as a single case. Comparison of incidence rates over time was conducted using the exact Poisson test. Multivariable logistic regression models were employed to estimate the odds ratios (OR) and 95% CI for factors associated with IOFB removal; this comprised sociodemographic covariates such as age, sex, race and ethnicity, median income, and urban/rural status.

Two linear mixed-effects models were then employed to assess predictors of post-IOFB VA, incorporating random intercepts at the eye level to account for the non-independence of repeated measurements. For the small number of bilateral cases, one eye was selected at random for VA modelling. A random slope for time was included to model potential heterogeneity in individual VA trajectories over time. Sociodemographic factors and clinical features present at baseline were included as covariates. The first model examined the change in post-procedure VA at each month post-IOFB compared to baseline to map the trajectory of VA change. The second model was a subgroup analysis of patients with pre-IOFB VA measurements to evaluate the possibility of poorer visual outcomes secondary to pre-existing ocular comorbidities in this cohort.

To test the robustness of the findings under the potential influence of outliers, a sensitivity analysis was performed using a mixed-effects quantile regression model focused on the median rather than the mean. This is because the median is less sensitive to extreme values (e.g., very poor or very good VA) and does not assume normality of the residuals. All *P*-values for model coefficients were adjusted using the Benjamini–Hochberg procedure to control the false discovery rate (FDR) across multiple comparisons.

Data analysis was performed using R version 4.4.2 (R Core Team, 2024). Predictors were considered statistically significant at a level of $P<0.05$.

Results

Epidemiology

A total of 4784 eyes (4684 patients) met the criteria for inclusion within the study period. The mean annual incidence was 2.28 (95% CI 2.09-2.49) per 100,000 patient-years. There was a small, gradual decrease in annual incidence from 2017 to 2023 (from 2.84

per 100,000 patient-years in 2017 to 1.95 in 2023, $P < 0.001$). Although this trend continues into 2024, data for the year are incomplete (up to October 2024) (Table 1).

Table 2 summarizes the sociodemographic characteristics of the overall study cohort. The median age was 55 years (IQR 36-70), with a total of 172 pediatric patients aged under 18 (3.7%, 176 eyes). Most patients were male (70.3%), White (59.6%), and resided in urban areas (82.6%). They were treated in practices that were predominantly based in the South (42.6%). The majority resided in areas with a median income of USD 35,000-74,999 (52.0%), broadly aligning with the national average.

After adjustment for relevant covariates, factors independently associated with an increased odds of IOFB removal included male sex (OR 3.44, 95% CI 3.22-3.67), Other race (OR 1.61, 95% CI 1.16-2.23) or Hispanic/Latino ethnicity (OR 1.49, 95% CI 1.35-1.64), and residence in a rural area (OR 1.65, 95% CI 1.52-1.79). Older age (OR 0.88 per decade over 65, 95% CI 0.87-0.90) and a median income category of USD 75,000-149,999 (OR 0.80, 95%CI 0.74-0.86) were protective.

Demographic trends across time are reported at the eye level due to a small proportion (33, 0.66%) of patients sustaining IOFBs in their fellow eye sequentially. While there were minor year-to-year fluctuations in absolute percentages, the majority of demographic categories (such as male sex, White ethnicity, urban residence, Southern geographic region, and mid-range income bracket) remained consistent with the overall cohort profile throughout the study period (Supplementary Table 3, available at https://www.ophthalmologyretina.org/).

Clinical characteristics and procedures at baseline

Clinical characteristics and procedures performed at baseline are summarized in Table 3. Most cases were unilateral (96.9%). The majority of IOFBs were located in the posterior segment (51.8%), followed by the anterior segment (46.6%), with a small percentage affecting both (1.6%). IOFB extraction methods were not recorded in cases occurring in the anterior segment (46.6%); where this was recorded for IOFBs in the posterior segment, non-magnetic extraction was most common (40.9%), followed by magnetic (12.1%), and both techniques (0.3%).

A B-scan ultrasound was performed in 9.0% of patients at baseline. Procedures conducted contemporaneously with the IOFB removal included pars plana vitrectomy (PPV) with or without retinal detachment (RD) repair (42.5%), repair of anterior segment laceration(s) (17.8%), anterior chamber (AC) washout (14.6%), and lens extraction

(11.5%). Intravitreal injections (drug unspecified) were performed in 3.7%, while intravitreal antibiotic injections (ceftazidime/vancomycin) were recorded in an additional 1.8%. Of note, 1367 eyes (28.6%) had ≥2 additional procedures (Table 3).

The most common complications at baseline were RD (12.5%), cataract (10.5%), vitreous hemorrhage (7.9%), and endophthalmitis (3.9%) (Table 4). An additional 14.3% of eyes developed RD over the course of their follow-up at a mean of 9.4 months (median 2.4, IQR 1-9 months) at an incidence of 8.4 per 100 eye-years (95% CI 7.8-9.0) over a median follow-up of 16.9 months (IQR 4.2-43.9).

Visual outcomes post-IOFB removal

VA at presentation was available for 1941 eyes. Median VA at presentation was 1.24 logMAR (IQR 0.30-2.30) (approximately 20/400 Snellen), with 54.5% (1058/1941) having a vision of 1.00 logMAR (20/200 Snellen) or worse. Of the patients in this cohort, 12.2% (237/1941) presented with light perception (LP) and 1.3% (26/1941) with no light perception (NLP).

Predictors of changes in VA from baseline

VA data was available for longitudinal analysis in 1376 unique eyes, requiring one measure at baseline and at least two more within 18 months post-op. Changes in VA from baseline post-IOFB removal featured a distinct pattern of VA recovery, with no significant change at month 1 (β 0.01, 95% CI -0.02-0.04), a statistically significant improvement of 0.38 logMAR on average by month 2 (95% CI -0.41 to -0.34), and a gradual improvement to 0.59 logMAR that was maintained to month 18 (95% CI -0.69 to -0.48) (Figure 1).

After adjusting for baseline clinical characteristics, several factors were significantly associated with poorer VA outcomes (Supplementary Table 4, available at https://www.ophthalmologyretina.org/). Baseline complications including endophthalmitis (β 0.70, 95% CI 0.56–0.84), hyphema (β 0.74, 95% CI 0.55–0.93), RD (β 0.35, 95% CI 0.22–0.48), and vitreous hemorrhage (β 0.23, 95% CI 0.10–0.36) were strong predictors of worse overall vision. Compared to anterior segment-only injuries, IOFBs affecting the posterior segment (β 0.25, 95% CI 0.15–0.35) or both anterior and posterior segments (β 0.58, 95% CI 0.07–1.09) were also associated with significantly worse VA.

In terms of sociodemographic characteristics, self-identifying as Black or African American was independently associated with a worse visual outcome (β 0.35, 95% CI

0.17–0.52) even after controlling for all clinical and other socioeconomic variables. No statistically significant association was found for other socioeconomic factors, including median household income or urban-rural status. The interaction between race and median income was not significant as well. The final model explained a substantial portion of the variance in VA outcomes (marginal $R^2 = 0.200$, conditional $R^2 = 0.750$).

Sensitivity analysis

Sensitivity analysis was conducted using a mixed-effects quantile regression model to assess predictors of the median visual outcome and provide a model robust to outliers. Median logMAR VA improved over time, with a stable improvement of 0.26-0.36 logMAR units from month 2 onwards compared to baseline (all adjusted $P<0.001$). Compared to the earlier analysis, only three clinical factors remained associated with a poorer median VA – the presence of endophthalmitis (β 0.42, 95%CI 0.05-0.79]) and RD (β 0.418, 95%CI 0.17-0.67), and IOFB affecting both anterior and posterior segments (β 0.50, 95% CI 0.07–0.93) at baseline. In this median-focused model, sociodemographic factors and presence of other complications at presentation were not significant predictors of VA (Supplementary Table 5, available at https://www.ophthalmologyretina.org/).

Subgroup analysis of eyes with pre-IOFB VA

A subgroup analysis comprising 625 eyes with at least one pre-IOFB VA measure (between 1 to 12 months pre-IOFB) and post-IOFB VA reading was performed. In general, this subgroup was older, had a greater proportion of White patients, more female representation, and a higher proportion of baseline complications compared to the overall cohort (see Supplementary Table 6 for cohort characteristics, available at https://www.ophthalmologyretina.org/). For this analysis, eyes were stratified into three groups based on their pre-IOFB VA: good (-0.3-0.49 logMAR), moderate (0.5-1.0 logMAR), and poor (>1.0 logMAR). Pre-IOFB VA was the strongest predictor of post-IOFB visual outcomes. While VA generally improved over time for all three groups, a significant interaction effect demonstrated that this improvement was attenuated for the group with poor pre-IOFB VA (>1.0 logMAR).

Consistent with previous findings, in this subgroup, several other clinical factors were associated with worse visual outcomes, including the presence of endophthalmitis (0.73, 95%CI 0.56-0.91), RD (0.52, 95%CI 0.31-0.73), vitreous hemorrhage (β 0.39, 95%CI 0.14-0.64), and hyphema (β 0.37, 95%CI 0.16-0.58). Patients identifying as Black or African American (β 0.31, 95%CI 0.12-0.50) and Other (β 0.25, 95%CI 0.08-0.41) also had worse visual outcomes. IOFB location was not found to be a significant predictor of

visual outcomes in this model (Supplementary Table 7, available at https://www.ophthalmologyretina.org/).

Discussion

In this large longitudinal IRIS Registry study of eyes that underwent IOFB removal, we have mapped the epidemiology from 2016-2024, identified a distinct trajectory of visual recovery, and delineated key clinical and socio-demographic factors associated with visual outcomes post-IOFB removal.

Our main findings were: 1) mean incidence rates of 2.28 per 100,000 patient-years across ophthalmology practices participating in the IRIS Registry, which represent approximately 70% of practicing ophthalmologists across the US[13]; 2) presence of endophthalmitis or RD at baseline was consistently associated with poorer visual outcomes; 3) mean and median VA typically improve following IOFB removal, with a rapid period of recovery by two months that subsequently plateaus; and 4) pre-IOFB VA was the strongest predictor of post-IOFB removal visual outcomes in the subgroup of patients where this was available, with poor VA (logMAR 1.0 or worse) attenuating any improvement in VA.

We found that IOFB injuries in our cohort disproportionately affect middle-aged males, which may reflect the occupational risk in male-dominated manual trades such as construction metalwork. The sex predilection was consistent with previous studies in the literature, albeit with lower proportions of males affected compared to the literature (70.4% versus 80-100%).[1–9] The median age (55 years) in our cohort remained within the working age population, but was one to two decades older than that described in these previous studies, many of which originate from low- and middle-income countries (LMICs), where injuries may more commonly affect younger men engaged in high-risk industrial or agricultural work. The older age and sex distribution may also reflect demographic shifts in the US workforce or the exposure of older individuals to home-based DIY (do-it-yourself) activities. These findings underscore the importance of tailoring injury prevention strategies to evolving risk profiles in high-income countries.

Notably, patients self-identifying as Black or African American had a significantly worse mean visual outcome after controlling for pre-injury VA and a wide range of sociodemographic and clinical presentation factors. Our findings align with reports of racial and ethnic disparities in OGI risk and poorer visual outcomes in the US,[14] as well

as a broader body of evidence documenting disparities in ophthalmic care outcomes for conditions such as RD and glaucoma,[15–17] and broader systemic trauma outcomes.[18] However, this disparity may still reflect some degree of unmeasured confounding from social determinants of health, differential access or adherence to follow-up care, or systemic biases within the healthcare system. Given that the association was not observed in a sensitivity analysis using a median-focused mixed effects quantile regression model, the effect of race and ethnicity on visual outcome appears to be driven by a subgroup with particularly poor outcomes. Further research is needed to validate, understand, and address the underlying causes of the racial and ethnic disparities identified which are likely to be social determinants of health, ensuring that efforts to optimize visual outcome and prevention strategies are equitable for all patient populations.

Direct comparison of visual outcome predictors with the published literature is complicated by differing follow-up periods, covariate selection, and statistical modelling strategies. We reviewed recent large studies evaluating predictors of post-IOFB VA. One study of 1176 eyes with IOFB in Southwest China identified predictors broadly consistent with ours, including RD, traumatic cataract, endophthalmitis, and posterior segment IOFB, in a multivariable model examining risk factors for VA >20/200 at discharge. However, additional predictors such as wound size (not available in our study) and poor presenting VA were also reported as predictors.[3] In contrast, another study of 159 eyes from North China found presenting VA, size of IOFB, size of wound, and macular lesions to be the only factors influencing VA post-IOFB removal.[9] These variations likely also reflect differences in patient populations, case severity, surgical techniques, and timing of outcome assessment. VA assessment methodology may also vary.[19] Notably, the follow-up period in these studies was not defined. In our study, we were able to characterize the trajectory of visual recovery up to 18 months post-IOFB removal, which provides new insights into the sustained improvements and plateau phases of visual outcomes after IOFB removal, and may be helpful in informing patient expectations.

Our visual outcome analysis also benefited from the complementary use of two distinct modeling strategies. The linear mixed-effects model, which predicts the mean, was sensitive to extreme outcomes. It identified the presence of endophthalmitis, RD, vitreous hemorrhage, and hyphema at baseline as significant predictors of a poorer visual outcome on average. Sensitivity analyses employing quantile regression, which is more robust to outliers and predicts the median (i.e. typical) outcome, found that only RD and hyphema were associated with worse vision. This divergence suggests that while

most patients experiencing RD and hyphema experience worse vision, other patients with complications such as endophthalmitis and vitreous hemorrhage may have a more varied effect, creating a 'high risk, high variability' profile, wherein some patients experience reasonable recovery, but where a subset suffers catastrophic vision loss, thereby heavily skewing the overall mean.

Strengths and limitations

Limitations reflect common challenges inherent to research utilizing large administrative EHR databases such as the IRIS Registry, which rely on the completeness and accuracy of routinely collected clinical and billing data.[13,20–22] This is exemplified by the coding for IOFB material – although specific CPT Z-codes exist to specify IOFB material type, these codes were so infrequently used (n=15/4784 cases) as to render the variable analytically unusable. While it would be clinically relevant to report on the time from diagnosis to repair and on primary versus secondary IOFB removal, this information was unavailable for a number of cases. In addition, such registries typically do not contain granular clinical data obtainable from manual chart review of free-text letters (e.g., etiology or mechanism of injury, injury zone, IOFB material), although advances in natural language processing may make large-scale data extraction possible in the future.[23,24] Similarly, the IRIS Registry contains very limited data on non-ophthalmic imaging (consistent with previous work examining orbital imaging[25]), which precluded analysis of ancillary trauma investigations such as computed tomography scans and/or X-rays.

Beyond data completeness, the potential for missing data and coding inaccuracies poses another challenge in EHR-based research. For example, pre-IOFB VA was a strong predictor of visual recovery, but pre-IOFB VA data was only available for a subset of patients known to an eye care provider. Given the potential systematic bias (e.g., if these patients were more likely to have pre-existing eye conditions), we opted to conduct a subgroup analysis for the subset of patients with pre-IOFB VA. As a further example, among the 5.5% of patients who received an intraoperative intravitreal injection, 1.8% had a recorded antibiotic, while the drug was unspecified in the other 3.7%. Given the baseline endophthalmitis rate of 4.0% and the procedural context, it is likely that the unspecified drug was an antibiotic, although this could not be confirmed. With regard to the risk of coding inaccuracies, we conducted a review of CPT codes contemporaneous to the time of IOFB removal and identified codes for procedures such as aqueous shunt or anterior segment drainage device revision or insertion, goniotomy, trabeculotomy etc. – interventions which would not be typically performed in the context of OGI repair and IOFB removal. To mitigate this, we adopted a pragmatic and stringent approach in

defining our cohort, and incorporated exclusion criteria to remove cases with implausible procedural combinations, with the aim of improving specificity in identifying true IOFB injuries.

Overall, as the largest real-world ophthalmic clinical registry, the IRIS Registry has enabled a robust, population-level analysis of IOFB injuries that underwent surgery across a diverse range of socio-demographic and practice settings in the US. The cohort size and national scope provide a powerful foundation for studying clinical questions at scale and estimating trends and outcomes, overcoming the principal constraint of prior literature – namely the limited generalizability of small, single-center series. The large sample size and longer follow-up duration in our cohort allowed us to characterize visual recovery trajectories beyond initial discharge, offering valuable insights into both early and sustained improvements post-IOFB removal, which were not captured in earlier studies. This also facilitated robust evaluation of baseline predictors of visual outcomes. Future work will explore the effect of subsequent complications and procedures.

In summary, this comprehensive longitudinal analysis provides a robust, data-driven model for predicting visual outcomes after IOFB injury and removal. We have mapped the standard VA trajectory experienced post-IOFB removal in a large cohort of patients, demonstrated the importance of pre-IOFB VA in predicting visual outcomes, and quantified the additional risk conferred by specific complications and sociodemographic factors. Together, these findings offer clinicians a model for prognostication to help manage patient expectations, guide clinical decision-making, and ultimately optimize patient care. Future work should aim to integrate granular clinical data to refine these predictive models and facilitate external validation.

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Figure Legends

Figure 1: Longitudinal trajectory of visual acuity up to 18 months after sustaining an intraocular foreign body injury (IOFB). The error bars indicate the 95% confidence interval.

Figure 2: Longitudinal trajectory of visual acuity up to 18 months after sustaining an intraocular foreign body (IOFB) injury, stratified by pre-IOFB visual acuity (logMAR -0.3 to 0.5, 0.5-1.0, and >1.0). The error bars indicate the 95% confidence interval.

Table 1: Frequency and incidence of IOFB cases undergoing surgery in the IRIS Registry.

Year	IOFB (N)*	Total population in that year (N)	Incidence with 95% CI per 100,000 patient-years
2016	456	17,518,467	2.60 (2.37, 2.85)
2017	546	19,232,704	2.84 (2.61, 3.10)
2018	573	20,654,335	2.77 (2.55, 3.01)
2019	532	22,258,778	2.39 (2.19, 2.60)
2020	541	21,137,177	2.56 (2.35, 2.79)
2021	600	25,515,248	2.35 (2.17, 2.55)
2022	550	27,233,664	2.02 (1.85, 2.20)
2023	573	29,324,229	1.95 (1.80, 2.12)
2024^	346	23,820,914	1.45 (1.30, 1.61)

Legend: CI- confidence interval; IOFB- intraocular foreign body; N- number.

*Bilateral IOFB cases undergoing surgery on the same date were treated as 1 case (patient-level analysis for incidence calculations).

^Data for 2024 were only available till October 2024.

Table 2: Socio-demographic characteristics of the overall patient cohort.

		N (%)
Age (Median, IQR) (years)		55 (36-70)
Sex	**Female**	1311 (27.4)
	Male	3362 (70.3)
	Unknown	111 (2.3)
High school graduation percentage	**≤ 60**	28 (0.6)
	61-70	127 (2.7)
	71-80	414 (8.7)
	81-90	1,435 (30.0)
	91-100	2,117 (44.3)
	Unknown	663 (13.9)
Urban/ Rural Status	**Urban**	3950 (82.6)
	Rural	799 (16.7)
	Unknown	35 (0.7)
Median Income	**≤$34,999**	138 (2.9)
	$35,000 - $74,999	2,488 (52.0)
	$75,000 - $149,999	1,375 (28.7)
	≥ $150,000	106 (2.2)
	Unknown	677 (14.2)
Race	**White**	2,853 (59.6)
	Asian	96 (2.0)
	Black or African American	382 (8.0)
	Other	590 (12.3)
	Unknown	863 (18.0)
Ethnicity	**Hispanic or Latino**	604 (12.6)
	Not Hispanic or Latino	2875 (60.1)
	Unknown	1305 (27.3)
Practice Region	**Midwest**	697 (14.6)
	Northeast	703 (14.7)
	South	2,039 (42.6)
	West	854 (17.9)
	US Territory	13 (0.3)
	Unknown	478 (10.0)

Legend: IQR, interquartile range; N, number.

Table 3: Clinical characteristics and procedures performed at baseline.

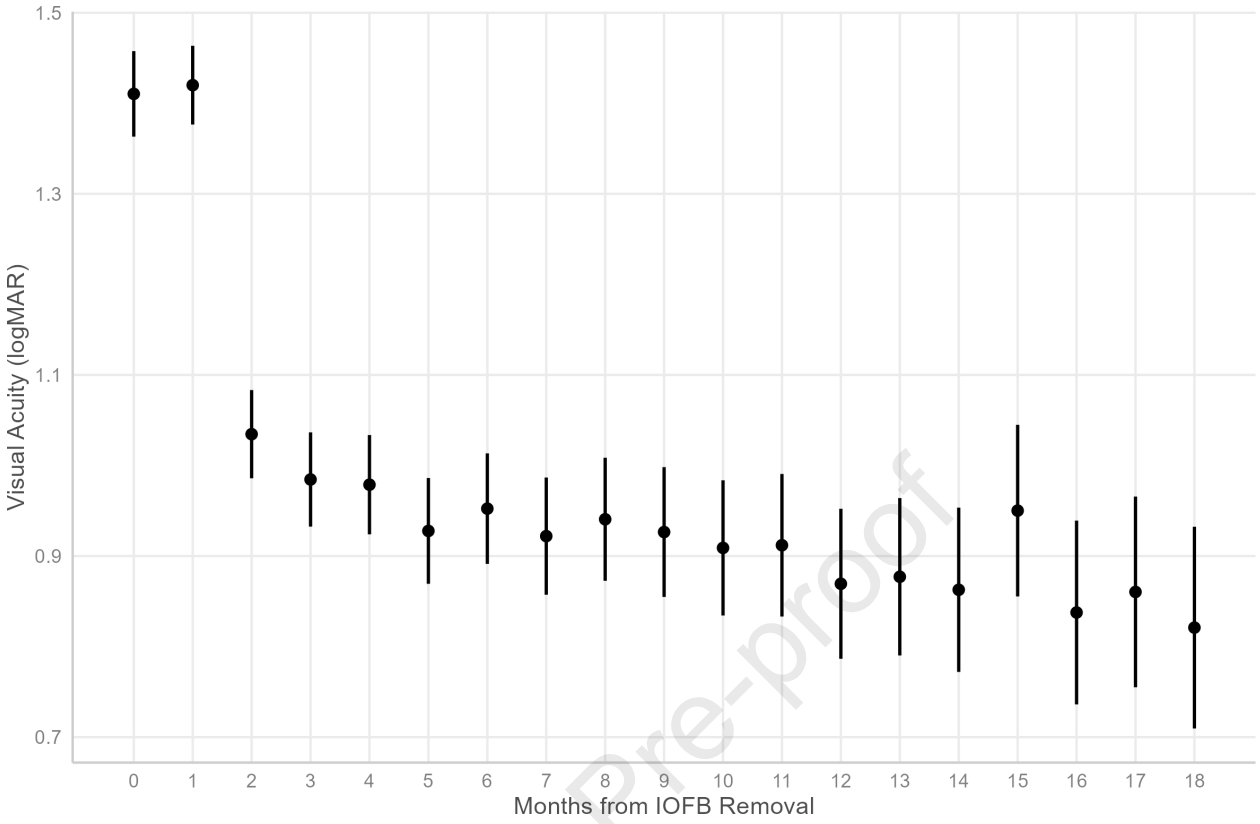
		N (%)
Unilateral		4636 (96.9)
IOFB Location	**Anterior segment**	2229 (46.6)
	Posterior segment	2478 (51.8)
	Both	77 (1.6)
IOFB Extraction Method	**Not recorded**	2229 (46.6)
	Non-magnetic	1958 (40.9)
	Magnetic	581 (12.1)
	Both	16 (0.3)
Concurrent Procedures	**PPV**	2032 (42.5)
	Repair of cornea and/or sclera and/or anterior segment laceration	853 (17.8)
	AC washout	700 (14.6)
	Lens extraction	548 (11.5)
	Intravitreal injection (drug not specified)	179 (3.7)
	AC paracentesis	139 (2.9)
	Intravitreal injection (Ceftazidime/ Vancomycin)	86 (1.8)
	Anterior vitrectomy	42 (0.9)
Ocular Investigations	**B-scan**	432 (9.0)

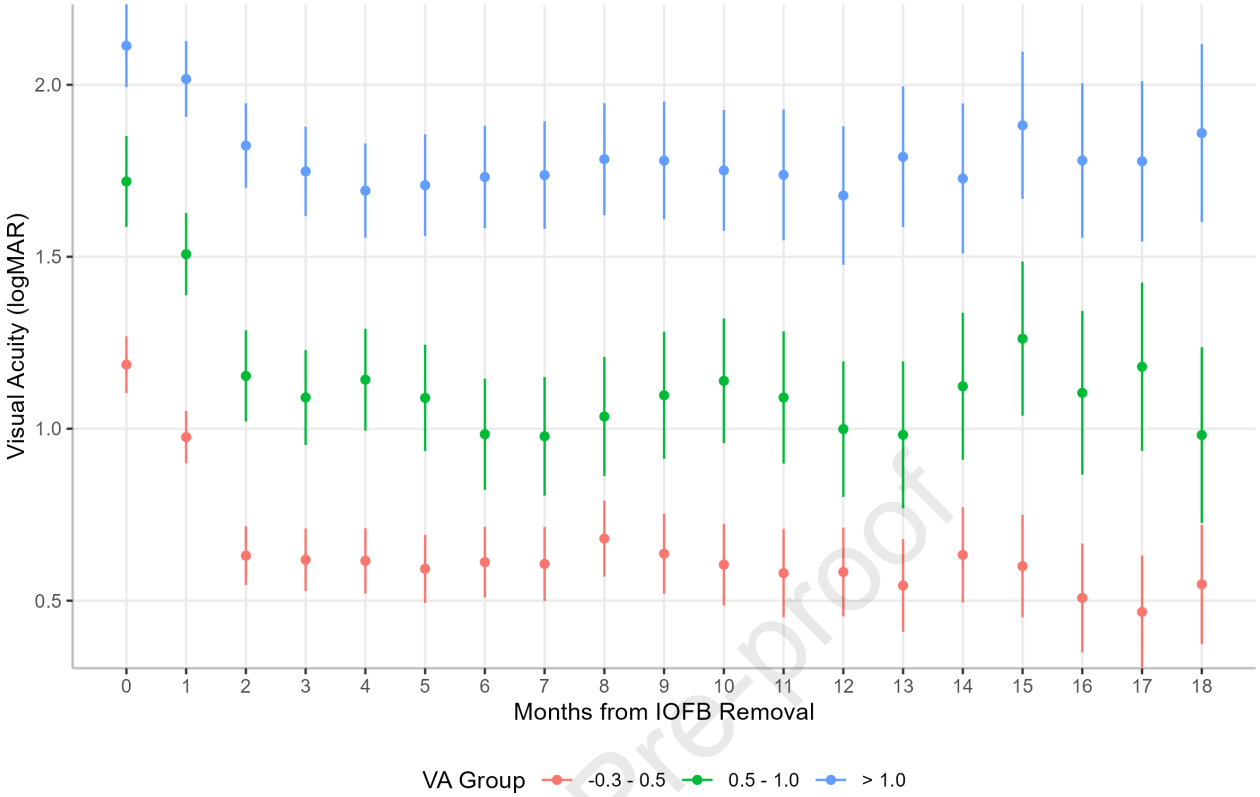
Legend: IOFB, intraocular foreign body; AC, anterior chamber; PPV, pars plana vitrectomy; N, number.

Table 4: Incident complications at baseline, early (1-6 days), and late (7 days to 18 months).

	Baseline (N, %)	Early (N, %)	Late (N, %)
Retinal detachment	597 (12.5)	52 (1.1)	633 (13.2)
Cataract	501 (10.5)	78 (1.6)	749 (15.7)
Vitreous hemorrhage	378 (7.9)	74 (1.5)	153 (3.2)
Endophthalmitis	187 (3.9)	12 (1.7)	27 (0.6)
Hyphema	160 (3.3)	36 (0.8)	67 (1.4)
Retinal tear	130 (2.7)	27 (0.6)	93 (1.9)
Raised intraocular pressure or glaucoma	86 (1.7)	36 (0.8)	354 (7.4)
Proliferative vitreoretinopathy	21 (0.4)	7 (0.2)	92 (1.9)
Iridodialysis	6 (0.1)	1 (0.0)	10 (0.2)
Enucleation		2 (0.0)	17 (0.4)
Evisceration		2 (0.0)	9 (0.2)
Corneal scar			237 (5.0)
Siderosis			4 (0.1)
Traumatic optic neuropathy			3 (0.1)
Sympathetic ophthalmia			1 (0.0)

Legend: N, number.





This IRIS® Registry analysis of intraocular foreign body injuries defines visual recovery benchmarks, with vision improving from two months and plateauing thereafter. Baseline complications and Black or African American race were associated with worse vision outcomes.