Intraocular Foreign Bodies: Clinical Characteristics and Prognostic Factors for Visual Outcomes

Corpos Estranhos Intraoculares: Caraterísticas Clínicas e Fatores de Prognóstico para Resultados Visuais

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ABSTRACT

INTRODUCTION: Our objective was to evaluate the clinical presentation of patients with intraocular foreign bodies (IOFB) and establish prognostic factors for visual outcomes.

METHODS: Medical records of all patients undergoing surgery for an intraocular foreign body at Centro Hospitalar Universitário de Santo António in the last decade were retrospectively reviewed.

RESULTS: This study included 108 eyes of 107 patients. Most patients were adult males (88.9%) of working age (88.9% were 18-64 years old). Retinal lesions were documented in 40.7% of the eyes and 17 (15.7%) eyes presented with retinal detachment. Seven (6.5%) eyes presented with endophthalmitis. The majority (78.7%) of IOFB were metallic and entered the globe mainly through the cornea (68.5%). The median (interquartile range) time to first procedure was 1 (0-2) days, with most IOFB (72.2%), retrieved at that moment. Pars plana vitrectomy were performed in 74 eyes. In this study, good presenting visual acuity (VA), lens sparing, absence of hyphema and retinal detachment and the presence of vitreous hemorrhage were associated with good final VA.

CONCLUSION: Open-globe injuries with IOFB are a public health issue that impose preventable social and economic burden as it affects mostly working-age subjects. Hence, early intervention and preventive measure are of uttermost importance to prevent social and visual disability.

KEYWORDS: Eye Foreign Bodies; Eye Injuries, Penetrating; Treatment Outcome; Vitrectomy.

RESUMO

INTRODUÇÃO: O nosso objectivo foi avaliar a apresentação clínica de pacientes com corpo estranho intraocular (CEIO) e estabelecer fatores prognósticos para resultados visuais.

MÉTODOS: Os processos clínicos de todos os pacientes submetidos a cirurgia pela presença de corpo estranho intraocular no Centro Hospitalar Universitário Porto na última década revistos retrospetivamente.

RESULTADOS: Este estudo incluiu 108 olhos de 107 pacientes. A maioria dos pacientes eram adultos (88,9%) em idade ativa (88,9% tinham 18-64 anos). As lesões de retina foram documentadas em 40,7% dos olhos e 17 (15,7%) olhos apresentaram-se com descolamento de retina.

Sete (6,5%) olhos tinham endoftalmite à presentação. A maioria (78,7%) dos CEIOs eram metálicos e entraram no globo pela córnea (68,5%). A mediana (intervalo interquartil) do tempo para o primeiro procedimento foi de 1 (0-2) dias, com a maioria dos CEIOs (72,2%) recuperados naquele momento. A vitrectomia via pars plana foi realizada em 74 olhos. Neste estudo, boa acuidade visual (AV) à admissão, ausência de lesão lenticular, hifema e descolamento de retina e presença de hemorragia vítrea foram associados a boa AV final.

CONCLUSÃO: Os traumas oculares abertos com CEIOs são um problema de saúde pública que impõe despesas sociais e económicas evitáveis, pois afetam principalmente indivíduos em idade ativa. Assim, a intervenção precoce e as medidas preventivas são de extrema importância para prevenir a incapacidades sociais e visuais.

PALAVRAS-CHAVE: Corpos Estranhos no Olho; Ferimentos Oculares Penetrantes; Resultado do Tratamento; Vitrectomia.

INTRODUCTION

Intraocular foreign body (IOFB) can be defined as an intraocularly retained, unintentional projectile. It is an ophthalmic emergency that requires urgent treatment to prevent blindness or globe loss.[1,2] It is estimated that IOFBs account for 16%-41% of all open-globe injuries.[3-5] A 15-year retrospective study of ocular trauma in the North of Portugal found that IOFBs corresponded to 20.2% of open-globe injuries.[6] Most IOFBs are metallic (75%-85%) and the most common location is the posterior segment.[1,2,7] Young men are most affected, accounting for more than 90% of cases in some series.[8,9] These accidents are often work-related and frequently without the use of protective eye measures in some cases.[1,2]

Visual loss can be caused by direct tissue damage by IOFB at the time of the accident but may also occur by subsequent injury, such as retinal detachment and post-trauma endophthalmitis (especially with organic IOFBs).[1,2] Several factors have been used to predict final visual outcomes, such as the visual acuity at presentation, size and location of IOFB, size and location of IOFB entry wound, presence of a relative afferent pupillary defect (RAPD), retinal detachment and endophthalmitis.[1,10]

When IOFB is suspected, it is paramount to perform a thorough yet directed clinical history, slit-lamp biomicroscopy and fundus examination. Additional diagnostic techniques, including computerized tomography (CT), should be used to identify and measure IOFB, the extension of the damaged eye structures and the orbital status. Treatment is mainly surgical and aims to remove the IOFB, reconstruct ocular anatomy, treat complications, and prevent further damage.

Further knowledge on the management of IOFB are warranted as this condition accounts for a considerable portion of ocular trauma affecting working-age individuals, with direct and indirect economic and social burden. This study aims to evaluate the clinical presentation of patients with IOFB and establish prognostic factors for visual outcomes.

METHODS

A retrospective analysis was carried out of all IOFB, as defined in the Birmingham Eye Trauma Terminology (BETT) system, submitted to surgery at Centro Hospitalar Universitário de Santo António (CHUdSA), Portugal, a tertiary referral hospital center, between January 2010 and December 2020.

An anonymous data extraction from medical records was performed including admission data of the ophthalmology emergency or interhospital referral, surgical reports of all surgical procedures and medical records of postoperative appointments at CHUdSA. This study adhered to the tenets of the Declaration of Helsinki. All patients signed an informed consent form for all the interventions performed. The need for informed consent regarding this study was waived by the local Institutional Review Board since all data presented here are deidentified.

CLINICAL ASSESSMENT AND OUTCOMES

Demographic data included age, sex, trauma environment and mechanism, and time between injury and repair. The use of protective eyeglasses was not retrieved due to inconsistent records. Clinical variables included best-corrected visual acuity (BCVA), biomicroscopic and fundoscopic findings, entry site, type and intraocular location of IOFB and wound length. The Ocular Trauma Score (OTS),[11] the extension and the structural damage of the lesions were defined based on the initial observation but modified according to the information recorded in the surgical procedure. Detailed information of surgeries was retrieved. Relative afferent pupillary defect (RAPD) was not included as a predictive factor due to the limited number of cases.

Visual acuity (VA) was categorized as define by the Ocular Trauma Classification Group[12]: No light perception (NLP); light perception (LP) or hand movements (HM); 1/200 to 19/200; 20/200 to 20/50 and ≥20/40. The most recent available BCVA was considered the final VA. The prognos-

tic analysis was performed using final visual acuity as binary outcome, using 20/40 as cut-off as it is the minimum visual acuity for driving license.

TREATMENT PROTOCOL

All patients with a leaking wound underwent primary repair of lacerations performed by general ophthalmologists. For IOFBs located in the anterior segment, removal was performed with primary globe repair. When the IOFB was located in the posterior segment of the eye, or associated with vitreoretinal complications, the patient was referred to the trauma unit for IOFB removal, and pars plana vitrectomy. Lensectomy or phacoemulsification was performed in patients with traumatic cataract or lens injuries. Intravitreal administration of antibiotics in the emergency setting were at discretion of the ophthalmologist responsible for the initial evaluation. A standard three-port pars plana vitrectomy (23-gauge) was performed by a retinal specialist with experience in ocular trauma. IOFBs were extracted through an enlarged sclerotomy or limbal incision using intraocular forceps. External magnets or magnetic forceps were used in selected cases. Additional procedures including cryotherapy, laser photocoagulation, chorioretinectomy, intravitreal antibiotics administration and type of tamponade were performed at surgeon's discretion.

STATISTICAL ANALYSIS

Categorical variables were described through absolute and relative frequencies and continuous variables through means and standard deviations, or medians and interquartile range for variables with a skewed distribution. Parametric and non-parametric tests were used according to the distribution of the data. A multivariable analysis was performed using a logistic regression model through a stepwise approach to fit the model and find independent clinical predictors at baseline for final VA, as previously defined. The area under the curve of a receiving operating characteristic curve was used to test the predictive value of the model in each group. The Hosmer-Lemeshow test was used to test the goodness of fit of the model. A p for trend test was used to compare ordinal variables between groups. A sensitivity analysis was performed to compare the presenting characteristics of patients lost to follow-up with those with complete follow-up at our Institution. A *p*-value of <0.05 was considered as statistically significant. All analyses were performed with Stata software (version 14.2).

RESULTS

This study included 108 eyes of 107 patients with a mean±standard deviation (SD) age of 42.05±15.08 years. The demographic characteristics of injured eyes are presented in Table 1. The majority of patients were males (88.9%) at working age (88.9% were 18-64 years old). Four underage patients (3.7%) were included. Most patients (84.1%) were referred to our institution; of those, 2 (2.2%) had a suspicion of long-term IOFB and were referred to the outpatient clinic for observation by the Trauma Unit and examination with ultrasound biomicroscopy 3 months and 1 year after the alleged trauma. Trauma occurred mainly at home (34.3%), industrial (30.6%) and rural (21.3%) settings and as result of hammering (38.9%) or cutting (37.0%).

Table 1. Demographic characteristics of eyes with intraocular foreign bodies.

	TOTAL 108 eyes
Age, y (mean±SD)	42.05±15.08
Age, y (categoric)	
<18	4 (3.7%)
18-64	96 (88.9%)
65-79	7 (6.5%)
>80	1 (0.9%)
Male gender, n (%)	96 (88.9%)
Right eye, n (%)	60 (55.6%)
Referral, n (%)	90 (84.1%)
Setting, n (%)	
Home	37 (34.3%)
Industrial places	33 (30.6%)
Rural places	23 (21.3%)
Public outdoors	3 (2.8%)
Sport places	2 (1.8%)
Miscellaneous/Unknown	10 (9.3%)
Work-related accident, n (%)	42 (38.9%)
Mechanism, n (%)	
Hammering	42 (38.9%)
Cutting	40 (37.0%)
Electric grass trimmer	9 (8.3%)
Gunshot	2 (1.8%)
Explosion	1 (0.9%)
Miscellaneous/Unknown	14 (13.0%)

SD, standard deviation

Clinical characteristics of injured eyes are presented in Table 2. Almost half of the eyes (49.1%) presented with LP) or HM and a significant proportion (35.2%) had a VA above 20/40. Three (2.8%) patients, including one child, did not collaborate for visual acuity assessment. Of the phakic eyes (n=105, 97.2%), 41 (38.0%) presented with lens injury. Retinal lesions were documented in 40.7% of the eyes, with lacerations (63.6%) being the most common lesion. Overall, 17 (15.7%) eyes presented with retinal detachment, with half having the macula still attached. Seven (6.5%) eyes presented with endophthalmitis; no differences were found between patients with vs without endophthalmitis at admission other than worse visual acuity for the former (*p* for trend=0.007). Most patients had an OTS class III (53.7%) or V (35.2%) and none was in class I.

Table 2. Presenting ophthalmic characteristic of injured eyes.

	TOTAL 108 eyes
BCVA, n (%)	
≥20/40	38 (35.2%)
20/20 to 20/50	6 (5.6%)
1/200 to 19/200	5 (4.6%)
LP/HM	53 (49.1%)
NLP	3 (2.8%)
Missing	3 (2.8%)
Wound size (mm), mean±SD	3.31±2.05
Lens status, n (%)	
Phakic	105 (97.2%)
IOFB injury	41 (38.0%)
Pseudophakic	3 (2.8%)
Hyphema, n (%)	14 (13.0%)
Vitreous Hemorrhage, n (%)	36 (33.3%)
Uveal herniation, n (%)	14 (13.0%)
Retinal lesions, n (%)	
None	64 (59.3%)
Laceration	28 (25.9%)
Tear	7 (6.5%)
Dialysis	3 (2.8%)
Tear+Laceration	3 (2.8%)
Giant tear	2 (1.8%)
Tear+Dialysis	1 (0.9%)
Retinal detachment, n (%)	17 (15.7%)
Number of quadrants, n (%)	
1	3 (17.6%)
2	6 (35.3%)
3	5 (29.4%)
4	3 (17.6%)
Macula-on, n (%)	8 (50.0%)
Endophthalmitis, n (%)	7 (6.5%)
OTS	
Class I (0–44)	0 (0.0%)
Class II (45–65)	3 (2.8%)
Class III (66–80)	58 (53.7%)
Class IV (81–91)	6 (5.6%)
Class V (92–100)	38 (35.2%)
Cannot be assessed	3 (2.3%)

BCVA, best-corrected visual acuity; HM, hand movement; IOFB, intraocular foreign body; LP, light perception; NLP, no light perception; OTS, ocular trauma score; SD, standard deviation

Table 3. Presenting characteristics of intraocular foreign bodies (IOFB).

	TOTAL 108 eyes
IOFB material, n (%)	
Metal	85 (78.7%)
Stone	8 (7.4%)
Wood	6 (5.6%)
Bullet	2 (1.8%)
Glass	2 (1.8%)
Organic	2 (1.8%)
Other	6 (5.6%)
IOFB penetrating site, n (%)	
Cornea	74 (68.5%)
Limbus	6 (5.6%)
Sclera	20 (18.5%)
Corneosclera	8 (7.4%)
IOFB location, n (%)	
Anterior segment	
Cornea	10 (9.3%)
Limbus	1 (0.9%)
Anterior chamber	18 (16.7%)
Iris	6 (5.6%)
Lens	2 (1.8%)
Posterior segment	
Vitreous	9 (8.3%)
Peripapillary region	3 (2.8%)
Posterior pole	10 (9.3%)
Peripheral retina	44 (40.7%)
Ora serrata/Pars plana	2 (1.8%)
Sclera	3 (2.8%)

The characteristics of IOFB are presented in Table 3. The majority (78.7%) of IOFB were metallic and entered the globe mainly through the cornea (68.5%). Overall, 71 (65.7%) of the IOFB were found in the posterior segment; of those, the majority (n=44, 62.0%) were located in the peripheral retina. Among those identified in the anterior segment (n=37, 34.3%), the anterior chamber was the more frequent location (n=18, 48.6%).

The surgical procedures are described in Table 4. The median (interquartile range, IQR) time to first procedure was 1 (0-2) days, with most IOFB (72.2%), retrieved at that moment. One (0.9%) IOFB could not be retrieved due to anatomical disorganization and impossibility of reconstruction. Forty-one eyes (38.0%) were submitted to pars plana vitrectomy (PPV) as first procedure, with silicone oil tamponade and chorioretinectomy in 12 (29.3%) eyes. Intravitreal antibiotics were injected in 28 (25.9%) eyes in the first procedure and an injection of amphotericin was performed during the follow-up in one (0.9%) patient.

Overall, the mean±SD number of surgeries was 1.64±0.87 surgeries and 46 (42.6%) eyes were submitted to

Table 4. Description of surgical procedures.

	TOTAL	Tamponade		CR	IV ATB
	108 eyes	Gas	SO		
Time to surgery (d), median (IQR)	1 (0-2)				
Primary IOFB extraction, n (%)	78 (72.2%)				
1st procedure, n (%)					
IOFB extraction	17 (15.7%)				2 (11.8%)
Wound repair					
alone	23 (21.3%)				3 (13.0%)
plus IOFB extraction	20 (18.5%)				4 (20.0%)
plus iris repair	4 (3.7%)				0 (0.0%)
PPV + IOFB extraction					
alone	16 (14.8%)	8 (50.0%)	2 (12.5%)	6 (37.5%)	5 (31.2%)
plus WR	4 (3.7%)	2 (50.0%)	2 (25.0%)	2 (25.0%)	2 (50.0%)
plus CS	8 (7.4%)	0 (0.0%)	2 (25.0%)	2 (25.0%)	3 (37.5%)
plus WR + CS	13 (12.0%)	3 (23.1%)	6 (46.1%)	2 (15.4%)	6 (46.1%)
Intravitreal ATB alone	3 (2.8%)				3 (100%)
All procedures, n (%)					
Cataract surgery	46 (42.6%)				
PPV	74 (68.5%)				
Glaucoma surgery	1 (0.9%)				
Corneal transplant	1 (0.9%)				
Evisceration	1 (0.9%)				

The second column display the number and with-in column relative frequencies. The columns of tamponade, CR and IV ATB display the number and with-in row relative frequencies.

ATB, antibiotics; CR, chorioretinectomy; CS, cataract surgery; d, days; IOFB, intraocular foreign body; IV, intravitreal; PPV, pars plana vitrectomy; WR, wound repair;

Table 5. Logistic regression model for final visual acuity ≥20/40.

	Univariable		Multivariable	
	OR [95%CI]	*p*-value	OR [95%CI]	*p*-value
Age (years)	0.99 [0.96-1.02]	0.492		
Male gender	1.02 [0.29-3.61]	0.977		
Clinical presentation				
Visual acuity*	12.67 [3.45-46.46]	<0.001	8.44 [1.70-41.94]	0.009
Wound size*	0.18 [0.07-0.45]	<0.001		
Lens injury	0.20 [0.08-0.50]	0.001	0.13 [0.04-0.46]	0.002
Hyphema	0.17 [0.04-0.67]	0.012	0.12 [0.01-1.00]	0.050
Vitreous hemorrhage	0.30 [0.12-0.73]	0.008	3.44 [0.80-14.74]	0.095
Uveal herniation	0.17 [0.04-0.67]	0.012		
Retinal lesion*	0.37 [0.16-0.88]	0.024		
Retinal detachment	0.07 [0.02-0.34]	0.001	0.02 [0.003-0.18]	<0.001
Endophthalmitis	1	-		
IOFB characteristics				
Metal*	0.99 [0.37-2.70]	0.996		
Posterior segment*	0.33 [0.13-0.87]	0.025		
Cornea entry site*	0.099 [0.41-2.39]	0.976		
Surgical approach				
Time to 1st procedure	1.13 [0.83-1.55]	0.442		
Primary IOFB extraction	4.34 [1.68-11.18]	0.002		
Primary PPV	0.975 [0.41-2.30]	0.954		
Intravitreal ATB	0.96 [0.37-2.44]	0.929		

ATB, antibiotics; CI, confidence interval; IOFB, intraocular foreign body; OR, odds ratio; PPV, pars plana vitrectomy

*transformed in a binary variable; VA was considered <20/40 vs ≥20/40 at baseline; wound size was considered <4 vs ≥4 mm.

more than 1 surgery. Forty-six (42.6%) patients were submitted to cataract surgery and 74 (68.5%) underwent PPV. The median (IQR) time to cataract surgery and PPV was 2 (1-4) and 2 (1-3) days, respectively. Excluding the patients who were submitted to cataract surgery as primary intention, the median (IQR) time to secondary phacoemulsification was 178 (163-427) days. Of those submitted to PPV, 67 (90.5%) underwent the procedure within the first 4 days after trauma. Three (2.8%) patients lacked capsular support for in-the-bag or sulcus intraocular lens (IOL) implantation, thus scleral IOL suspension was performed. Silicone oil tamponade was used in a total of 32 (43.2% of PPV) eyes, of which 16 (50%) needed long-term tamponade. One (0.9%) eye was eviscerated during the follow-up.

Regarding the complications during follow-up, 6 (5.5%) eyes suffered retinal detachment, 3 (2.8%) developed proliferative vitreoretinopathy (PVR), 2 (1.8%) had ocular hypertension, one of which needed glaucoma surgery for intraocular pressure control, 1 (0.9%) eye developed retinal necrosis, 1 (0.9%) eye presented hyphema that resolved with conservative treatment, 1 (0.9%) eye developed a leucoma affecting the visual axis and a penetrating keratoplasty was performed and 1 (0.9%) eye presented a vitreous hemorrhage with need of PPV.

As 17 patients would rather continue ophthalmologic surveillance after urgent management at other healthcare institutions (either closer to their residency or at insurance's ophthalmologists), final visual acuity is available for 91 eyes that were included in the prognostic analysis. A sensitivity analysis (Supplementary Table) revealed that those lost to follow-up presented better VA (p for trend=0.004), shorter mean wound lengths (2.29±1.31 *vs* 3.51±2.12, p=0.025) and less frequency of vitreous hemorrhage (6% *vs* 38%, p=0.010) and retinal detachment (0% *vs* 19%, p=0.068).

Considering the final VA, 50 (54.9%) eyes had ≥20/40, 12 (13.2%) eyes had 20/200 to 20/50, 13 (14.3%) eyes had 1/200 to 19/200, 7 (7.7%) had LP/HM and 9 (9.9%) had NLP. Among those with endophthalmitis at presentation, 2 out of 6 eyes (1 was lost to follow-up) ended up with NLP. Table 5 presents the univariable and multivariable logistic regression models using demographics, clinical presentation, IOFB characteristics and primary surgical approach as potential predictors of final VA. In the multivariable analysis, independent predictors of final VA ≥20/40 were good VA at presentation (≥20/40), lens sparing, absence of hyphema and retinal detachment and presence of vitreous hemorrhage (p=0.779 for Hosmer-Lemeshow test). Area under the curve [95% confidence interval] of the receiving operating characteristic curve for the model was 0.88 [0.81–0.95].

Table 6 presents the final VA of the present study compared with the OTS study[11]. For more severe lesions (OTS classes 2 and 3), our results were worse than the OTS study. Regarding the higher OTS classes (4 and 5), the results were similar. Lower OTSs were associated with worse visual outcomes at final of follow-up (p for trend < 0.001).

DISCUSSION

Intraocular foreign bodies comprise 16% to 41% of open-globe trauma,[3-5] affecting mainly working-age men which results in social and economic burden due to labor absence, healthcare expenses and long-term visual sequelae. In the present study, we reported one of the biggest European series of ocular trauma with IOFB. Almost 90% of our patients were of working age and almost half of them presented with very low visual acuity (LP/HM). Pars plana vitrectomy were performed in 74 eyes with more than 90% occurring within the first 4 days after trauma. Cataract surgery was performed in more than 40% of the eyes and only one patient lost the globe. More than half of patients ended up with a visual acuity equal or better than 20/40 (the minimum legally required for driving). In this study, good presenting VA, lens sparing, absence of hyphema and retinal detachment and the presence of vitreous hemorrhage were associated with this outcome.

Our demographic results and IOFB characteristics were consistent with previous reports on this subject.[1,2,8,13] Working-age males are the most affected population by this kind of trauma, most IOFB are metallic and their most common location is the posterior segment, mainly in the peripheral retina. Retinal lesions were found in over 40% of the eyes. In addition, retinal detachment at admission decreased significantly the odds of final VA ≥20/40. These facts highlight the relevance of using eyewear protection, as IOFB impose direct and indirect vision-threatening risks. In addition, it is paramount to be proactive in the management of these lesions. In this study, we report two facts that we believe to be pivotal in the management of complex ocular trauma: early vitrectomy and chorioretinectomy.

Trauma experts recommend that vitrectomy must be performed within the first 4 days for severely injured eyes.[14] In the present study, over 90% of PPV were performed according to this rule, which allowed that half of our patients

Table 6. Comparison of final visual acuities of the present study with the OTS score predictions.

OTS	NLP		LP-HM		1/200 - 19/200		20/200 - 20/50		≥20/40	
	Score	Study	Score	Study	Score	Study	Score	Study	Score	Study
I	74%	0%	15%	0%	7%	0%	3%	0%	1%	0%
II	27%	100%	26%	0%	18%	0%	15%	0%	15%	0%
III	2%	11%	11%	13%	15%	19%	31%	21%	41%	36%
IV	1%	0%	2%	0%	3%	0%	22%	20%	73%	80%
V	0%	0%	1%	0%	1%	11%	5%	0%	94%	89%

HM, hand movement; LP, light perception; NLP, no light perception; OTS, Ocular Trauma Score.

Supplementary Table S1. Aensitivity analysis of patients lost vs not lost to follow-up.

	LFU = 0	LFU= 1	*P*-value
	N=91	N=17	
Age, y (mean±SD)	42.85±14.87	37.76±15.97	0.20
Male gender, n (%)	80 (88%)	16 (94%)	0.69
Referral, n (%)	77 (86%)	13 (76%)	0.35
Work-related accident, n (%)	34 (37%)	8 (47%)	0.59
Setting, n (%)			
Rural Places	17 (19%)	6 (35%)	
Home	33 (36%)	4 (24%)	
Industry places	27 (30%)	6 (35%)	0.66
Public outdoors	3 (3%)	0 (0%)	
Sport places	2 (2%)	0 (0%)	
Miscellaneous/unknown	9 (10%)	1 (6%)	
Mechanism, n (%)			
Blunt trauma	2 (2%)	1 (6%)	
Cutting	33 (36%)	7 (41%)	
Electric grass trimmer	6 (7%)	3 (18%)	
Explosion	1 (1%)	0 (0%)	0.53
Gunshot	2 (2%)	0 (0%)	
Hammering	37 (41%)	5 (29%)	
Miscellaneous	10 (11%)	1 (6%)	
BCVA, n (%)			
≥20/40	28 (31%)	10 (62%)	
20/200 to 20/50	5 (6%)	1 (6%)	
1/200 to 19/200	3 (3%)	2 (12%)	0.004
LP/HM	50 (56%)	3 (19%)	
NLP	3 (3%)	0 (0%)	
Wound size (mm), mean±SD	3.51±2.12	2.29±1.31	0.025
Lens injury, n (%)	37 (41%)	4 (24%)	0.18
Hyphema, n (%)	14 (15%)	0 (0%)	0.12
Vitreous Hemorrhage, n (%)	35 (38%)	1 (6%)	0.010
Uveal herniation, n (%)	14 (15%)	0 (0%)	0.12
Retinal lesions, n (%)	37 (41%)	7 (41%)	1.00
Retinal detachment, n (%)	17 (19%)	0 (0%)	0.068
Endophthalmitis, n (%)	6 (7%)	1 (6%)	1.00
IOFB material, n (%)			
Bullet	2 (2%)	0 (0%)	
Glass	2 (2%)	0 (0%)	
Metal	71 (78%)	14 (82%)	0.56
Organic	1 (1%)	1 (6%)	
Other	6 (7%)	0 (0%)	
Stone	7 (8%)	1 (6%)	
Wood	2 (2%)	1 (6%)	
IOFB location, n (%)			
Anterior chamber	15 (16%)	3 (18%)	
Cornea	8 (9%)	2 (12%)	
Iris	3 (3%)	3 (18%)	
Lens	2 (2%)	0 (0%)	
Limbus	1 (1%)	0 (0%)	
Ora serrata/Pars plana	2 (2%)	0 (0%)	0.53
Peripapillary region	3 (3%)	0 (0%)	
Peripheral retina	39 (43%)	5 (29%)	
Posterior pole	9 (10%)	1 (6%)	
Sclera	2 (2%)	1 (6%)	
Vitreous	7 (8%)	2 (12%)	
IOFB penetrating site, n (%)			
Cornea	62 (68%)	12 (71%)	
Corneosclera	7 (8%)	1 (6%)	0.85
Limbus	6 (7%)	0 (0%)	
Sclera	16 (18%)	4 (24%)	

IOFB, intraocular foreign body; LFU, lost to follow-up; SD, standard deviation

presenting with retinal detachment had the macula still attached at time of surgery. During the follow-up, only 6 eyes presented *de novo* retinal detachment and 3 eyes developed PVR. In addition, vitreous hemorrhage was associated with higher odds of final VA ≥20/40 in the multivariable model. A putative explanation for this result comes from the proactive approach towards early vitrectomy when this finding is present, aiming to repair as soon as possible any retinal lesion, preventing retinal detachment. In a previous study from our group assessing the outcomes of globe ruptures,[10] we concluded that early vitrectomy was an effective approach as our final results even surpassed the final VA predictions for the OTS class. The facts from both studies support the recommendation of early vitrectomy for both types of open-globe injuries since delaying the eye structures' reconstruction increases the risk of proliferative vitreoretinopathy and macula detachment, leading to more complex surgeries and a higher incidence of reoperations with worse prognosis.

Chorioretinectomy consists on removing the retina and choroid around a wound, creating a ring of bare sclera that separates the remaining retina from the evolving scar, preventing the proliferative process that yields PVR and retinal folds.[15-17] This technique allows the removal of incarcerated tissue, retained IOFB fragments and fibroproliferative tissue at the choroid/sclera interface of the wound.[16] A recent systematic review reported the prophylactic chorioretinectomy lowered PVR rates to 6.5%-15.4% compared with 40-60% rate of PPV without this technique. In the present study, only 3 eyes developed PVR. Thus, we support that chorioretinectomy should be performed in eyes with IOFB in the posterior segment at risk of PVR, namely those with impact zone in the retina or choroid.

Post-traumatic endophthalmitis is one of the most devastating complications of open-globe injuries, with an incidence ranging from 4.7 to 13.3% in series with IOFB.[18] In the present study, seven (6.5%) eyes presented with endophthalmitis, which goes in line with other series[1,8,18] but far below reports that only include posterior segment IOFBs,[7,19] as expected. The risk factors for the development of endophthalmitis after ocular trauma include the presence of IOFB, delay in primary repair, increasing age, disruption of the crystalline lens, and a rural setting.[18,20,21] We did not perform a prognostic analysis for this complication due to the low number of events.

In the present study, eyes with more severe lesions presented poorer visual outcomes than expected, considering the OTS class. The most probable explanation for this fact is that OTS might be overestimated for severe lesions due to lack of RAPD assessment which might have been present for those eyes and led to a lower OTS class. In addition, this type of trauma occurs very often with high-impact and high-velocity projectiles, which makes the prognosis less predictable due to complex injuries and the need of approaching both eye segments.

Considering the population mainly affected by this kind of trauma, we decided to perform a prognostic analysis for VA compatible with driving (≥20/40). This analysis revealed that good VA at admission (≥20/40), lens sparing, absence of hyphema and retinal detachment and the presence of vitreous hemorrhage were associated with this outcome. The prognostic value of retinal detachment and presenting VA in this context is well documented in other series.[1,13,22,23] In our study, the initial VA was not affected by the time interval to primary repair, as reported by others.[2,23] Previous reports have also suggested that final VA is not influenced by the time interval to IOFB retrieval.[23-25] In the present work, we found lens lesion to be associated with worse visual outcome. This may suggest these eyes may present with more complex lesions (due to higher velocity, impact and size of the IOFB), thus more complex surgeries will be needed since the integrity of the lens bag will be disrupted and the posterior segment is more frequently affected. Other studies also reported older age, longer wound lengths, posterior segment IOFB and endophthalmitis as prognostic factors for worse visual outcomes[1,13] but those associations were not found in our study.

This study has several limitations. It is retrospective, thus has the drawbacks associated with the design. Despite this, we performed a thorough review of different registries (including admission records, operative reports and outpatient clinic records) which yielded a very complete database with residual missing data. The use of protective eyewear was the only variable that was dropped off due to lack of consistent recording. As aforementioned, some patients opted for surveillance at other Institutions for their own convenience. Our sensitivity analysis revealed that those patients had less severe injuries, which strengthens and supports our conclusions.

CONCLUSION

In summary, open-globe injuries with IOFB are a public health issue that impose preventable social and economic burden as it affects mostly working-age subjects. Given the nature of the trauma, with the agent entering the globe, there may be a higher probability of ocular morbidity, due to the higher risk of endophthalmitis and lens and retinal lesions compared with other types of ocular trauma. A proactive approach with early intervention and preventive measures is strongly advised. Given the social and economic implications, it would be of interest to evaluate the proven benefits of protective eyewear regarding not only ocular morbidity but also the global burden of disease.

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All authors contributed to the study design and data acquisition and interpretation.

All authors participated in the writing and critical revision of the manuscript and approved its final version.

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