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Clinical characteristics and prognostic factors of open globe injuries in a North Spain population: a 10-year review

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OBJECTIVES: To describe the epidemiologic and clinical characteristics of open globe injuries (OGIs) treated in a tertiary hospital and analyse predictors of visual outcome.

METHODS: This retrospective observational study included all patients with OGIs admitted to Cruces University Hospital between 2010 and 2020. The descriptive analysis included demographic data, type of injury classified as "rupture", "penetration", "perforation", or "intraocular foreign body", trauma mechanism and setting, injury zone, Ocular Trauma Score, delay to surgery, length of hospital stay, antibiotic prophylaxis, initial and final best corrected visual acuity (BCVA), complications and further surgery. Univariate analysis and logistic regression were performed to identify prognostic factors, based on final BCVA.

RESULTS: Overall, 207 OGI cases were reported. The most common type of injuries were ruptures caused by domestic falls. Notably, 44.4% of eyes developed phthisis bulbi. In the univariate analysis, the following variables were significantly linked to visual outcome: age > 60 years, "rupture", "fall", posterior and/or combined zones of injury, lens damage, retinal/choroidal detachment, initial BCVA of no light perception, and Ocular Trauma Score ≤ 2 ($p < 0.001$). Delay to surgery, length of stay and further surgery did not have prognostic value. In the logistic regression, initial BCVA of no light perception ($p < 0.001$) and injury zone III ($p = 0.005$) remained significant predictors of poor outcome.

CONCLUSIONS: In the population studied, most OGIs were caused by domestic falls usually affecting elderly patients with comorbidities. Visual outcome depended on patients´ specific characteristics and the nature of the trauma itself, whereas environmental factors failed to show any prognostic value.

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INTRODUCTION

Ocular trauma is known to be the leading cause of avoidable unilateral blindness worldwide [1]. In the last three decades, many studies concerning open globe injuries (OGIs) have attempted to establish a universal standard of care [2–4]. Unfortunately, published data are biased by the high variability across different populations, in terms of demographics, lifestyle and socioeconomic status.

According to the largest study carried out in our country by the "*Grupo Español Multicéntrico de Traumatismos Oculares*" (GEMTO) in the 1990s, most OGIs in Spain were occupational, followed by domestic accidents and injuries related to leisure activities [5]. The results varied notably across the regional cohorts, and moreover, may not be representative of the current pattern of population. The average life expectancy in Spain is currently one of the highest in the world, this leading to population aging and substantial changes in socioeconomical structure [6]. These circumstances can be expected to significantly influence the profile of OGIs in terms of epidemiology, etiopathogenesis and comorbidities, directly affecting visual outcomes.

During the study period, Cruces University Hospital, located in Basque Country in the north of Spain, had a catchment population of approximately 400,000 people, with a higher proportion between 40 and 70 years and a male/female ratio close to 1. The objectives of our research were, first, to describe the current epidemiologic and clinical characteristics of OGIs in our setting and, second, validate the OTS score and identify potential risk factors that may affect visual outcome. To our knowledge, this is the largest single-center series published in our country focused exclusively on OGIs.

METHODS

Data source and target population

A retrospective observational study was conducted in 204 patients with 207 OGIs at Cruces University Hospital between January 2010 and December 2020, with a minimum follow-up period of 6 months. OGIs were defined as any ocular trauma with a full-thickness wound in the cornea or sclera. The research was performed in accordance with the Declaration of Helsinki, and was approved by the institutional Ethical Review Board, in May 2020.

The primary objective of this study was to describe the characteristics and management of OGI in our region. To address the secondary objective, statistical analysis was carried out to identify prognostic factors, taking the final best corrected visual acuity (BCVA) obtained as a reference.

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Patient-related information was provided by the Clinical Documentation, Archives and Management Control Service. We included all OGIs seen in our hospital in the specified period, without age or sex limitations, but requiring a minimum follow-up of 6 months. Patients with closed globe injuries or medical records with missing data were excluded from the study.

Data collected are listed below:

1. Demographic characteristics: Age, sex, and laterality, setting and mechanism of the OGI.
2. Type of injury based on the Birmingham Eye Trauma Terminology (BETT) system, grouping injuries as "rupture" (eyewall full-thickness wound caused by a blunt object), "penetration" (entrance wound only), "perforation" (entrance and exit wound), and injuries with an intraocular foreign body (IOFB) [7, 8].
3. Emergency department examination: Initial BCVA expressed as a decimal, pupil reflex, slit-lamp examination and fundoscopy if feasible, and computed tomography scan of the orbit.
4. Zone of injury: Wound location was classified into three groups, based on Pieramici´s system [9]: zone I (limited to the cornea or corneoscleral limbus); zone II (from limbus to a point 5 mm posterior into the sclera) and zone III (posterior to the anterior 5 mm of the sclera). When more than one zone was affected, the injury was classified by the zone of most posterior involvement.
5. Ocular Trauma Score (OTS) [10, 11], if data required were available. The sum of each patient´s raw scores, based on the initial visual acuity and/or the presence of globe rupture, penetration, endophthalmitis, retinal detachment and/or afferent pupillary defect, was converted into an OTS category ranging from 1 to 5. In our report, OTS was expressed in two formats: (1) as one of the aforementioned five categories; and (2) as one of two groups based on their category: >2 and ≤2. Data collected were compared with published reference values.
6. Inpatient care data: Delay between patient admission and first surgery (hours); details of surgical intervention; length of hospital stay (days); and antimicrobial prophylaxis.
7. Initial and final BCVA.
8. Medium and long-term complications and further surgery, if any.

Statistical analysis

Continuous variables were expressed as mean (SD) when the data were normally distributed and median [25th; 75th] otherwise. Categorical variables were expressed as percentages. Differences between groups were analysed using Mann–Whitney *U* or Kruskal–Wallis tests for continuous variables and Chi-square tests for categorical variables. *P*-values were adjusted for multiple comparisons by the Benjamini and Hochberg method.

Multivariate analysis was carried out using logistic regression models to determine the factors associated with poor visual outcome, based on final BCVA. Specifically, BCVA > 0.1 (decimal visual acuity) was considered a

Table 1. Summary of descriptive characteristics of the open-globe traumas by type of injury.

Variables	Overall *N* (%)	Rupture *N* (%)	Penetration *N* (%)	IOFB[a] *N* (%)	*P* value
Mechanism, *N* = 198[b]					<0.001
Others[c]	70 (35.4)	29 (24.6)	32 (57.1)	9 (37.5)	
Fall	66 (33.3)	66 (55.9)	0 (0.00)	0 (0.00)	
Work tool/machinery	36 (18.2)	7 (5.93)	14 (25.0)	15 (62.5)	
Assaults/fights	26 (13.1)	16 (13.6)	10 (17.9)	0 (0.00)	
Zone, *N* = 198					0.103
I	74 (37.4)	36 (30.5)	26 (46.4)	12 (50.0)	
II	65 (32.8)	40 (33.9)	19 (33.9)	6 (25.0)	
III	59 (29.8)	42 (35.6)	11 (19.6)	6 (25.0)	
Initial BCVA, *N* = 180					<0.001
NLP	79 (43.9)	61 (55.0)	11 (23.9)	7 (30.4)	
Final BCVA, *N* = 198					<0.001
NLP	97 (49.0)	76 (64.4)	15 (26.8)	6 (25.0)	
OTS, Median [25th;75th], *N* = 179	37.0 [16.0;60.0]	27.0 [16.0;37.0]	70.0 [50.8;90.0]	70.0 [46.0;89.5]	<0.001
OTS categorized, *N* = 179					<0.001
>2	43 (24.0)	5 (4.55)	26 (56.5)	12 (52.2)	
≤2	136 (76.0)	105 (95.5)	20 (43.5)	11 (47.8)	
History of lens extraction	57 (28.8)	55 (46.6)	2 (3.57)	0 (0.00)	<0.001
History of corneal transplant	27 (13.0)	27 (20.3)	0 (0.00)	0 (0.00)	<0.001
Lens/IOL damage	158 (79.8)	104 (88.1)	36 (64.3)	18 (75.0)	0.002
Choroidal/retinal detachment	138 (69.7)	98 (83.1)	23 (41.1)	17 (70.8)	<0.001
Corneal graft failure	15 (7.58)	12 (10.2)	3 (5.36)	0 (0.00)	0.163
Infection	11 (5.56)	6 (5.08)	4 (7.14)	1 (4.17)	0.907
Ocular hypertension	28 (14.1)	18 (15.3)	6 (10.7)	4 (16.7)	0.772
Further surgery[d]	90 (45.5)	49 (41.5)	25 (44.6)	16 (66.7)	0.078

IOFB intraocular foreign body, *BCVA* best corrected visual acuity, *NLP* no light perception, *PL* light perception, *HM* hand motion @two feet, *OTS* Ocular Trauma Score, *IOL* intraocular lens.

[a]IOFB included 19 metallic projectiles, 2 wood splinters, 1 glass fragment, 1 fish hook, 1 firecracker and 1 brick chip.

[b]9 patients were excluded from the univariate analysis due to missing data.

[c]"Others" category is detailed in Table 2.

[d]Vitreoretinal surgery with or without lens extraction (*n* = 67); evisceration (*n* = 27); lensectomy with implant of intraocular lens, excluding cases of traumatic lens extrusions (*n* = 22); corneal transplant (16 penetrating keratoplasty and 1 Descemet stripping automated endothelial keratoplasty); glaucoma surgery (7 drainage device implantation, 1 trabeculectomy, 1 cyclophotocoagulation); 3 intravitreal antibiotic injections, 2 amniotic membrane transplants, 2 corneoscleral resutures, 2 lid repairs, 2 strabismus surgeries, 1 arcuate corneal incision.

Table 2. Mechanism and setting of the open globe injuries, overall and stratified by age.

Variables	Overall	≤30 years, *N* (%)	31–60 years, *N* (%)	>60 years, *N* (%)
Mechanism				
Fall	68	0 (0.0)	7 (9.3)	61 (70.1)
Work tool/machinery	38	9 (20.0)	25 (33.3)	4 (4.6)
Assaults/fights	27	8 (17.8)	16 (21.4)	3 (3.4)
Organic materials (vegetable matter)	15	1 (2.2)	8 (10.7)	6 (6.9)
Others	59	27 (60.0)[a]	19 (25.3)[b]	13 (15.0)[c]
Setting				
Domestic (Home/surroundings)	75	10 (22.2)	15 (20.0)	50 (57.5)
Leisure-related	53	20 (44.4)	27 (36.0)	6 (6.9)
Workplace	36	7 (15.6)	25 (33.3)	4 (4.6)
Public highway	22	2 (4.4)	5 (6.7)	15 (17.3)
Unknown	8	1 (2.2)	0 (0.0)	7 (8.0)
Residential care facilities	5	0 (0.0)	0 (0.0)	5 (5.7)
Sport-related	5	2 (4.4)	3 (4.0)	0 (0.0)
School	3	3 (6.8)	0 (0.0)	0 (0.0)

[a]This group includes 3 stones, 3 fireworks, 2 balls, 2 pens, 2 rulers, 2 plastic plates, 2 toys, 2 glass shards, 1 barrel, 1 dart, 1 pellet, 1 fork, 1 pencil, 1 finger, 1 calendar, 1 scooter, and 1 unknown projectile.
[b]This group includes 3 bottles, 2 pellets, 2 stones, 1 blind, 1 ball, 1 glass shard, 1 fishing lead, 1 fish hook, 1 finger, 1 foot, 1 golf club, 1 car hood, 1 firecracker, 1 bottle cap, and 1 cow horn.
[c]This group includes 3 house doors, 1 garage door, 1 blind, 1 tap, 1 tile, 1 pellet, 1 glass shard, 1 shoe, 1 unknown projectile, 1 car (the patient having been run over), and 1 unknown.

"good outcome", and BCVA ≤ 0.1 a "poor outcome". In cases of visual acuity <0.3 prior to the trauma, individuals with a final BCVA less than or equal to a third of their original BCVA were considered to have a "poor outcome". Nine out of 207 OGIs were excluded from the statistical analyses due to missing data. All the analyses were performed with R (version 4.1.1) R: A Language and Environment for Statistical Computing (Vienna, Austria).

RESULTS

Epidemiology and ophthalmologic history

In this retrospective study, we recruited 204 patients with 207 OGIs admitted to Cruces University Hospital, in the period between January 2010 and December 2020. Three out of 204 patients presented with a second OGI in the same eye during the follow-up period. A total of 158 (76.3%) of the OGIs were in men and 49 (23.7%) in women, yielding a male:female ratio of approximately 3 to 1.

118 (57%) of the injuries were in the left eye and 89 (43%) in the right eye.

The overall mean age was 53.3 ± 26.2 years (range 2–95 years) and the median was 54.0 years [33.0; 77.0]. 42% of patients were over 60 years old.

Regarding history of eye surgery (prior to the trauma), the most frequent interventions were cataract extraction and corneal transplant (Table 1). Notably, 96.5% of patients who had undergone cataract surgery and all of those who had received transplants were in the rupture group ($p < 0.001$). Among the 27 transplanted patients, 25 had undergone penetrating keratoplasty. Twenty-five out of the 27 transplanted patients evidenced lacerations in zone I, showing wound dehiscence at the graft-host junction, while the other two had severe trauma with complex and extensive corneoscleral wounds affecting combined globe zones.

Type of injury

Classifying the sample based on the BETT system, we identified 123 cases of rupture (59.4%), 59 of penetration (28.5%) and 25 of IOFB (12.1%). In our cohort, we did not detect any perforations. The median age was highest in the rupture group (72.0 years [52.0; 85.0]), followed by the IOFB and penetration groups (45.0 years [33.2; 57.2] and 31.5 years [15.2; 47.0] respectively) ($p < 0.001$). The patients were distributed according to their age and sex, as illustrated in Supplementary Fig. S1. Remarkably, there were more men in all three categories ($p < 0.001$). Women were most likely to have globe rupture and most of the women in the sample were >60 years old.

OGI mechanism and setting

Overall, the most common mechanisms of injury were falls (33.3%), work tools/machinery (18.2%), and assaults/fights (13.1%). An additional group called "Others" was created to include a wide variety of objects and materials responsible for injuries not classifiable in the categories above (Table 2). Some significant associations were found between type of injury and mechanism categories, namely, ruptures were correlated with falls, IOFBs with work tool/machinery-related injuries and perforations with other causes ($p < 0.001$) (Table 1). Within the IOFB group, 19 injuries were caused by metallic projectiles, and most of them occurred in the workplace. Concerning the setting of the trauma, overall, most of OGI (36.2%) took place in a domestic environment. After stratifying by age, injuries at home or in surrounding areas were the most common among the elderly, whereas younger people were found to be at greater risk of occupational and leisure-related injuries (Table 2).

Initial evaluation of suspected OGI and OTS score

Data on VA were available for 180 patients and expressed as a decimal. Initial BCVA of NLP, seen in 43.9% of the patients overall, was significantly more prevalent in the rupture group ($p < 0.001$). Regarding the eye structures involved, lens/intraocular lens damage or loss ($p = 0.002$) and choroidal and/or retinal detachment ($p < 0.001$) were common findings, especially in the rupture and IOFB groups. As for the anatomic site, in general terms, most injuries were to the anterior globe (Table 1).

The OTS score was calculated in the 179 patients for whom sufficient data were available (Table 1). Analysing the categorized

Table 3. Comparison of final visual acuities and Ocular Trauma Score categorical values between the OTS study and our results.

Sum of raw points	NLP A/B	LP-HM A/B	1/200-19/200 A/B	20/200-20/50 A/B	≥20/50 A/B	*P*-value
0–44	74/82.5	15/14.6	7/1.9	3/0	1/1	0.172
45–65	27/27.3	26/24.2	18/0	15/27.3	15/21.2	<0.001
66–80	2/0	11/19	15/0	31/4.8	41/76.2	<0.001
81–91	1/0	2/7.7	3/7.7	22/0	73/84.6	<0.001
92–100	0/0	1/0	1/0	5/0	94/100	0.029

OTS Ocular Trauma Score, *NLP* No light perception, *LP* light perception, *HM* Hand motion, *A* OTS Study results (%), *B* Our study results (%). (Chi-square test).

OTS, almost all ruptures were associated with a score ≤2 ($p < 0.001$). Comparing our results with the reference values reported by Kuhn et al. [10], we found statistically significant differences in all the categories ($p < 0.001$), except the first one corresponding to 0–44 points ($p = 0.172$) (Table 3).

Surgical management and postoperative care

Over half of the sample (52%) had a delay to surgery ≤6 h (Table 4). Direct wound closure by corneoscleral suture was the preferred procedure in most cases. A total of 10 eviscerations were performed as a primary procedure, due to extensive and irreparable eye wounds. Most of these injuries happened as a result of accidental falls at home or in residential care facilities.

For antimicrobial prophylaxis, the regime used routinely (67%) was IV vancomycin 1 g BID + IV ceftazidime 1 g TID. In the case of allergy, quinolones or amoxicillin-clavulanic acid were used. At discharge, third or fourth generation oral quinolones were prescribed on an outpatient basis. The admission time varied considerably at the surgeon´s discretion. However, no significant correlation was found between length of admission and visual outcome (Table 4).

Complications

In our study, nearly half ($n = 97$, 49%) of patients obtained a final BCVA of NLP. In this group, 76 (78%) were ruptures, 47 (48%) were injuries in zone III and 70 (72%) showed an BCVA of NLP at admission. Notably, 88 patients (44.4%) suffered high-energy trauma with irreparable functional and anatomic damage and/or developed phthisis bulbi. Both phthisis and final BCVA of NLP were more prevalent in the rupture category ($p < 0.001$).

A total of 10 infectious events were detected: 6 cases of endophthalmitis, 3 corneal abscesses and 1 case of preseptal cellulitis. The causative agent was only identified in four patients, the pathogen isolated being a coagulase-negative staphylococcus in all cases. All of the cases of endophthalmitis were linked to relatively small-sized lacerations in zone I.

Another complication considered in our study was graft failure in patients with corneal transplant prior to the eye injury. Overall, 11 graft failures were confirmed during the follow-up period, and the final BCVA was ≤0.1 in 10 out of the 11 cases.

Posttraumatic ocular hypertension was reported in 28 patients. Among these, 7 required glaucoma surgery, 21 obtained a final BCVA ≤ 0.1, and 5 ended up with phthisis bulbi.

Further surgery seeking to restore vision was a common practice during the study period. In general terms, 90 patients in our series underwent further surgery, on 1 ($n = 57$), 2 ($n = 16$), 3 ($n = 8$) or ≥ 4 ($n = 9$) occasions. The most common procedures were vitreoretinal surgery (pars plana vitrectomy and/or scleral buckling) and evisceration. The rest are listed in Table 1.

The univariate analysis failed to find any statistically significant associations of the three "Type of injury" groups (rupture, penetration and IOFB) with the development of infection ($p = 0.907$), graft failure ($p = 0.163$), posttraumatic hypertension ($p = 0.772$) or the need for further surgery ($p = 0.078$).

Analysis of prognostic factors

In the univariate analysis, a final BCVA > 0.1 was considered "good" and ≤ 0.1, "poor", with the exceptions detailed in the Methods section. The distribution of the variables considered by outcome and their association with final BCVA of NLP and/or phthisis bulbi are shown in Table 4.

Stratifying by type of injury, rupture was markedly linked to a poor prognosis, with a poor outcome in over 80% of cases and phthisis bulbi in almost 60% ($p < 0.001$). As for the mechanism of injury, the poorest prognosis was seen in the fall group ($p < 0.001$), with a high risk of phthisis bulbi (59.1%). Visual outcome was significantly poorer in wounds affecting posterior and/or combined globe zones. Patients presenting NLP at their first visit was strongly associated with the poor outcome group (97.5%), with a rate of phthisis bulbi of nearly 80% ($p < 0.001$). Circumstantial factors like delay to surgery ($p = 0.880$), length of stay ($p = 0.628$) and further surgery ($p = 0.880$) failed to show any significant correlation with the final VA.

In the logistic regression model, the BCVA of NLP at admission, the injury zone III and the age groups [0–30] years and [61–100] years remained predictors of poor outcome, although a significant association was only detected for the first two of the aforementioned variables. The IOFB and penetration categories and injury zone II seemed to be protective factors, although the latter was not statistically significant (Table 5).

DISCUSSION

In the current study, we highlighted globe ruptures as the most frequent cause of OGI, followed by penetrating lacerations caused by a miscellany of objects/materials, and finally IOFBs, which were usually linked to workplace accidents. In our sample, we did not observe any perforations, probably because these injuries are often caused by projectiles or sharp objects in war settings or workplaces without appropriate measures for eye protection, neither of which are common scenarios in our society.

Our data illustrate a particularly vulnerable patient profile, characterized by age >60 years, comorbidities, globe rupture as a result of an accidental fall at home or in residential care, affecting posterior and/or combined globe zones, a VA of NLP at admission, and a OTS score <2. In this type of patient, our model predicts a high probability of irreparable functional and structural damage to the ocular globe, phthisis bulbi developing in two-thirds of patients with ruptures versus a quarter of patients with penetrations or IOFBs.

The present study supports the view that the distribution of OGIs in terms of age, sex and type of trauma is highly dependent on the characteristics of the population of interest. Our region shows a growing proportion of the population aged between 40 and 70 years, as a result of gradual aging and a decreasing birth rate [12]. This is consistent with the high prevalence of globe ruptures in geriatric patients found in our study. In contrast, in the largest multicentre study in Spain, conducted by GEMTO three decades ago [5], workplace accidents were the leading cause of

Table 4. Summary of descriptive characteristics by prognosis, stratified into good and poor outcome, and their association with final visual acuity of NLP and development of phthisis bulbi.

	Overall *N* (%)	Good outcome[a] *N* (%)	Poor outcome[a] *N* (%)	*P* value	Final BCVA NPL *N* (%)	*P* value	Phthisis Bulbi *N* (%)	*P* value
Sex, $N = 198$				0.008				
Female	48 (24.2)	8 (16.6)	40 (83.3)					
Male	150 (75.8)	58 (38.6)	92 (61.3)					
Laterality, $N = 198$				0.388				
Right eye	85 (42.9)	25 (29.4)	60 (70.6)					
Left eye	113 (57.1)	41 (36.3)	72 (63.7)					
Age (years), $N = 198$				<0.001				
Median [25th; 75th]	54.0 [33.0;77.0]	37.0 [16.5;54.2]	69.0 [46.0;82.2]					
0–30	43 (21.7)	23 (53.5)	20 (46.5)					
31–60	71 (35.9)	32 (45.1)	39 (54.9)					
61–100	84 (42.4)	11 (13.1)	73 (86.9)					
History of eye surgery, $N = 198$								
Cataract extraction	57 (28.8)	9 (15.8)	48 (84.2)	0.002				
Corneal transplant	24 (12.1)	5 (20.8)	19 (79.2)	0.248				
Type of injury, $N = 198$				<0.001		<0.001		<0,001
Rupture	118 (59.6)	19 (16.1)	99 (83.9)		76 (64.4)		69 (58.5)	
Penetration	56 (28.3)	34 (60.7)	22 (39.3)		15 (26.8)		13 (23.2)	
IOFB	24 (12.1)	13 (54.2)	11 (45.8)		6 (25.0)		6 (25.0)	
Mechanism, $N = 198$				<0.001		<0.001		0.007
Others	70 (35.4)	37 (52.9)	33 (47.1)		21 (30.0)		21 (30.0)	
Fall	66 (33.3)	6 (9.09)	60 (90.9)		47 (71.2)		39 (59.1)	
Work tool/ machinery	36 (18.2)	14 (38.9)	22 (61.1)		15 (41.7)		15 (41.7)	
Assaults/fights	26 (13.1)	9 (34.6)	17 (65.4)		14 (53.8)		13 (50.0)	
Zone, $N = 198$				<0.001		<0.001		<0.001
I	74 (37.4)	39 (52.7)	35 (47.3)		16 (21.6)		13 (17.6)	
II	65 (32.8)	22 (33.8)	43 (66.2)		34 (52.3)		31 (47.7)	
III	59 (29.8)	5 (8.5)	54 (91.5)		47 (79.6)		44 (74.6)	
Initial BCVA, $N = 180$				<0.001		<0.001		<0.001
≥ LP	101 (56.1)	52 (51.5)	49 (48.5)		24 (23.8)		21 (20.8)	
NLP	79 (43.9)	2 (2.53)	77 (97.5)		70 (88.6)		63 (79.7)	
OTS score, $N = 179$								
Median [25th; 75th]	37.0 [16.0;60.0]	70.0 [59.0;90.0]	27.0 [16.0;39.0]					
0–44	103 (57.5)	2 (1.9)	101 (98.1)					
45–65	33 (18.4)	14 (42.4)	19 (57.6)					
66–80	21 (11.7)	17 (80.9)	4 (19.1)					
81–91	13 (7.26)	11 (84.6)	2 (15.4)					
92–100	9 (5.03)	9 (100.0)	0 (0.00)					
OTS category, $N = 179$				<0.001				
> 2	43 (24.0)	37 (86.0)	6 (14.0)					
≤ 2	136 (76.0)	16 (11.7)	120 (88.3)					
Delay to surgery (hours) $N = 196$				0.880				
≤ 6	102 (52.0)	36 (60.0)	66 (30.0)					
7–12	60 (30.6)	19 (26.0)	41 (74.0)					
>12	34 (17.4)	11 (16.9)	23 (83.1)					

Table 4. continued

	Overall *N* (%)	Good outcome[a] *N* (%)	Poor outcome[a] *N* (%)	*P* value	Final BCVA NPL *N* (%)	*P* value	Phthisis Bulbi *N* (%)	*P* value
Length of stay (days), $N = 198$				0.628				
1	60 (30.3)	20 (33.3)	40 (66.6)					
2–4	73 (36.9)	27 (37.0)	46 (63.0)					
>4	65 (32.8)	19 (29.2)	46 (70.8)					
Complications								
Lens damage	158 (79.8)	30 (19.0)	128 (81.0)	<0.001				
Choroidal/retinal detachment	138 (69.7)	19 (13.7)	119 (86.3)	<0.001				
Graft failure	15 (7.58)	2 (13.3)	13 (86.6)	0.154				
Infection	11 (5.56)	0 (0.00)	11 (100.0)	0.019				
Ocular hypertension	28 (14.1)	10 (35.7)	18 (64.3)	0.943				
Further surgery, $N = 198$				0.880		0.305		0.473
Yes	90 (45.5)	29 (32.2)	61 (67.8)		57 (52.8)		51 (47.2)	
No	108 (54.5)	37 (34.3)	71 (65.7)		40 (44.4)		37 (41.1)	

BCVA best corrected visual acuity, *NLP* no light perception, *LP* light perception, *OTS* Ocular Trauma Score, *IOFB* intraocular foreign body.
[a]Final BCVA > 0.1 (decimal visual acuity) was considered a "good outcome", and final BCVA ≤ 0.1 a "poor outcome". In cases of visual acuity < 0.3 prior to the trauma, individuals with a final BCVA less than or equal to a third of their original BCVA were considered to have a "poor outcome".

Table 5. Multivariate analysis of factors associated with poor visual outcome (based on final BCVA), using logistic regression models.

Variables	OR	95% CI	*p*-value
Age 0–30[a] (years)	–	–	–
Age 31–60	1.49	(0.42; 5.54)	0.500
Age 61–100	4.13	(0.99; 18.4)	0.054
Rupture[a]	–	–	–
Penetration	0.30	(0.09; 0.91)	0.035
IOFB	0.23	(0.06; 0.83)	0.028
Initial BCVA > NLP[a]	–	–	–
Initial BCVA of NLP	30.7	(7.51; 220)	<0.001
Zone I[a]	–	–	–
Zone II	0.98	(0.35; 2.71)	0.962
Zone III	6.12	(1.80; 23.9)	0.005

OR odds ratio, *CI* confidence interval, *IOFB* intraocular foreign body, *BCVA* best corrected visual acuity, *NLP* no light perception.
[a]Reference variables.

ocular trauma; the difference is attributable to that study having included a younger cohort with a higher proportion of active population, mainly employed in risky workplaces with poor safety records (agriculture, industry and construction sectors). A similar trend has also been illustrated in more recent Spanish studies, with smaller cohorts [13, 14].

In our study, non-fall-related OGIs were mostly penetrations and IOFBs in young males, and occurred in leisure or work environments. Injuries in women were almost all ruptures in > 60-year-olds, with only five penetrations and no IOFBs detected in the female cohort. This could be explained by the fact that nearly 90% of working women are employed in the service sector, whereas the sectors with the highest accident and injury rates in our region (construction and industry) have a predominantly male workforce (>80%), as well as assaults or fights linked to leisure activities usually involving men (>80%) [15].

Our results may contrast with other reports involving populations that differ widely in social structure and socioeconomic status. A review of OGI conducted in the United States by Mir et al. revealed that the leading cause of trauma was being struck by an object or a person, especially in young males of low socioeconomic status [16]. In the series of Zhang and Mansouri et al. [17, 18], penetrations and IOFBs at home or in the workplace were the most frequent cause of OGIs, mostly in children and young male adults, reflecting the higher percentage of young people in these populations and the lack of use of eye protective measures in domestic and work settings. These findings are inconsistent with our study, in which only 21% of patients were under 30 years.

The correlation between wound location and surgery prior to trauma is well known. In the present work, the great majority of patients with a history of cataract surgery and all the transplanted patients had injuries classified as ruptures. Furthermore, almost all the transplants were associated with wound dehiscence at the graft-host junction. Among patients who undergo cataract extraction, penetrating keratoplasty or deep anterior lamellar keratoplasty, wound weakness seems to be a lifelong risk regardless of the indication, suture technique or time since surgery [19–22]. In our opinion, this issue underlines the need to provide these patients with information about specific preventive measures.

One of the broader goals of this study was to validate the OTS score [10, 11]. Many authors have attempted to reproduce OTS results, with inconsistent outcomes [23–25]. Our study failed to validate all the OTS categories except 1, and we attribute this to inaccuracy in the data recording process. It is evident that initial examination may be affected by severe eye trauma, ocular adnexal damage, neurologic comorbidities and uncooperative or shocked patients. The relative afferent pupillary defect and retinal detachment are often difficult to detect in patients with media opacity or severe anatomic damage. Finally, in our opinion, perforation and endophthalmitis are so infrequent in our setting that their inclusion in the classification could be a source of error in the prognosis of visual outcome. In this context, the International Globe and Adnexal Trauma Epidemiology Study (IGATES) is developing a multicentre cloud-computing data

system to create an up-to-date and enhanced OTS, incorporating a wider range of variables affecting visual outcome [2].

Much research in recent years has focused on the prevention and management of posttraumatic endophthalmitis. Several factors have been associated with an increased risk of infection, such as retained IOFB, injuries in rural settings, delay of surgery by more than 24 h and small wounds in zone I which can promote the inoculation and proliferation of pathogenic microorganisms [26–30]. In our report, six cases of endophthalmitis were identified, corresponding to a rate of 2.9%. It should be emphasized that all the eyes had small-sized corneal wounds with little tissular disruption. Reviewing the literature, the rate of posttraumatic endophthalmitis varies widely, between 0% and 54% [17, 27, 31–34]. This fluctuation could be explained by the great heterogeneity in the study populations in terms of lifestyle, trauma mechanism, causative agent and immediate management. The aforementioned series of Zhang and Mansouri reported endophthalmitis rates of 11.91% and 5%, respectively, with a higher risk in small wounds located in zone I, in line with our results [17, 18].

It is generally the standard of care to give systemic antibiotics immediately after admission [32]. Nonetheless, the actual benefit of antibiotic prophylaxis remains unclear. In the absence of evidence-based antimicrobial management guidelines, several trials have attempted to find the most effective therapy to prevent posttraumatic endophthalmitis, with inconclusive results [34–36]. On the whole, vancomycin, cephalosporins, aminoglycosides and quinolones are considered first-line drugs to prevent endophthalmitis by many authors [29, 37, 38]. Our antimicrobial protocol consists of the administration of IV vancomycin + ceftazidime, similar to protocols described elsewhere [26, 32, 39]. Regardless of their excellent intraocular penetration, fluoroquinolones remain a second-line therapy in our institution.

The limitations of our study are its retrospective observational nature, and the lack of data in some cases due to the difficulty of carrying out a complete and reliable assessment in this context. Finally, we assume that the inclusion of multiple variables in the analysis and intra-practitioner heterogeneity in the way the injuries are described and handled are factors that might bias the study results.

In summary, our study concludes that the prognosis of OGI is critically linked to the type of injury, initial impaired VA and wound extension and location, all of these being patient-dependent variables. Environmental factors concerning timing of primary wound repair, inpatient care, length of stay or further surgery, are circumstantial and subject to change, and they do not seem to significantly influence visual outcome. Besides, standards of care are commonly conditioned by institutional factors, such as the availability of medical staff or hospital resources. In our series, we highlight a particularly vulnerable patient profile, characterized by age older than 60 years, comorbidities, and proneness to accidental falls in a domestic environment. In this scenario, the implementation of personalized screening and fall prevention programs could be a valuable strategy for minimizing OGIs [40–43]. Nonetheless, the impact of these interventions on eye injury rates is inconclusive [44]. Therefore, future studies should be based on well-designed randomized controlled trials with a longer follow-up period, allowing the development of cost-efficient OGI prevention strategies and helping reduce their socioeconomic consequences.

SUMMARY

What was known before

- Clinical and epidemiological characteristics of open globe injuries (OGI) in our country depend on the socioeconomical structure, and vary notably across the different regional cohorts.
- Currently, the most frequent OGI are globe ruptures in elderly patients, as a result of population aging and a decreasing rate in work-related accidents during the last decades.

What this study adds

- Our model predicts a high probability of irreparable functional and structural damage to the ocular globe in elderly patients suffering accidental falls, phthisis bulbi developing in two-thirds of patients with ruptures versus a quarter of patients with penetrations or IOFBs.
- In our cohort, visual outcome was critically linked to patient-dependent variables and the nature of the trauma itself, whereas environmental factors failed to show any prognostic value.

DATA AVAILABILITY

The datasets generated and analysed during the current study are not publicly available due to confidentiality agreements, but are available from the corresponding author on reasonable request.

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AUTHOR CONTRIBUTIONS

ASC was responsible for designing the review protocol, writing the protocol and report, conducting the search, screening potentially eligible studies, extracting and analysing data, interpreting results, updating reference lists and creating figures and tables. SPF was responsible for the statistical analysis. She contributed to creating'Summary of findings' tables. AOB, RFL, BLE, and JEE contributed to writing the report, arbitrating potentially eligible studies, and provided feedback on the report.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

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