

Functional Outcomes and Prognostic Markers After Ocular Trauma: A Nine-Year Tertiary-Care Cohort

Resultados Funcionais e Marcadores Prognósticos Após Trauma Ocular: Coorte de Nove Anos num Centro Terciário

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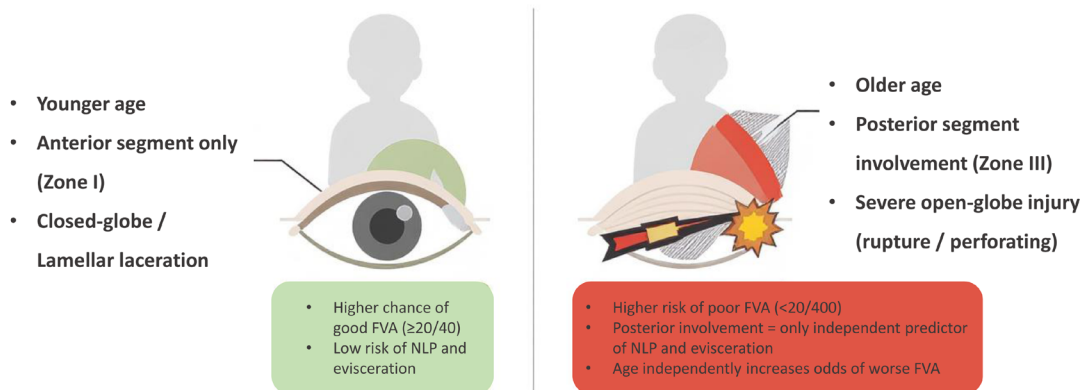
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GRAPHICAL ABSTRACT

Functional Outcomes and Prognostic Markers After Ocular Trauma

Nine-year tertiary-care cohort, 216 eyes



Age and anatomical extension are key independent predictors of visual outcome.
Posterior segment involvement drives NLP and evisceration, regardless of initial VA.

ABSTRACT

INTRODUCTION: We aimed to characterize the clinical profile of ocular trauma over nine years in a Portuguese tertiary center and to identify independent predictors of final visual outcomes.

METHODS: Retrospective observational cohort study with 216 eyes of 216 patients admitted with ocular trauma between January 2015 and December 2023.

Demographic, clinical, and surgical data were retrieved from electronic medical records. Injuries were classified according to the Birmingham Eye Trauma Terminology (BETT). Final visual acuity (FVA) was categorized as $\geq 20/40$, $20/40-20/400$, or $< 20/400$. Additional outcomes included no light perception (NLP) and evisceration. Associations between clinical variables and outcomes were assessed using non-parametric tests, Kaplan-Meier survival analysis, and multivariable logistic and ordinal regression.

RESULTS: Open-globe injuries predominated, mainly penetrating trauma and globe ruptures. Poorer FVA was associated with older age ($p=0.002$), involvement of the posterior segment, more posterior BETT zones ($p<0.001$), and open-globe mechanisms, particularly rupture and perforating injuries ($p<0.001$). Increasing age independently increased the odds of worse FVA by 3.4% per year (OR 1.034, 95% CI 1.011–1.056, $p=0.004$), while injuries confined to the anterior segment were associated with a better visual outcomes (OR 0.09, 95% CI 0.03–0.22, $p<0.001$). Posterior segment involvement emerged as the only independent predictor of progression to no light perception (NLP) (aOR 0.14, 95% CI 0.03–0.55, $p=0.005$) and was also independently associated with subsequent evisceration (aOR 0.07, 95% CI 0.01–0.74, $p=0.027$), reflecting the most severe anatomical outcome in this cohort on multivariable analysis. Time to primary surgery was not significantly associated with visual outcomes.

CONCLUSION: In this nine-year tertiary-care cohort, age, posterior segment involvement, and severe open-globe mechanisms were key prognostic markers of poor visual outcome after ocular trauma. Injuries limited to the anterior segment conferred a markedly better prognosis, whereas posterior extension was the sole independent predictor of NLP and evisceration. These findings reinforce the importance of established prognostic factors and may support more realistic counselling of patients and their families after severe ocular trauma.

KEYWORDS: Eye Injuries; Prognosis; Visual Acuity.

RESUMO

INTRODUÇÃO: O nosso objetivo foi caracterizar o perfil clínico do trauma ocular ao longo de um período de nove anos num centro terciário português e identificar preditores independentes do resultado visual final.

MÉTODOS: Estudo observacional e retrospectivo com 216 olhos de 216 doentes admitidos por trauma ocular entre janeiro de 2015 e dezembro de 2023.

Os dados demográficos, clínicos e cirúrgicos foram recolhidos a partir do processo clínico eletrónico. As lesões foram classificadas de acordo com a *Birmingham Eye Trauma Terminology* (BETT). A acuidade visual final (AVF) foi categorizada como $\geq 20/40$, $20/40-20/400$ ou $< 20/400$. Os desfechos adicionais incluíram ausência de perceção luminosa (NLP) e evisceração. As associações entre as variáveis clínicas e os desfechos foram avaliadas através de testes não paramétricos, análise de sobrevivência de Kaplan-Meier e regressão logística e ordinal multivariável.

RESULTADOS: As lesões de globo aberto foram predominantes, sobretudo traumatismos penetrantes e ruturas do globo. Uma AVF mais baixa associou-se a idade mais avançada ($p=0.002$), envolvimento do segmento posterior, zonas BETT mais posteriores ($p<0.001$) e mecanismos de globo aberto, particularmente ruturas e lesões perfurantes ($p<0.001$). O aumento da idade incrementou de forma independente em 3,4% por ano a probabilidade de pior AVF (OR 1,034; IC 95% 1,011–1,056; $p=0.004$), enquanto as lesões confinadas ao segmento anterior se associaram a melhores resultados visuais (OR 0,09; IC 95% 0,03–0,22; $p<0.001$). O envolvimento do segmento posterior foi o único preditor independente de NLP (OR ajustado 0,14, 95% CI 0,03–0,55, $p=0.005$) e evisceração (OR ajustado 0,07, 95% CI 0,01–0,74, $p=0.027$) na análise multivariável. O tempo até à cirurgia primária não se associou de forma significativa aos resultados visuais.

CONCLUSÃO: Nesta coorte de cuidados terciários ao longo de nove anos, a idade, o envolvimento do segmento posterior e os mecanismos graves de globo aberto constituíram marcadores prognósticos fundamentais de mau resultado visual após trauma ocular. As lesões limitadas ao segmento anterior conferiram um prognóstico marcadamente mais favorável, enquanto a extensão posterior foi o único preditor independente de NLP e evisceração. Estes resultados reforçam a importância dos fatores prognósticos estabelecidos e podem apoiar um aconselhamento mais realista dos doentes e das suas famílias após trauma ocular grave.

PALAVRAS-CHAVE: Acuidade Visual; Prognóstico; Traumatismos Oculares.

INTRODUCTION

Ocular trauma remains a leading cause of visual morbidity and monocular blindness worldwide, disproportionately affecting young and working-age adults. Global estimates indicate that tens of millions of people sustain eye injuries each year, with a substantial proportion requiring hospital care and progressing to permanent visual impairment or blindness. Despite improvements in safety legislation and emergency care, trauma-related vision loss continues to impose a significant individual and socioeconomic burden.¹⁻³

To standardize the description of mechanical globe injuries, the Birmingham Eye Trauma Terminology (BETT) system distinguishes closed-globe (contusion, lamellar laceration) from open-globe injuries (rupture, penetrating, perforating, intraocular foreign body), providing a reproducible framework for grading trauma severity and mechanism.^{4,5} Based on these parameters, the Ocular Trauma Score (OTS) was developed to predict post-injury visual prognosis and assist in patient counselling.⁶ Several cohort studies have since confirmed the prognostic relevance of initial visual acuity (IVA), anatomical extension, and injury mechanism in determining long-term outcomes after ocular trauma.

In Portugal, however, data on the epidemiology and prognostic factors of ocular trauma remain limited, particularly regarding multivariable models that integrate anatomical and functional endpoints such as no light perception (NLP) and evisceration.⁷ We therefore conducted a nine-year retrospective cohort study at a tertiary referral center in northern Portugal to: characterize the clinical and anatomical profile of ocular trauma; and identify independent predictors of final visual acuity (FVA), NLP and evisceration, with particular emphasis on age, IVA, BETT-defined injury type, and posterior segment involvement.

MATERIAL AND METHODS

This was a retrospective observational study including all patients admitted with ocular trauma to the Ophthalmology Department of Hospital de Braga, Portugal, between January 2015 and December 2023. Demographic, clinical and surgical data were collected from electronic medical records. Patients with incomplete data or loss to follow up, as well as those with isolated eyelid or adnexal trauma without globe involvement, were excluded.

The variables analyzed included age, sex, laterality, place of injury, anatomical zone of injury, mechanism of trauma, IVA and FVA. IVA was defined as the best-corrected visual acuity recorded at the first ophthalmologic assessment after trauma. FVA was defined as the visual acuity recorded at the last ophthalmology consultation attended by the patient at Hospital de Braga. According to FVA, patients were divided into three groups: group 1 (FVA $\geq 20/40$), group 2 (FVA $< 20/40$ and $\geq 20/400$) and group 3 (FVA $< 20/400$).

The type of injury was classified according to the Birmingham Eye Trauma Terminology (BETT) system into closed globe and open globe injuries, with further subdivision as contusion, lamellar laceration, rupture, penetrating,

perforating or intraocular foreign body (IOFB).⁴⁻⁶ The BETT categories used in this study are summarized in Table 1.

Table 1. Birmingham Eye Trauma Terminology (BETT) categories used in this study

BETT category	Injury type (definition)
Closed globe	Contusion (no full thickness wound of the eyewall)
	Lamellar laceration (partial thickness eyewall wound)
Open globe	Rupture (inside out eyewall disruption)
	Penetrating (single full thickness wound)
	Perforating (through and through wound)
	Intraocular foreign body (IOFB within the globe)

BETT: Birmingham Eye Trauma Terminology; IOFB: intraocular foreign body.

The anatomical zone of injury was also defined according to BETT as Zone I, Zone II or Zone III, based on the most posterior extent of the wound. Zone I involved the cornea and limbus, Zone II extended from the limbus to 5 mm posterior into the sclera, and Zone III comprised injuries posterior to this point. For closed globe injuries, Zone I included the external anterior segment (conjunctiva, sclera and cornea), Zone II the internal anterior segment (lens, zonules and pars plicata) and Zone III the posterior segment (vitreous, retina, optic nerve, choroid and ciliary body). Segment involvement was recorded separately from the BETT zones and categorized as anterior, posterior or both. Anterior segment involvement included injuries confined to the cornea, limbus, conjunctiva, and sclera within 5 mm of the limbus, as well as the anterior chamber, iris and lens. Posterior segment involvement included damage to the vitreous, retina, optic nerve head, choroid or ciliary body. Eyes with lesions affecting structures from both compartments were classified as involving both segments. For multivariable regression analyses, segment involvement was entered as a three level categorical variable (anterior only, posterior only, or both), using anterior segment only as the reference category.

Statistical analyses were performed using IBM SPSS Statistics, version 26 (IBM Corp., Armonk, NY, USA). Categorical variables were compared using the chi-square test or Fisher's exact test, and continuous variables were analyzed with non-parametric tests as appropriate. Continuous variables with skewed distributions, such as follow-up time, were described as median and interquartile range (IQR), whereas approximately normally distributed variables were summarized as mean $\pm$ standard deviation. Correlations were evaluated with Spearman's rho, and statistical significance was defined as $p < 0.05$.

Binary logistic regression was used to identify independent predictors of no light perception (NLP) and evisceration, and ordinal logistic regression was applied to model FVA categories. Age, IVA, anatomical zone, segment involvement and mechanism of injury were included as covariates in the multivariable models, based on clinical relevance.

RESULTS

A total of 216 eyes from 216 patients were included in the analysis. Mean follow up was 21 months (IQR 4–37).

BASELINE CHARACTERISTICS

Baseline demographic and clinical characteristics are summarized in Table 2. Most patients were male (79.2%, $n=171$). The left eye was affected in 115 cases (53.2%). Most injuries occurred at home (36.6%) or in the workplace (34.7%), followed by the street (19.9%), countryside (7.4%), school (0.9%) and sports (0.5%) (Table 2). No significant associations were found between FVA and gender ($p=0.643$), laterality ($p=0.437$) or place of injury ($p=0.290$).

Mean age was 53.0 ± 18.8 years (range 3–90). Age differed significantly across FVA groups ($p=0.002$): patients with FVA $\geq 20/40$ were younger (47.2 ± 19.3 years) than those with intermediate (56.6 ± 18.7 years) or poor outcomes (56.9 ± 17.3 years). A positive Spearman correlation ($\rho=0.228$, $p=0.001$) indicated that older age was associated with poorer FVA. Among eyes undergoing primary surgical repair, median time from trauma to surgery was 0 days (IQR 0–1).

INJURY TYPE ACCORDING TO BETT

The distribution of injury types according to the BETT classification is shown in Table 3. Open globe injuries predominated (88.5%), comprising penetrating trauma (53.7%), globe ruptures (19.4%), intraocular foreign body (11.6%) and perforating injuries (3.7%), whereas closed globe in-

juries included contusions (6.9%) and lamellar lacerations (4.6%). There was a highly significant association between injury type and FVA ($\chi^2(10)=45.497$, $p<0.001$). Closed globe injuries, particularly lamellar lacerations, were predominantly associated with good visual outcomes (90.0% with FVA $\geq 20/40$), while ruptures (78.6% with FVA $<20/400$) and perforating injuries (75.0% with FVA $<20/400$) clustered in the poorest FVA category. Penetrating injuries showed an intermediate distribution (45.7% with FVA $\geq 20/40$ and 43.1% with FVA $<20/400$).

ANATOMICAL ZONE OF INJURY

The relationship between the anatomical zone of injury and FVA is presented in Table 4. The anatomical zone of injury was significantly associated with FVA ($p<0.001$). The proportion of eyes with FVA $<20/400$ progressively increased from 37.8% in Zone I (anterior segment) to 55.9% in Zone II and 70.0% in Zone III, demonstrating a clear gradient of poorer visual outcomes with more posterior involvement.

INITIAL AND FINAL VISUAL ACUITY

The association between IVA and FVA is shown in Table 5. IVA showed a strong association with FVA ($p<0.001$). All eyes presenting with IVA $\geq 20/40$ ($n=16$) maintained good visual outcomes (100% with FVA $\geq 20/40$) at the last follow up. Among eyes with IVA 20/40–20/400 ($n=20$), 85.0% achieved FVA $\geq 20/40$, 10.0% had FVA 20/40–20/400 and 5.0% had FVA $<20/400$. Of the 180 eyes with

Table 2. Baseline characteristics and distribution of final visual acuity (FVA)

Variable	Category	n	%	FVA $\geq 20/40$ n (%)	FVA 20/40–20/400 n (%)	FVA $<20/400$ n (%)	p value
Sex	Male	171	79.2	69 (40.4)	24 (14.0)	78 (45.6)	0.643
	Female	45	20.8	16 (35.6)	5 (11.1)	24 (53.3)	
Eye	Right	101	46.8	43 (42.6)	15 (14.9)	43 (42.6)	0.437
	Left	115	53.2	42 (36.5)	14 (12.2)	59 (51.3)	
Place of injury	Home	79	36.6	27 (34.2)	15 (19.0)	37 (46.8)	0.290
	Workplace	75	34.7	29 (38.7)	10 (13.3)	36 (48.0)	
	Street	43	19.9	17 (39.5)	3 (7.0)	23 (53.5)	
	Countryside	16	7.4	10 (62.5)	1 (6.3)	5 (31.3)	
	School	2	0.9	2 (100.0)	0 (0.0)	0 (0.0)	
	Sports	1	0.5	0 (0.0)	0 (0.0)	1 (100.0)	

Table 3. Final visual acuity (FVA) according to injury type (BETT classification)

Injury type (BETT)	n	% of total	FVA $\geq 20/40$ (%)	FVA 20/40–20/400 (%)	FVA $<20/400$ (%)
Closed: Contusion	15	6.9	66.7	20.0	13.3
Closed: Lamellar laceration	10	4.6	90.0	0.0	10.0
Open: Rupture	42	19.4	4.8	16.7	78.6
Open: Penetrating	116	53.7	45.7	11.2	43.1
Open: Perforating	8	3.7	12.5	12.5	75.0
Open: IOFB	25	11.6	40.0	20.0	40.0
Total	216	100	39.4	13.4	47.2

FVA: final visual acuity; IOFB: intraocular foreign body; BETT: Birmingham Eye Trauma Terminology.
Chi square test.

Table 4. Final visual acuity (FVA) according to anatomical zone of injury

Injury type (BETT)	n	FVA ≥20/40 (%)	FVA 20/40–20/400 (%)	FVA <20/400 (%)
Zone I	127	52.0	10.2	37.8
Zone II	59	23.7	20.3	55.9
Zone III	30	16.7	13.3	70.0
Total	216	39.4	13.4	47.2

FVA: final visual acuity.
Chi square test.

Table 5. Relationship between initial visual acuity (IVA) and final visual acuity (FVA)

Initial VA (Snellen group)	FVA ≥20/40 n (%)	FVA 20/40–20/400 n (%)	FVA <20/400 n (%)	Total n
≥20/40	16 (100.0)	0 (0.0)	0 (0.0)	16
20/40–20/400	17 (85.0)	2 (10.0)	1 (5.0)	20
<20/400	52 (28.9)	27 (15.0)	101 (56.1)	180
Total	85	29	102	216

VA: visual acuity; FVA: final visual acuity.
Chi square test.

IVA <20/400, 56.1% remained in the poorest FVA category (<20/400), whereas 28.9% improved to FVA ≥20/40 and 15.0% reached intermediate vision (20/40–20/400).

At the end of follow up, 50 eyes (23.1% of the total) had progressed to no light perception (NLP), and 27 eyes (12.5% of the total) had undergone evisceration, representing the most severe functional and anatomical outcomes of ocular trauma.

MULTIVARIABLE ANALYSES OF PREDICTORS OF NLP, EVISCERATION AND FVA

Multivariable regression analyses for NLP, evisceration and FVA are summarized in Table 6. On multivariable logistic regression, posterior segment involvement was the only independent predictor of NLP, markedly reducing the odds of light perception at final follow-up (aOR 0.14, 95% CI 0.03–0.55, $p=0.005$). Age, IVA, anatomical zone and mechanism of injury were not independently associated with NLP. The model showed good fit ($\chi^2(15)=67.7$, $p<0.001$; Nagelkerke $R^2=0.49$; Hosmer–Lemeshow $p=0.60$). Similarly, posterior segment involvement was the only independent predictor of evisceration (aOR 0.07, 95% CI 0.01–0.74, $p=0.027$; Table 6). Eyes with anterior involvement alone had a markedly lower likelihood of evisceration compared with those with posterior extension of trauma. Age showed a non significant trend towards increased risk, while initial visual acuity, anatomical zone and mechanism of injury were not independently associated with evisceration ($\chi^2(15)=54.8$, $p<0.001$; Nagelkerke $R^2=0.49$; Hosmer–Lemeshow $p=0.97$).

In the ordinal regression model for FVA, older age and anatomical involvement were significant independent predictors of outcome. Each additional year of age increased the odds of worse FVA by 3.4% (OR 1.034, 95% CI 1.011–1.056, $p=0.004$). Injuries confined to the anterior segment were strongly protective compared with posterior involve-

ment (OR 0.09, 95% CI 0.03–0.22, $p<0.001$), whereas combined anterior–posterior injuries did not differ significantly. The model showed good overall fit ($\chi^2(10)=64.7$, $p<0.001$; Nagelkerke $R^2=0.49$).

Time to primary surgery was not significantly associated with FVA, suggesting that injury characteristics outweighed surgical timing in determining visual outcomes in this cohort (Kruskal–Wallis $H=0.254$, $p=0.881$).

DISCUSSION

This nine year tertiary care cohort confirms that IVA, anatomical extension of the injury and mechanism of trauma are key determinants of long term visual outcome after ocular trauma. Our results align with multiple series in which poor presenting vision, posterior segment involvement and globe rupture consistently predict worse prognosis and lower ocular survival after open globe injuries.^{8–11} Together with recent prognostic models such as the Ocular Trauma Score and its revised versions, these findings reinforce the value of early risk stratification to guide counseling and surgical planning in severe eye injuries.^{8,9}

Age emerged as an independent predictor of FVA in our cohort, with each additional year increasing the odds of poorer FVA, even after adjustment for anatomical factors and initial VA. This is consistent with large contemporary series of open globe injuries in which older age has been associated with higher risk of blindness at follow up and worse Ocular Trauma Score categories.^{9,12} Possible explanations include age related tissue fragility, greater comorbidity burden and delays in accessing emergency care among older patients, particularly in the context of high energy domestic falls and workplace injuries. Further studies are warranted to explore whether tailored preventive strategies and rehabilitation pathways could mitigate the age related disparity in visual outcomes.

Anatomical extension of trauma showed a clear gradi-

Table 6. Baseline characteristics and distribution of final visual acuity (FVA)**A) Predictors of no light perception (NLP) – binary logistic regression**

Predictor	aOR (95% CI)	p value
Age (per year)	1.02 (0.99–1.05)	0.26
IVA 20/40–20/400 vs ≥20/40	—	<i>p</i> >0.05
IVA <20/400 vs ≥20/40	—	<i>p</i> >0.05
Zone II vs I	—	<i>p</i> >0.05
Zone III vs I	—	<i>p</i> >0.05
Open vs closed injury	—	<i>p</i> >0.05
Segment: posterior vs anterior	0.14 (0.03–0.55)	0.005
Both segments vs anterior segment	0.44 (0.06–3.15)	0.41

IVA: initial visual acuity; OR: odds ratio; CI: confidence interval.

Model fit: $\chi^2(15)=67.7$, $p<0.001$; Nagelkerke $R^2=0.49$; Hosmer–Lemeshow $p=0.60$.**B) Predictors of evisceration – binary logistic regression**

Predictor	aOR (95% CI)	p value
Age (per year)	1.03 (0.99–1.07)	0.11
IVA 20/40–20/400 vs ≥20/40	—	<i>p</i> >0.05
IVA <20/400 vs ≥20/40	—	<i>p</i> >0.05
Zone II vs I	—	<i>p</i> >0.05
Zone III vs I	—	<i>p</i> >0.05
Open vs closed mechanism	—	<i>p</i> >0.05
Segment: posterior vs anterior	0.07 (0.01–0.74)	0.027
Both segments vs anterior segment	0.32 (0.03–3.75)	0.36

IVA: initial visual acuity; OR: odds ratio; CI: confidence interval.

Model fit: $\chi^2(15)=54.8$, $p<0.001$; Nagelkerke $R^2=0.49$; Hosmer–Lemeshow $p=0.97$.**C) Predictors of final visual acuity (FVA) – ordinal logistic regression**

Predictor	B	SE	Wald	p value	OR (Exp(B))	95% CI (Exp(B))
Age (years)	0.033	0.011	8.50	0.004	1.034	1.011–1.056
IVA (20/40–20/400 vs ≥20/40)	-1.682	0.941	3.19	0.074	0.19	0.02–1.17
Anterior only	-2.469	0.492	25.20	<0.001	0.085	0.03–0.22
Both segments	-0.799	0.953	0.70	0.402	0.45	0.11–1.07

IVA: initial visual acuity; OR: odds ratio; CI: confidence interval.

Model: logit link; $\chi^2(10)=64.7$, $p<0.001$; Nagelkerke $R^2=0.49$.

ent of risk in our series: posterior injuries (Zone III) were strongly associated with FVA <20/400, and posterior segment involvement was the sole independent predictor of NLP and evisceration. These findings mirror prior reports where zone III injuries and posterior segment damage are among the most powerful predictors of poor visual outcome and globe loss in open globe trauma.^{8,11,13,14} In practical terms, eyes with posterior extension should be regarded as a high risk subgroup requiring intensive follow up, early vitreoretinal input and realistic discussion of the probability of NLP and eventual evisceration, even when initial anatomical reconstruction is successful.

As in previous studies, we found that severe open globe mechanisms, particularly rupture and perforating injuries, clustered in the poorest visual category, whereas closed globe injuries and lamellar lacerations were largely compatible with good FVA.^{8,10–13} IVA remained a strong univari-

able predictor of outcome, and patients presenting with IVA ≥20/40 almost uniformly maintained good vision, in line with the central role of presenting VA in the Ocular Trauma Score and related models.^{8,14} However, our multivariable analyses suggest that, once posterior extension is taken into account, baseline VA adds limited prognostic information for NLP and evisceration, underscoring the dominant impact of posterior segment damage on ultimate anatomical survival.

We did not observe significant associations between gender, eye laterality or place of injury and final visual outcomes, whereas some multicenter cohorts have reported worse prognosis in women and in certain occupational settings.^{10,15} These discrepancies may reflect differences in case mix, referral patterns and sample size, and highlight the need for multicenter Portuguese data to clarify the role of social and environmental factors in trauma prognosis.

Similar to several series, time to primary surgery showed no independent association with final FVA. Although time to primary surgery was not independently associated with visual outcome in our cohort, most eyes underwent repair within an acceptable time frame, which may have limited our ability to detect timing related differences in FVA.^{8,12}

This study has several limitations that should be considered when interpreting its findings. First, its retrospective design relies on electronic medical records, which may be subject to information bias and incomplete data, despite the exclusion of cases with insufficient follow up. Second, as a single-center study conducted in a tertiary referral hospital, the generalizability of the results may be limited, given the potential referral bias toward more severe cases and the likely under-representation of closed-globe injuries, which are more frequent, often managed without inpatient admission and sometimes, definitively treated in local or peripheral hospitals without referral to our center. Although the sample size is considerable, it may still be insufficient to detect independent associations for certain variables in multivariable analyses; for instance, the lack of association between time to primary surgery and visual outcomes may reflect the relatively homogeneous timing of surgical intervention in this cohort.

Overall, our results support the routine use of standardized classifications and simple multivariable models focused on age, initial VA and anatomical extension to refine prognostic assessment and to improve communication with patients and families facing severe ocular trauma.

CONCLUSION

In this nine year tertiary care cohort, ocular trauma was predominantly characterized by severe open globe injuries, with a substantial risk of poor visual and anatomical outcomes. Age, mechanism of injury and, in particular, the anatomical extent of trauma emerged as key determinants of prognosis. Posterior segment involvement was the strongest independent predictor of both no light perception and evisceration, whereas injuries confined to the anterior segment were associated with significantly better visual outcomes. These findings highlight the importance of early anatomical assessment to guide prognosis and patient counselling.

CONTRIBUTORSHIP STATEMENT / DECLARAÇÃO DE CONTRIBUIÇÃO

AMSampaio, CNCruz and KSousa: Made substantial contributions to the work, participated in the drafting and/or critical revision of the manuscript, approved the final version for publication, and agree to be accountable for all aspects of the work.

AMSampaio, CNCruz e KSousa: Contribuíram substancialmente para o trabalho, participaram na redação e/ou revisão crítica do manuscrito, aprovaram a

versão final para publicação e concordam em assumir a responsabilidade por todos os aspetos do trabalho.

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Proteção de Pessoas e Animais: Os autores declaram que os procedimentos seguidos estavam de acordo com os regulamentos estabelecidos pela Comissão de Ética responsável e de acordo com a Declaração de Helsínquia revista em 2024 e da Associação Médica Mundial.

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Protection of Human and Animal Subjects: The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and those of the Code of Ethics of the World Medical Association (Declaration of Helsinki as revised in 2024).

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REFERENCES

1. Négrel AD, Thylefors B. The global impact of eye injuries. *Ophthalmic Epidemiol.* 1998;5:143-69. doi:10.1076/oep.5.3.143.8364
2. May DR, Kuhn FP, Morris RE, Witherspoon CD, Danis RP, Matthews GP, et al. The epidemiology of serious eye injuries from the United States Eye Injury Registry. *Graefes Arch Clin Exp Ophthalmol.* 2000;238:153-7. doi:10.1007/PL00007884
3. Pellegrini M, Roda M, Di Geronimo N, Lupardi E, Giannaccare G, Schiavi C. Changing trends of ocular trauma in the time of COVID-19 pandemic. *Eye.* 2020;34:1248-50. doi:10.1038/s41433-020-0933-x
4. Kuhn F, Morris R, Witherspoon CD, Heimann K, Jeffers JB, Treister G. A standardized classification of ocular trauma. *Ophthalmology.* 1996;103:240-3. doi:10.1016/s0161-6420(96)30710-0
5. Kuhn F, Morris R, Witherspoon CD, Mester V. The Birming-

- ham Eye Trauma Terminology system (BETT). *J Fr Ophthalmol.* 2004;27:206-10. doi:10.1016/s0181-5512(04)96122-0
6. Pieramici DJ, Sternberg P Jr, Aaberg TM Sr, Bridges WZ Jr, Capone A Jr, Cardillo JA, et al. Ocular Trauma Classification Group. A system for classifying mechanical injuries of the eye (globe). *Am J Ophthalmol.* 1997;123:820-31. doi:10.1016/S0002-9394(14)71132-8
 7. Marta A, Silva N, Correia N, Pessoa B, Ferreira N, Beirão M, et al. A 15-year retrospective epidemiologic study of ocular trauma in the north of Portugal. *Eur J Ophthalmol.* 2021;31:1079-84. doi:10.1177/1120672120934399
 8. Tan SI, Hoskin AK, Khatri A, Dave VP, Bhalerao S, Romero J, et al. Prognostic factors of open-globe injuries: a review. *Indian J Ophthalmol.* 2023;71:3587594. doi:10.4103/IJO.IJO_1496_23
 9. Kemchoknatee P, Patumanond J, Chantira S, Thongtong P, Vongsa N, Kreesang R, et al. Revised Ocular Trauma Score (rOTS): to develop and internally validate a predictive model for visual outcomes after open globe injury. *BMJ Open Ophthalmol.* 2025;10:e002265. doi:10.1136/bmjophth-2025-002265
 10. Rao LG, Ninan A, Rao KA. Descriptive study on ocular survival, visual outcome and prognostic factors in open globe injuries. *Indian J Ophthalmol.* 2010;58:321-3. doi:10.4103/0301-4738.64116
 11. Mayer CS, Reznicek L, Baur ID, Khoramnia R. Open globe injuries: classifications and prognostic factors for functional outcome. *Diagnostics.* 2021;11:1851. doi:10.3390/diagnostics11101851
 12. Entezari M, Rabei HM, Badalabadi MM, Mohebbi M. Visual outcome and ocular survival in open-globe injuries. *Injury.* 2006;37:633-7. doi:10.1016/j.injury.2006.02.043
 13. Fujikawa A, Mohamed YH, Kinoshita H, Matsumoto M, Uematsu M, Tsuiki E, et al. Visual outcomes and prognostic factors in open-globe injuries. *BMC Ophthalmol.* 2018;18:138. doi:10.1186/s12886-018-0804-4
 14. Knyazer B, Levy J, Rosen S, Belfair N, Klemperer I, Lifshitz T. Prognostic factors in posterior open globe injuries (zone III injuries). *Clin Exp Ophthalmol.* 2008;36:836-41. doi:10.1111/j.1442-9071.2009.01922.x
 15. Greenfield JA, Malek DA, Anant S, Antonietti M, Jammal A, Casella A, et al. A multi-center analysis of visual outcomes following open globe injury. *Sci Rep.* 2024;14:16638. doi:10.1038/s41598-024-67564-y



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