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Post-surgery outcome in children with ocular trauma

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RESUMO

Introdução | O trauma ocular é uma causa importante de morbilidade e uma das principais causas de baixa visão monocular adquirida em crianças [1]. O principal objetivo deste estudo foi avaliar o *outcome* visual (melhor acuidade visual corrigida) pós-cirurgia no contexto de trauma ocular numa população pediátrica.

Métodos | Realizou-se um estudo observacional retrospectivo de crianças com trauma ocular que se apresentaram no serviço de urgência de oftalmologia do Hospital de Santa Maria, entre 8 de agosto de 2008 e 31 de dezembro de 2022. Todas as crianças menores de 18 anos, que foram submetidas a cirurgia oftalmológica, foram incluídas. Foram recolhidos dados demográficos, *follow-up*, circunstâncias da lesão traumática, abordagem e melhor acuidade visual corrigida. As lesões oculares foram categorizadas utilizando o sistema *Birmingham Eye Trauma Terminology (BETT)* e o *Paediatric Ocular Trauma Score (POTS)* foi determinado.

Resultados | Foram identificadas um total de 46 crianças. O rácio masculino:feminino foi de 1.6:1. A idade média foi de 8.57 (±5.01) anos. A maioria dos doentes (76,1%) tiveram lesão de globo aberto. O tipo de lesão incluiu penetração (45.7%), perfuração (13.0%), corpo estranho intraocular (CEIO) (17.4%), contusão (15.2%), ruptura (4.3%) e laceração lamelar (2.2%). As lesões cortantes foram documentadas em 47.7% dos casos, e as contusas em 24.0%. Foi realizada cirurgia de emergência na maioria das crianças, sutura corneoscleral em 82.6% delas. Mais de metade dos doentes (54.5%) tiveram diminuição leve/não tiveram diminuição da AV, 12.1% tiveram diminuição moderada e 33.4% tiveram diminuição grave/cegueira. A AV (logMAR) média final foi de 0.92 ± 1.1. Nesta amostra, 41.3% das crianças obtiveram um POTS do grupo 1, 32.6% do grupo 2, 19.6% do grupo 3 e 6.5% do grupo 5. A correlação entre o POTS e a AV final demonstrou uma má previsão da AV utilizando este *score* (o coeficiente de correlação de Pearson mostrou uma correlação linear negativa moderada (-0.312, p=0.06) e o coeficiente de correlação rho de Spearman indicou uma correlação negativa mais forte (-0.369, p=0.025)).

Conclusão | O traumatismo ocular em crianças permanece com mau prognóstico. Os rapazes em idade escolar ainda são os mais expostos, e as lesões são maioritariamente unilaterais. O trauma com objetos cortantes ocorre duas vezes mais frequentemente do que o trauma contuso. No entanto, este último demonstrou pior prognóstico. A AV inicial não é muitas vezes registada. O POTS subestima grosseiramente o resultado visual final. A melhor AV final corrigida foi favorável em mais da metade dos doentes e variou consoante o tipo e objeto do trauma, as estruturas afetadas e o número de cirurgias realizadas, embora sem significado estatístico. No entanto, um terço das crianças apresentou grave diminuição da AV/cegueira, o que apela à necessidade de implementação de medidas preventivas e de segurança pediátrica mais eficazes, bem como o estabelecimento de uma equipa de trauma ocular de ação rápida, garantindo o tratamento em tempo útil.

Palavras-chave: traumatismo ocular pediátrico; lesão ocular penetrante; POTS; acuidade visual; cirurgia oftalmológica.

ABSTRACT

Background | Eye trauma is a major cause of morbidity and one of the leading causes of acquired monocular low vision in children [1]. The main objective of this study was to evaluate the visual outcome (best corrected visual acuity, BCVA) post-surgery in the context of eye trauma in a paediatric population.

Methods | We conducted a retrospective observational study of children with ocular trauma who presented to the ophthalmology emergency department of the Hospital de Santa Maria between August 8, 2008, and December 31, 2022. All children under the age of 18 who underwent ophthalmic surgery were included. Data were collected on demographic data, follow-up, circumstances of traumatic injury, management, and BCVA. The Birmingham Eye Trauma Terminology (BETT) system was used to categorise ocular injuries, and the Paediatric Ocular Trauma Score (POTS) was determined.

Results | A total of 46 patients were identified. The male-female ratio was 1.6:1. The mean age was 8.57 (±5.01) years. Most patients (76.1%) had an open-globe injury. Types of injury included penetration (45.7%), perforation (13.0%), intraocular foreign body (IOFB) (17.4%), contusion (15.2%), rupture (4.3%), and lamellar laceration (2.2%). Sharp injuries were documented in 47.7% of cases and blunt in 24.0%. Emergency surgery was performed on most children, with corneoscleral sutures in 82.6%. Over half of the patients (54.5%) had mild/no VI, 12.1% moderate VI, and 33.4% severe VI/blindness. The mean final logMAR BCVA was 0.92±1.1. In this sample, 41.3% of the children scored a POTS of group 1, 32.6% of group 2, 19.6% of group 3, and 6.5% of group 5. Assessment between POTS and final BCVA found a poor prediction of the final VA using this score (Pearson correlation coefficient showed a moderate negative linear correlation (-0.312, p=0.06), and Spearman's rho correlation coefficient indicated a stronger negative correlation (-0.369, p=0.025)).

Conclusions | Ocular trauma injuries in children remain poorly prognostic. School-aged boys are still the most exposed, and injuries are mainly unilateral. Ocular trauma with sharp objects occurs twice as often as blunt trauma. However, the latter showed a worse prognosis. Initial VA is often not recorded. The POTS shows a gross underestimation of the final visual outcome. The final BCVA was favourable in more than half of the patients and varied depending on the type and object of trauma, structures affected, and the number of surgeries carried out, although not statistically significant. Nevertheless, a third of the patients developed severe visual impairment/blindness, which calls for implementing more effective preventive and paediatric safety measures and establishing a rapid-action eye trauma team to ensure timely treatment.

Keywords: paediatric ocular trauma; penetrating eye injury; POTS; visual acuity; ophthalmic surgery.

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ABBREVIATIONS

BCVA = Best Corrected Visual Acuity

BETTS = Birmingham Eye Trauma Terminology System

CF = Counting Fingers

CHULN = Centro Hospitalar Universitário Lisboa Norte

CI = Confidence Intervals

HM = Hand Movement

IOFB = Intraocular Foreign Body

LP = Light Perception

NLP = No Light Perception

OR = Odds Ratio

OTS = Ocular Trauma Score

POTS = Paediatric Penetrating Ocular Trauma Score

RAPD = Relative Afferent Pupillary Defect

SD = Standard Deviation

VA = Visual Acuity

VI = Visual Impairment

WHO = World Health Organisation

INTRODUCTION

Paediatric ocular trauma is a key issue for ophthalmologists [2]. It is frequent and one of the least acknowledged causes of eyesight loss in the developed world, contributing significantly to visual morbidity as it can have a significant impact on a child's growth and adult life [3].

Ocular trauma accounts for 8–14% of all traumas [4], 10-15% of all eye diseases, and is one of the most frequent causes of non-congenital monocular blindness in children [5-8]. A quarter of a million (5%) of the 6 million children who suffer ocular injuries of some kind each year throughout the world may need to be hospitalised, and trauma accounts for up to one-third of these hospitalisations [2,7,9-12]. Hence, eye injuries are the leading reason for the hospitalisation of ophthalmological patients in developed countries, and due to the relatively high prevalence of trauma in the paediatric age range, the significance of ocular damage has grown [12]. Children's immature motor skills, inattentiveness, and poor risk assessment make them more prone to these accidents.

Over 15-year-old children account for more than 40% of all significant ocular injuries that occur before the age of 20. All age groups experience a high rate of incapacity due to eye injuries, but children are disproportionately affected since ocular maturity is not reached until around age 8. Although this kind of injury seldom poses a life-threatening risk, it may cause long-term morbidity, raising the likelihood of amblyopia since the injury is typically uniocular, the number of years with reduced vision, and the most severe spectrum of gravity blindness. Therefore, the clinical course for children with globe trauma may be more complicated than for adults, as its assessment and management differ [2].

From the standpoint of public health, eye injuries have an impact on patients' productivity and quality of life in addition to their eyes [4]. A youngster who suffers from post-traumatic vision impairment may be severely handicapped, which would cause considerable emotional suffering and social impact [4,6,8]. Because they affect the vocational development of 8–14% of these young victims as well [7], their socioeconomic repercussions (for the patient, their family, and healthcare professionals) are crucial [8–10]. This socioeconomic loss is closely correlated with morbidity and the degree of trauma, although it can be avoided if certain safeguards are followed.

Aetiologies of ocular damage vary throughout countries, regions of the world, and different demographic or socioeconomic strata [8]. Penetrating trauma, blunt trauma (10%), projectile injuries (20%), body parts (such as fingers or fists) (12%), sharp objects (9%), and motor vehicle accidents (4%) are common causes of juvenile eye injuries. Around 20% of penetrating globe injuries fall on the extreme end of the severity continuum and typically happen more frequently at home (55%) [9–11], unattended by an adult. Injury to the eye that penetrates the cornea poses a serious risk to eyesight, whether it occurs at work, at home, during sports, or even at school [8]. A rooster attack, pencil points, bursting microwaved eggs, doorknobs, chopsticks, fizzy drinks, and dishwasher detergent were also listed as contributing factors in the studies of Salvin, J., and Awidi, A. *et al.* [2,5]. Children might sustain injuries through actions that seem innocuous to adults since they can be unpredictable at times and frequently behave foolishly. Salvin J. found that fireworks, paintball injuries, and all-terrain vehicle (ATV) collisions were the causes of more severe eye injuries [5].

Children under 2 years old have the lowest rate of injury from consumer products. Between the ages of 2 and 12, the incidence is steady, but after that, children over 12 experience an increase. For older children, there is a consistent trend toward more sports-related injuries but fewer injuries from household cleaners. Toy injuries are most prevalent in children 2-4 years old, while desk supply injuries peak in children 5-8 years old. Children under the age of 5 are more likely to sustain falls and blow injuries because they are more likely to unintentionally run into sharp furniture edges or trip over things as they learn to walk [11].

Paediatric ocular trauma presents with a paucity of data on clinical characteristics, although anterior segment pathology—including corneal or scleral laceration, iris prolapse, and lens abnormalities—characterises injuries. According to most studies, males are more than twice as likely as girls to experience ocular trauma and need hospitalisation (69.7% [2]) for ocular damage, with an average stay of 2-4 days for treatment of an open wound of the ocular adnexa [10].

Several ocular trauma score systems have been created to aid in the triage of globe injuries and forecast results (final visual acuity). The usefulness of a system for ocular trauma classification is significant to facilitate the dialogue between treating emergency workers and ophthalmologists and to provide information on prognosis [2]. To categorise injuries, several classification systems have been developed, but the Birmingham Eye Trauma Terminology (BETT) is the most commonly used. The BETT was created by Kuhn *et al.* [13] in 1996 to provide a simple, clear definition of all injury types and place the injuries within a comprehensive framework. According to this classification, ophthalmic trauma can be classified into open and closed-globe injuries (table 1 and figure 1). Open-globe injuries can be further classified as rupture if a full-thickness injury occurs, or laceration if a partial-thickness injury occurs. Furthermore, laceration can be classified into penetrating (an entrance wound is present), intraocular foreign body (IOFB), and perforating (both an entrance and an exit wound are present). On the other hand, closed globe injuries are classified into contusion (no wound of the eye globe with damage caused by a shock wave) and lamellar laceration (partial thickness wound).

Table 1: Terms and definitions by Birmingham Eye Trauma Terminology (BETT), adapted from [13].

Term	Definition	Comment
Eye wall	Sclera and cornea	Though the eye wall has three layers posterior to the limbus, clinical and practical purposes dictate that violation of only the most external tissue (sclera) is to be considered
Closed globe injury	No full-thickness wound of eye wall	The cornea and the sclera are not breached through and through
Open globe injury	Full-thickness wound of the eye wall	The cornea and/or sclera is breached through and through
Contusion	No wound of the eye wall	The damage may be due to direct energy delivery/shock wave by the object (e.g., choroidal rupture), or to changes in the shape of the globe (e.g., angle recession)

Lamellar laceration	Partial-thickness wound of the eye wall	The wound in the eye wall is not "through" but "into"
Rupture	Full-thickness wound of the eye wall, caused by a large blunt object	Since the eye is filled with incompressible liquid, the impact results in instant IOP elevation. The eye wall yields at its weakest point (rarely at the impact site, rather, for instance, along an old cataract wound); the actual wound is produced by an inside-out mechanism, and tissue prolapse is almost unavoidable.
Laceration	Full-thickness wound of the eye wall, caused by a sharp object	The wound is at the impact site and is created by an outside-in mechanism; since IOP elevation is unavoidable, tissue prolapse is common
Penetrating injury	An entrance wound is present	If more than one wound is present, each must have been caused by a different object
IOFB	One or more foreign objects are present	Technically a penetrating injury, but grouped separately because of different clinical implications (management, prognosis)
Perforating injury	Both an entrance and an exit wound are present	The two wounds caused by the same agent

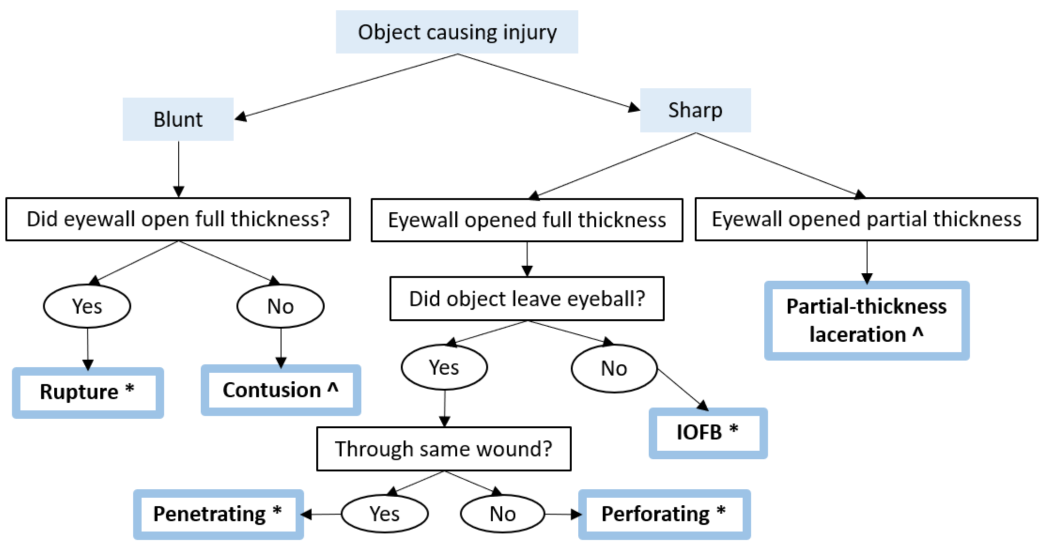

Figure 1: A practical guide to classifying mechanical eye injuries in BETT. The bold boxes indicate those diagnoses that are used as clinical entities. Injuries marked with an asterisk are open globes; those with a caret are closed globes. Figure adapted from [13].

It is uncertain if a distinct paediatric trauma score enables better outcome forecasting. These classification systems may subsequently be utilised for communication (clear and standardised language to be more consistent in the clinical description and treatment of ocular injuries, as well as in the scientific literature), prognosis, and publication.

Therefore, in 2011, a paediatric ocular trauma score (POTS) (table 3) was created to analyse the prognostic value of this score in paediatric penetrating injuries [12]. Presenting VA and RAPD, two criteria for the Ocular Trauma Score (OTS) (table 2), can be difficult for children to meet. As a result, POTS eliminated RAPD and downplayed presenting VA in its predictive model. POTS provided an equation to enable scoring when no initial VA could be obtained and included patient characteristics like age and location of the injury [2,12].

Table 2: Original Ocular Trauma Score (OTS) variables and scoring, retrieved from [12].

Variables	*Raw points*
Initial visual acuity	
No light perception	60
Light perception/hand motion	70
1/200–19/200	80
20/200–20/50	90
<20/40	100
Rupture	−23
Endophthalmitis	−17
Perforating injury	−14
Retinal detachment	−11
Afferent pupillary defect	−10

Table 3: Calculating Paediatric Ocular Trauma Score (POTS) and waypoints, retrieved from [12].

Variables	*Raw points*
Initial visual acuity	
NLP	10
LP/HM	20
Counting fingers	30
0.1–0.5	40
0.6–1.0	50
Age of the pediatric patients (years)	
0–5	10
6–10	15
11–15	25
Wound location	
Zone I	25
Zone II	15
Zone III	10
Concomitant eye pathologies	
Iris prolapse	–5
Hyphema	–5
Organic/unclean injury	–5
Delay of surgery (>48 h)	–5
Traumatic cataract	–10
Vitreous haemorrhage	–20
Retinal detachment	–20
Endophthalmitis	–30

Even though amblyopia and corneal opacities are the most frequent causes of decreased VA after trauma in children, many other troubling presenting and poor prognostic factors should be taken into consideration, such as young age at presentation, poor initial VA, posterior location of the injury, wound length, lens involvement, vitreous haemorrhage, retinal detachment, and endophthalmitis [2,5]. Additionally, a hurt youngster frequently has poor memory, making a full evaluation difficult. The initial assessment and prediction of the final visual outcomes of paediatric eye trauma may be less reliable because of presentation delays, hazy injury processes, poor cooperation during eye examination, inaccurate VA results, amblyopia, and an often imprecise and varied history [2]. These issues frequently recur over the follow-up period [4].

Patients with ocular injuries often report to the emergency room or the paediatrician's office for their first assessment. All healthcare professionals who work with children, such as paediatricians, emergency room doctors, and general and paediatric ophthalmologists, fall under the category of paediatric ocular trauma. To immediately determine the degree of the injury without endangering future damage to the eye or the need for subsequent sub-specialist consultation, the examination of children engaged in traumatic incidents needs to be methodical. If the kid is communicative and cognizant, an effort at visual acuity should be made and documented. If the globe or eyelid is suspected to be lacerated, a shield should be put over the eye, the patient should be maintained nil per os, pain, and nausea medicine should be given, and then the ophthalmologist should be contacted for additional surgical intervention. Any injury to the eye or adnexa that is lacerating or penetrating should prompt a check of the patient's tetanus immunisation status and, if necessary, a booster shot. If an orbital fracture, an intraocular or intraorbital foreign substance, or any type of cerebral damage is suspected, proper radiologic investigations should be conducted [5].

After ocular injuries, severe vision impairment and even blindness may develop if surgical intervention is not prompt and appropriate. Depending on the cause of damage and presenting symptoms, surgical therapy rates for paediatric ocular trauma range from 7.4% to 59% across centres and globally [4,9].

The likelihood of recovery in eyes with globe damage varies depending on the kind of damage, the site of the incision, the severity of the laceration, the involvement of the posterior segment, and the presence of infection (which is frequently severe overall) [4,8]. The prognosis for juvenile patients can fluctuate due to changes in paediatric eye structure and a more severe inflammatory response than in adults. Children are also susceptible to amblyopia, which is still a challenging treatment issue [4,8]. Those who have open-globe injuries have much worse results with more complications, which require more procedures and have a worse prognosis overall [2,4].

Fortunately, paediatric ocular trauma is believed to be avoidable in up to 90% of instances when risk factors for ocular damage are recognised [4,5,7,9-11]. Since youth continue to account for 30% of all ocular trauma, this has not been widely studied in the past. Clarifying the aetiology and mechanism of ocular trauma in the paediatric population is required before implementing such an efficient, focused intervention so that preventative measures may be aimed at the kids who are most at risk of harm. The great majority of these accidents could have been prevented with adequate parental supervision, both child and parent education, and the use of protective eyewear.

MATERIALS AND METHODS

Study design

We conducted a retrospective observational study of children with ocular trauma who presented to the ophthalmology emergency department of Hospital de Santa Maria, CHULN, in Portugal, between August 8, 2008, and December 31, 2022.

Population

All children under the age of 18 that suffered from an injury to any ocular structure as a result of trauma to the eye (including the eyelids, corneoscleral zone, posterior segment, and orbit) and underwent ophthalmic surgery, were included. A child was excluded due to not having surgery.

Methods

In CHULN, medical files are electronically recorded, and for each patient, data were collected on demographic data (age at the time of ocular trauma, sex), circumstances of traumatic injury (object of trauma, injury type, affected ocular structures), management (surgeries performed, presence of infection, and additional surgery), best corrected visual acuity (BCVA) and follow-up (months). The Birmingham Eye Trauma Terminology (BETT) system was used to categorise ocular injuries, and for each patient, the Paediatric Ocular Trauma Score (POTS) was determined. For those not having initial VA, the equation 2x (age at the time of trauma + location of injury) - corresponding pathologies was applied, and children >15 years old were deemed to have the same points as those between 11 and 15 for POTS. Patients were divided into groups 1–5 based on their scores (table 4). The correlation between the group and the final VA was researched. Through the use of an excel spreadsheet, the final VA was converted from Snellen fraction to LogMAR, which takes into account counting fingers (CF), hand movement (HM), perception of light (PL), and no light perception (NLP) [14]. The initial VA was also converted to LogMAR for comparison to the final VA. VA was posteriorly stratified according to the WHO classification of visual impairment (table 5).

An ophthalmological follow-up was conducted after discharge to assess the VA following surgical treatment.

Table 4. POTS score grouped 1 to 5.

Group	Points
1	<45
2	46-64
3	65-79
4	80-89
5	90-100

Table 5. Visual acuity range, category, and classification of visual impairment (VI) according to the World Health Organization classification. Adapted from [15].

VA (LogMAR)	Category	Classification
0.0 - 0.50	0	Mild or no VI
0.52 - 1.0	1	Moderate VI
1.02 - 1.30	2	Severe VI
1.32 -1.80	3	Blindness
1.82 - 3.0	4	Blindness

Note: Moderate and severe visual impairment constitute low vision.

Statistical analysis

Descriptive statistics and exploratory analyses were used to evaluate the distribution of variables. Qualitative data were expressed as absolute frequencies and percentages. Quantitative data were expressed as means (± standard deviation) and medians. Mean age differences per gender were assessed using the Mann-Whitney test. The independence of categorical variables stratified by gender was tested by chi-square tests using the Fisher exact test and the strength of the association by means of odds ratios (ORs) with the corresponding 95% confidence intervals (95% CIs). The correlation between continuous variables was analysed using the Pearson and Spearman correlation coefficients and between categorical variables using chi-square tests. Differences between categorical variables were analysed using the Kruskal-Wallis Test.

Statistical analyses were performed using Microsoft Excel (version 16.7) and the Statistical Package for Social Science (SPSS version 28.0.0.0). Statistical significance was defined and interpreted at a level of significance of 5%.

RESULTS

During the study period, a total of 46 patients aged between 3 months and 17 years were identified as having undergone surgery for traumatic eye injuries. The majority were males (60.9%), with a male-female ratio of 1.6:1 (Table 6). The mean age (±SD) of the whole population sample was 8.57 (±5.01) years, 8.89 (±5.49) years for males, and 8.06 (±4.26) for females. Frequencies of age are shown in figure 2.

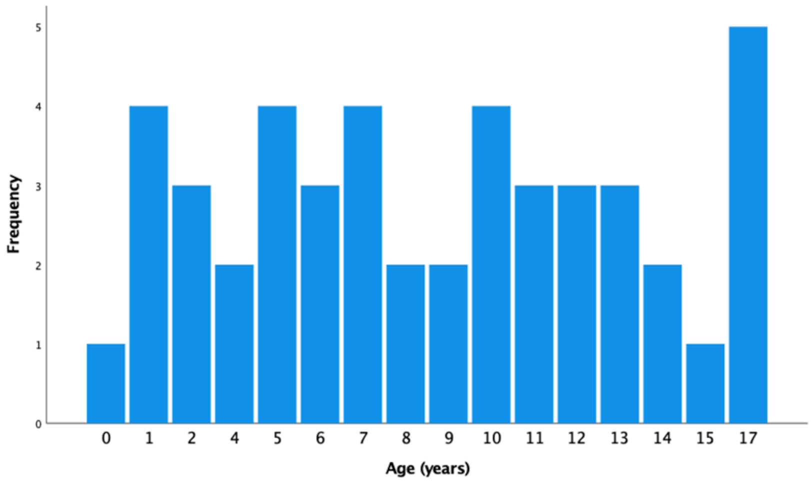

Figure 2. Frequencies of age for the whole population sample.

The majority were unilateral ocular traumas, and 56.5% affected the right eye; one (2.2%) patient had bilateral injuries; and in three patients, it was not registered which eye was affected (table 6).

According to the BETT classification system, the bulk of the traumas were labelled as open-globe (80.4%, n=37): penetrating (n=21), perforating (n=6), IOFB (n=8) and rupture (n=2). Contrarily, only eight (17.4%) of the children suffered closed globe trauma: contusion (n=7) and lamellar laceration (n=1). One patient (2.2%) was unable to be classified with BETT since the only lesion was to the eyelid (table 6).

Sharp and blunt objects were both contributing factors to the trauma. Sharp injuries were documented in 47.7% of the cases, and glass was the most often used object (15.2%). The most frequent cause of injury in blunt trauma (24%) was stone (6.5%). In patients with IOFB, the most frequent causative agents were metallic objects (n=2). No object was mentioned in the medical records for 28.3% of the patients (table 6).

Table 6. Demographics and types of injuries in children with ocular trauma.

N	*n*	%
Sex		
Male	28	60.9
Female	18	39.1
Age (mean±SD) (min-max) (years)	8.57±5.01 (0–17)	
Laterality		
Right	26	56.5
Left	16	34.8
Both	1	2.2
Unknown	3	6.5
Type of trauma		
Penetrating	21	45.7
Perforating	6	13.0
IOFB	8	17.4
Lamellar laceration	1	2.2
Contusion	7	15.2
Rupture	2	4.3
Other	1	2.2
Cause of injury by object		
Sharp	**22**	**47.7**
Glass	7	15.2
Metallic	4	8.6
Palm leaf	2	4.3
Knife	2	4.3
Pencil	2	4.3
Hairpin	1	2.2
Drawing compass	1	2.2
Keychain	1	2.2
Fork	1	2.2
Filings (rust)	1	2.2
Blunt	**11**	**24.0**
Stone	3	6.5
Bullet	2	4.3
Airbag	1	2.2
Doorknob	1	2.2
Hockey stick	1	2.2
Sport ball	1	2.2
Punch	1	2.2
Wood/organic material	1	2.2
Unknown	**13**	**28.3**

The corneoscleral zone was involved in the majority of children (n=41, 89.1%), followed by the crystalline lens (n=26, 56.5%), posterior segment (n=15, 32.6%), eyelids (n=7, 15.2%), and orbit (n=4, 8.7%) (table 7).

Most children (n=39, 84.8%) underwent surgery in the emergency department, while seven patients (15.2%) had their surgery postponed. Corneoscleral suture was performed on thirty-eight patients, accounting for 82.6% of all surgical procedures, followed by vitreoretinal surgery on six patients (13.0%), IOFB removal on four patients (8.7%), and lensectomy on two patients (4.3%). Evisceration was performed on one patient (2.2%) (table 7).

Although most patients had early surgery, the majority of children (n=26, 56.5%) needed subsequent surgery. The mean number of procedures (±SD) of the overall population sample was 1.59 (±0.65). The most frequent type of subsequent surgery was lensectomy (n=21, 45.7%), followed by vitreoretinal surgery (n=11, 23.9%), primary repair surgery (n=5, 10.9%), keratoplasty (n=3, 6.5%), IOFB removal (n=2, 4.3%), and pupilloplasty (n=1, 2.2%) (table 7). The correlation between the number of surgeries and the final BCVA was evaluated. A Pearson correlation coefficient of 0.124 (p=0.06) and a Spearman's rho correlation coefficient of 0.262 (p=0.112) were found.

Only one of the patients (2.2%) acquired an infection brought on by the trauma (table 7).

Table 7. Clinical presentation and treatment of paediatric eye injuries.

N	*n*	%
Affected structures		
Eyelids	7	15.2
Corneoscleral zone	41	89.1
Crystalline	26	56.5
Posterior segment	15	32.6
Orbit	4	8.7
Emergency surgery		
Yes	39	84.8
No	7	15.2
Type of surgery		
Corneoscleral suture	38	82.6
Lensectomy	2	4.3
Vitreoretinal	6	13.0
Evisceration	1	2.2
IOFB removal	4	8.7
Additional surgery		
Yes	26	56.5
No	20	43.5
Type of surgery		
Corneoscleral suture	5	10.9
Lensectomy	21	45.7
Vitreoretinal	11	23.9
Keratoplasty	3	6.5
Pupilloplasty	1	2.2
IOFB removal	2	4.3
Infection		
Yes	1	2.2
No	45	97.8

We were able to record the initial VA in only 11 of the 46 (23.9%) children. Of them, one had NLP (2.2%), six had LP (13.0%), three had BCVA between CF and 0.1 (6.5%) and one had BCVA 1.0 (2.2%).

When calculating POTS, most of the patients scored a POTS of group 1 (19 patients, 41.3%) or group 2 (15 patients, 32.6%), while nine patients (19.6%) had a POTS score of group 3 and three patients (6.5%) had a POTS score of group 5. No patients had a POTS score of group 4. The mean calculated POTS of the whole sample was 53.04 (±20.43) (equivalent to group 2), 59.1 (±22.3) for boys, and 43.6 (±12.6) for girls. The median was 45, also corresponding to group 2, 55 for boys, and 40 for girls (figure 3).

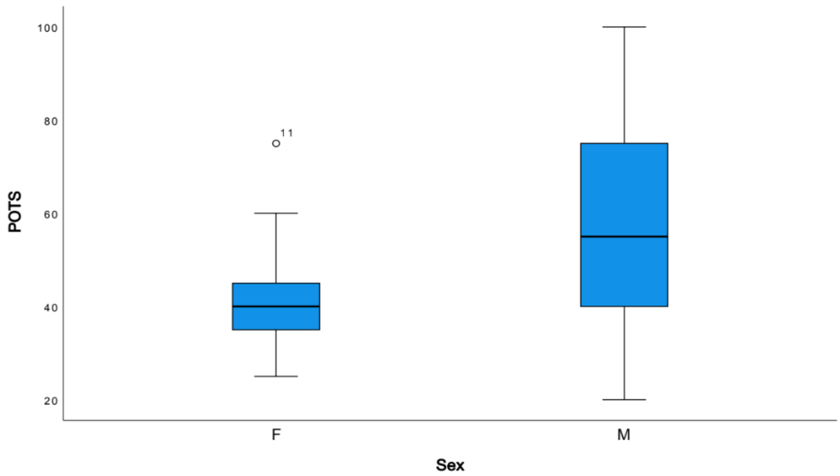

Figure 3. POTS values according to sex.

Following surgery, thirteen patients (28.3%) were lost to follow-up right after the surgery. The BCVA of the other thirty-three remaining children (71.7%) was determined more than six months later. Of them, 54.5% had mild/no visual impairment (VI), 12.1% moderate VI, and 33.4% severe VI/blindness. The mean final BCVA (±SD) was 0.92 (±1.1). The correlation between the initial VA and the final BCVA was tested. A Pearson correlation coefficient of 0.192 was found (p=0.621), and Spearman's rho coefficient was 0.112 (p=0.774).

Depending on the impacted structures, the final BCVA varied. The average final logMAR BCVA for eyelid-related ocular injuries was 1.58 (±1.45), corneoscleral zone 0.85 (±1.08), crystalline 0.85 (±1.07), posterior segment 1.52 (±1.23) and orbit 2.03 (±1.67). The mean final BCVA in open-globe trauma was 0.72 (±0.92) for penetrating trauma, 0.78 (±0.81) for perforating trauma, and 1.07 (±1.50) for IOFB; for closed globe trauma, it was 1.39 (±1.31) for contusion and 1.35 (±1.91) for rupture.

Nine (42.9%) of the 21 children who suffered penetrating trauma had mild/no VI, two children (9.5%) had moderate VI, and five children (23.8%) had severe VI/blindness. Two (33.3%) of the six children with perforating trauma had mild/no VI and one child (16.7%) had moderate VI. Three (37.5%) of the eight children with IOFB had mild/no VI, and one child (12.5%) had blindness. Two (28.6%) of the seven children with contusions had mild/no VI, one child (14.3%) had moderate VI and four children (57.1%) had severe VI/blindness. One child (50%) with rupture had mild/no VI and blindness, respectively. One child (100%) with a lamellar laceration had mild/no VI (table 8).

Table 8. Visual acuity according to the type of trauma.

Type of trauma *n* **(%)**	**BCVA (LogMAR)**			
	0.0-0.50	**0.52-1.0**	**1.02-1.30**	**1.82-3.0**
Penetrating	9 (42.9%)	2 (9.5%)	2 (9.5%)	3 (14.3%)
Perforating	2 (33.3%)	1 (16.7%)		
IOFB	3 (37.5%)			1 (12.5%)
Contusion	2 (28.6%)	1 (14.3%)		4 (57.1%)
Rupture	1 (50%)			1 (50%)
Lamellar laceration	1 (100%)			

Younger children were more affected by trauma with sharp objects compared to blunt trauma. Of those 22 children with sharp ocular trauma, eleven (50.0%) had mild/no VI, one (4.5%) had moderate VI and three (13.6%) had blindness. Of the eleven patients who were injured by blunt items, three (27.3%) had mild/no VI, two (18.2%) had moderate VI, and five (45.5%) had blindness (table 9).

Table 9. Correlation type of object/BCVA.

Type of object *n* **(%)**	**BCVA (LogMAR)**		
	0.0-0.50	**0.52-1.0**	**1.82-3.0**
Sharp	11 (50.0%)	1 (4.5%)	3 (13.6%)
Blunt	3 (27.3%)	2 (18.2%)	5 (45.5%)

Eight children (36.4%) with ocular trauma caused by sharp objects had a calculated POTS of group 1, seven children (31.8%) had a POTS of group 2, six (27.3%)

had a POTS of group 3, and one (4.5%) had a POTS of group 5. On the other side, five children (45.5%) with ocular trauma caused by blunt objects presented a POTS of group 1, four (36.4%) a POTS of group 2, and two children (18.2%) a POTS of group 3 (table 10).

Table 10. Correlation type of object/POTS group.

Type of object *n*(%)	**POTS group**				
	1	**2**	**3**	**4**	**5**
Sharp	8 (36.4%)	7 (31.8%)	6 (27.3%)		1 (4.5%)
Blunt	5 (45.5%)	4 (36.4%)	2 (18.2%)		0

Children characterised as having a POTS of group 1 presented a mean final logMAR BCVA of more than 0.8. Those with a POTS of group 2 presented a mean BCVA of 1.0. As to the ones with POTS of group 3, the mean BCVA corresponded to more than 0.6, and finally, a POTS of group 5 corresponded to a mean BCVA of more than 1.60 (figure 4). The correlation between the two variables, POTS and final BCVA, was tested. A Pearson correlation coefficient of -0.312 (p=0.06) and a Spearman's rho correlation coefficient of -0.369 (p=0.025) were found. However, when categorising both variables (POTS and BCVA) and analysing group differences by the Kruskal-Wallis Test, no significant differences were observed between groups (p=0.061).

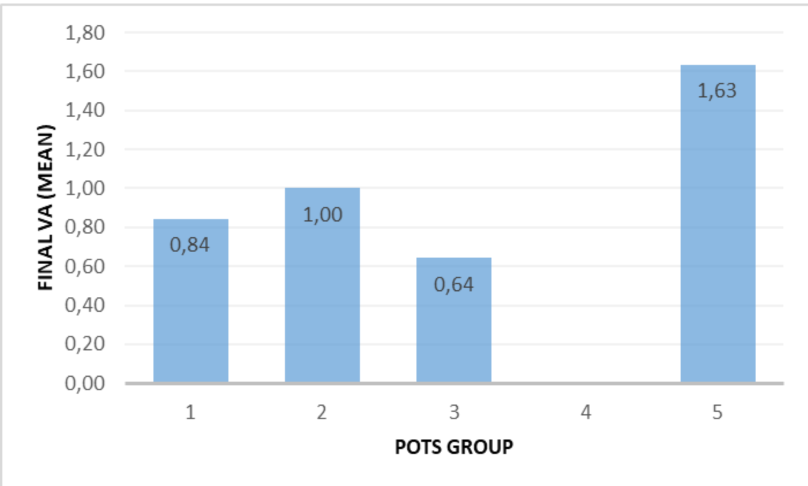

Figure 4. Correlation between mean BCVA and POTS.

DISCUSSION

Traumatic ocular injuries are a prominent cause of non-congenital monocular blindness, frequently resulting in severe visual loss in young children. However, with timely presentation, prompt treatment, and regular follow-up, the visual prognosis of individuals with ocular damage can be significantly improved.

In this retrospective study of paediatric ocular trauma presented over a 14-year period at a tertiary hospital, there were 46 cases with significant ocular damage requiring ophthalmic surgery.

There was a slight male preponderance (60.9%) (M:F=1.6:1), particularly for primary school children (the average age of the entire sample was 9 years). Half of the patients were still in the critical visual development period (<9 years old); therefore, despite successful trauma treatment, VA may not improve because of amblyopia [4]. Although not statistically significant (p=0.813 and p=0.635, respectively) to the ultimate visual outcome, these findings were consistent with previously reported data from other parts of the world [1,2,4,6-9,12,16-19], revealing a preponderance of injuries in boys. These patterns are most likely explained by boys' propensity to participate in more physically demanding activities than girls. School-aged children are also more susceptible because, although still relatively immature, they are slightly more independent, spending time away from home and parental authority, which may make them more vulnerable [8].

Most of the injuries (91.3%) were unilateral, whereby right eye injuries outnumbered left eye injuries (56.5% vs 34.8%). This is in contrast to other studies' descriptions, which showed a similar affection for both eyes or a larger affection for the left eye, as people tend to guard their right eye better than their left, attributing it to dexterity [6,16,17]. Only 2.2% (n=1) of bilateral injuries occurred. In our investigation, the laterality of the affected eye had no influence whatsoever on the final outcome (p=0.698).

The most frequent type of trauma in this series was open-globe (80.4%). This is in line with what was found in the literature and usually has a worse visual prognosis since it requires surgery [2,4,10,20]. A significant proportion of injuries were due to penetrating injury (45.7%) by a sharp implement (47.7%), of which glass was the most frequently used object. On the other hand, the stone was the most frequent source of blunt trauma, and injury involving IOFB was frequently linked to metallic objects, similar to what Akça Bayar *et al.* [4] and Chabbar I. *et al.* [8] described. In contrast, it is inconsistent with some other research, revealing that toys and domestic objects used at home, sports, or leisure activities were the main causes of injuries in children [1,6,7,21].

Despite this prevalence of sharp objects, children presented a higher proportion of favourable visual outcomes, with 50.0% having a final BCVA between 0.0-0.50 (no/mild visual impairment). In contrast and unexpectedly, injuries by blunt objects had a lower proportion of favourable outcomes, with only 27.3% having a final BCVA in that range and 45.5% leading to severe VI/blindness. Yet, the mean final BCVA in open-globe injuries was worse for IOFB, with a logMAR final BCVA of 1.07, consistent with what was found by MacEwen C. *et al.* [1]. In closed-globe injuries, the worst mean final BCVA was 1.39, caused by contusion trauma. This value was affected by the fact that the single patient submitted to evisceration suffered a contusion lesion.

The majority of patients (84.8%) underwent surgery immediately in the emergency department, and corneoscleral sutures were the most common surgical procedure (82.6%) since the corneoscleral zone was the most frequently involved structure (89.1%), similar to what was previously described by Barry R. *et al.* [10]. The crystalline lens was affected in over half of the patients (56.5%), the same percentage of patients that required subsequent surgeries, with lensectomy being the most frequent procedure, as the development of cataracts resulting from ocular damage is not uncommon [4,8]. Unfortunately, lens injuries are a sign of major eye damage, which can require multiple surgeries and a lengthy period of visual recovery.

The final BCVA also varied depending on the structures affected. Orbit-related injuries had the worst visual prognosis (mean BCVA of 2.03). Strangely, eyelid-related injuries followed with a mean final BCVA of 1.58 and posterior segment, which is known to affect the prognosis of the eye [8], of 1.52.

The initial VA was recorded for less than a quarter of the patients (23.9%). Since VA is an important parameter in the management of globe injuries, the correct assessment of VA is crucial when it comes to making significant decisions on immediate care. This low number might have been due to a lack of cooperation but also to missing data. Among them, just one patient had NLP, and one had a BCVA of 1.0.

Since most patients did not have an initial VA assessment, POTS was used to estimate the visual prognosis. Most of the patients scored a POTS of group 1 (41.3%) or group 2 (32.6%). A method for categorising ocular trauma is useful for facilitating communication among treating ophthalmologists and providing information regarding prognosis.

After surgery, 28.3% of the patients were lost to follow-up immediately, and the final BCVA of the remaining children was determined more than six months later. Over half of the patients (54.5%) had a final logMAR VA between 0.0-0.50, indicating relatively good visual outcomes. Nevertheless, a third of the children developed severe visual impairment/blindness following trauma. The average final logMAR BCVA was 0.92 (±1.10), compared to the mean initial logMAR VA (±SD) of the eleven patients of 2.08 (±0.86). Although this shows an improvement, the correlation was not statistically significant (Pearson correlation coefficient was 0.19, p=0.621 and Spearman's rho coefficient was 0.11, p=0.774).

The correlation between POTS and final BCVA was assessed, and in accordance with other studies, a poor prediction of final VA was observed. In our study, children with higher POTS scores generally had lower final BCVA values. The Pearson correlation coefficient showed a moderate negative linear correlation (-0.312, p=0.06), while Spearman's rho correlation coefficient indicated a stronger negative correlation (-0.369, p=0.025), which was statistically significant. On the other hand, when we analysed both variables, POTS and BCVA, using the Kruskal-Wallis Test, no statistically significant differences were obtained between the several categories of the two variables (p=0.061). Although there were eight patients with missing final VA values, these results show that POTS was not a good predictor of final VA and are in agreement with what was found by Chaudhary A. *et al.* [15], which indicated that POTS underestimated the final VA.

There was a positive correlation between the number of surgeries and the final BCVA, although it was not statistically significant (the Pearson correlation coefficient was 0.124, p=0.06 and the Spearman's rho coefficient was 0.262, p=0.112).

Limitations

This study has limitations due to its retrospective methodology, which resulted in lost patients to follow-up and a lack of reported data that was restricted to the patient’s medical records. The sample size was small, and the variables in the paediatric group were challenging to track, especially the initial VA, which was a frequent source of data shortage. In addition, POTS was estimated for all patients, not just those under 15 years old and with penetrating injuries.

CONCLUSIONS

Ocular trauma injuries in children continue to have a poor prognosis. The results of this study help us to better understand the pattern of childhood eye injuries in a Portuguese tertiary hospital. Timely presentation, prompt treatment, and regular follow-up can significantly improve the visual prognosis of individuals with traumatic ocular injuries.

School-aged boys remain the most exposed and injuries were mainly unilateral. Almost half of the patients suffered from a penetrating injury with a sharp object. However, injuries by blunt objects were responsible for more cases of severe visual impairment/blindness. The majority of patients underwent surgery in the emergency department, corneoscleral suture being the most common procedure. More than half of the patients underwent additional surgeries, with lensectomy needed in over half of the cases.

Initial VA was often not recorded. The POTS classification system was employed to offer prognostic data. Although it has been deemed a valid instrument to evaluate the visual prognosis post-trauma in several earlier studies, it did not perform to the expected level in this investigation. In our analysis, it demonstrated a glaring underestimate of the final visual result. Final BCVA was favourable in more than half of the patients and varied depending on the type and object of trauma, structures affected, and the number of surgeries carried out, although not statistically significant. Nevertheless, a third of the patients developed severe visual impairment/blindness, which calls for implementing more effective preventive and paediatric safety measures and establishing a rapid-action eye trauma team to ensure timely treatment.

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REFERENCES

1. MacEwen, C. J., Baines, P. S., & Desai, P. (1999). Eye injuries in children: the current picture. *British Journal of Ophthalmology*, *83*(8), 933–936. https://doi.org/10.1136/bjo.83.8.933;
2. Awidi, A., & Kraus, C. L. (2019). A comparison of ocular trauma scores in a pediatric population. *BMC Research Notes*, *12*(1). https://doi.org/10.1186/s13104-019-4602-8;
3. Puodžiuvienė, E., Jokūbauskienė, G., Vieversytė, M., & Asselineau, K. (2018). A five-year retrospective study of the epidemiological characteristics and visual outcomes of pediatric ocular trauma. *BMC Ophthalmology*, *18*(1). https://doi.org/10.1186/s12886-018-0676-7
4. Akça Bayar, S. (2021). Clinical characteristics and outcomes of ocular injuries in pediatric patients. *Turkish Journal of Trauma and Emergency Surgery*. https://doi.org/10.14744/tjtes.2021.54524;
5. Salvin, J. H. (2007). Systematic approach to pediatric ocular trauma. *Current Opinion in Ophthalmology*, *18*(5), 366–372. https://doi.org/10.1097/icu.0b013e3282ba54ac;
6. Boret, C., Brehin, C., Cortey, C., Chanut, M., Houzé-Cerfon, C.-H. ., Soler, V., & Claudet, I. (2020). Pediatric ocular trauma: Characteristics and outcomes among a French cohort (2007–2016). *Archives de Pédiatrie*, *27*(3), 128–134. https://doi.org/10.1016/j.arcped.2020.01.002;
7. García Mancebo, J., Ferrero García-Loygorri, C., Romero, A. I., & Vázquez López, P. (2021). Traumatismo ocular en Urgencias de Pediatría, características y factores de riesgo de secuelas inmediatas. *Anales de Pediatría*, *94*(3), 161–172. https://doi.org/10.1016/j.anpedi.2020.07.016;
8. Chabbar, I., & Berraho, A. (2020). Ocular penetrating injuries in children. *Ophthalmology Journal*, *5*(0), 120–124. https://doi.org/10.5603/oj.2020.0023;
9. Sii, F., Barry, R. J., Abbott, J., Blanch, R. J., MacEwen, C. J., & Shah, P. (2018). The UK Paediatric Ocular Trauma Study 2 (POTS2): demographics and mechanisms of

injuries. *Clinical Ophthalmology*, *Volume 12*, 105–111. https://doi.org/10.2147/opth.s155611;

10. Barry, R. J., Sii, F., Bruynseels, A., Abbott, J., Blanch, R. J., MacEwen, C. J., & Shah, P. (2019). The UK Paediatric Ocular Trauma Study 3 (POTS3): clinical features and initial management of injuries. *Clinical Ophthalmology*, *Volume 13*, 1165–1172. https://doi.org/10.2147/opth.s201900;
11. Abbott, J., & Shah, P. (2013). The epidemiology and etiology of pediatric ocular trauma. *Survey of Ophthalmology*, *58*(5), 476–485. https://doi.org/10.1016/j.survophthal.2012.10.007;
12. Acar, U., Tok, O. Y., Acar, D. E., Burcu, A., & Ornek, F. (2011). A new ocular trauma score in pediatric penetrating eye injuries. *Eye*, *25*(3), 370–374. https://doi.org/10.1038/eye.2010.211;
13. Kuhn, F. (2008). *Ocular traumatology*. Springer.
14. Moussa, G., Bassilious, K., & Mathews, N. (2020). A novel excel sheet conversion tool from Snellen fraction to LogMAR including “counting fingers”, “hand movement”, “light perception” and “no light perception” and focused review of literature of low visual acuity reference values. *Acta Ophthalmologica*. https://doi.org/10.1111/aos.14659
15. Maake, M. M., & Oduntan, O. A. (2015). Prevalence and causes of visual impairment in patients seen at Nkhensani Hospital Eye Clinic, South Africa. *African Journal of Primary Health Care & Family Medicine*, *7*(1), 6. https://doi.org/10.4102/phcfm.v7i1.728
16. Prognostic value of Ocular Trauma Score and pediatric Penetrating Ocular Trauma Score in predicting the visual prognosis following ocular injury. (2022). *Romanian Journal of Ophthalmology*, *66*(2). https://doi.org/10.22336/rjo.2022.29;
17. Serdarevic, R. (2015). The Ocular Trauma Score as a Method for the Prognostic Assessment of Visual Acuity in Patients with Close Eye Injuries. *Acta Informatica Medica*, *23*(2), 81–85. https://doi.org/10.5455/aim.2015.23.81-85;

18. D’Antone, V., Flórez, D. C. P., García, C. J. L., Manrique, F. D. M. C., & Barbosa, N. L. (2021). Epidemiological findings of childhood ocular trauma in a public hospital in Colombia. *BMC Ophthalmology*, *21*(1). https://doi.org/10.1186/s12886-021-02014-1
19. Kaçer, E. Ö., & Kaçer, İ. (2022). Ocular trauma in the pediatric age group: a systematic review. *Egyptian Pediatric Association Gazette*, *70*(1). https://doi.org/10.1186/s43054-022-00125-y
20. Zepeda-Romero, L. C., Saucedo-Rodríguez, L. R., Becerra-Cota, M., Gutiérrez-Padilla, J. A., Yanowsky-Reyes, G., Pérez-Rulfo-Ibarra, D., Díaz-Borrayo, N., Cabrera-Díaz, N. N., & Barrera-de-León, J. C. (2022). Clinical characteristics and functional outcome of pediatric ocular trauma in a third level reference hospital in Guadalajara, Mexico. *Boletin Medico Del Hospital Infantil de Mexico*, *79*(1), 26–32. https://doi.org/10.24875/BMHIM.21000077
21. Patel, P. S., Uppuluri, A., Zarbin, M. A., & Bhagat, N. (2022). Epidemiologic trends in pediatric ocular injury in the USA from 2010 to 2019. *Graefe’s Archive for Clinical and Experimental Ophthalmology = Albrecht von Graefes Archiv Fur Klinische Und Experimentelle Ophthalmologie*, *260*(4), 1387–1394. https://doi.org/10.1007/s00417-021-05368-w