Original Article

Epidemiology and Visual Outcome of Pediatric Ocular Trauma in a Major Tertiary Eye Center in Tunisia: A 6-Year Retrospective Study

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Abstract

Purpose: To describe the epidemiological profile, clinical characteristics, and visual outcome of pediatric ocular trauma in Tunisia.

Methods: In this retrospective cohort study, we reviewed the charts of 398 children younger than 16 years of age, presenting to the Emergency Department "B" of Hedi Rais Institute of Ophthalmology, for ocular trauma. The study period was between January 1, 2013, and January 1, 2019. The final best-corrected visual acuity (BCVA) was measured at the end of the follow-up period, which was 6 months. We used the Chi-squared test to compare the two groups of final visual acuities (good vs. poor visual outcome) for different prognostic factors. The ocular trauma score (OTS) and the pediatric OTS (POTS) were calculated for each child. We used the Cohen's kappa coefficient to evaluate the agreement between our final visual acuities using OTS and POTS.

Results: The mean age was 7.95 years with a sex ratio (males to females) of 5.32. Closed-globe injury (CGI) was found in 321 eyes, while 101 eyes had open-globe injury (OGI). Injuries were bilateral in 24 children. The majority of injuries occurred at home. The predominant mechanism of injury was fall in CGI and tree branch in OGI. Initial and final BCVA were predominantly ≤0.3 logMAR in both CGI and OGI. OTS category 3 and POTS category 2 were the most common. Factors associated with poor prognosis included delay to consultation >24 h ($P = 0.0001$); initial BCVA >1 logMAR ($P = 0.0001$); OGI ($P = 0.001$); size of injury ≥5 mm ($P = 0.01$); zone III in OGI ($P = 0.032$); endophthalmitis ($P = 0.001$); OTS 1 and 2 ($P = 0.01$); POTS 1 ($P = 0.0001$); and the following associated lesions: cataract ($P = 0.006$), retinal detachment ($P = 0.03$), and intraocular foreign body ($P = 0.03$). We found that both OTS ($P = 0.001$) and POTS ($P = 0.003$) were predictive of the final BCVA, with a moderate agreement between them (Cohen's kappa = 0.56).

Conclusions: Studying the epidemiological profile and identifying the risk factors for poor visual outcome of pediatric ocular trauma are necessary to implement preventive measures. A thorough clinical evaluation and close patient follow-up are crucial for identifying these risk factors. Both OTS and POTS were predictive of the final visual outcome. POTS has the advantage of bypassing the initial visual acuity which may be difficult to assess in children.

Keywords: Epidemiology, Eye, Pediatrics, Prognosis, Trauma

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Introduction

Ocular trauma is considered the most common cause of acquired monocular blindness in children.[1] According to global estimates, approximately 3.9 million people are living with bilateral visual loss and more than 18 million with unilateral visual loss caused by eye injuries.[2] Annually, serious ocular trauma affects approximately between

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160,000 and 280,000 children under 15 years old.[3] In addition to amblyopia risk, pediatric eye injuries may have serious social, economic, and psychological consequences on the child's life. Furthermore, these injuries may result in significant economic burdens to families, caregivers, and countries in general. Therefore, managing these injuries should be tactful, and the medicolegal concerns should be systematically addressed. This emphasizes the importance of prevention in pediatric ocular trauma. Fortunately, up to 90% of pediatric ocular trauma is preventable.[4-6] These preventive strategies are based on the epidemiological profile and on the identification of the various risk factors for such injuries. Although many preventive measures are global and could be applied in different countries, some measures are more country specific than others, particularly regarding policies and legislation. The aim of this study is to describe the epidemiological profile, clinical characteristics, and visual outcome of pediatric ocular trauma in Tunisia.

Methods

In this retrospective cohort study, we reviewed the records of all children younger than 16 years of age presenting to the Emergency Department "B" of Hedi Rais Institute of Ophthalmology for ocular trauma between January 1, 2013, and January 1, 2019. It is a major tertiary center in the North that receives patients from all over the country. This study was approved by the Ethical Board of Hedi Rais Institute of Ophthalmology of Tunis (Approval Number EC7/2020), and the research followed the tenets of the Declaration of Helsinki. The requirement for patient consent for inclusion was waived because of the retrospective nature of the study.

Our inclusion criteria were the following: all children younger than 16 years of age presenting with an ocular injury, which included closed-globe injury (CGI) with damage to the eyeball and open-globe injury (OGI), with or without intraocular foreign body (IOFB).

Exclusion criteria were the following: child abuse, shaken baby syndrome, self-inflicted eye injuries, chemical or thermal or radiation burns, isolated ocular adnexal injuries, isolated orbital injuries, obstetrical and delivery-related eye injuries, polytrauma, incomplete follow-up (<6 months), and missing data.

We collected the following data from each patient's record, when available: age, gender, medical and ocular history, initial best-corrected visual acuity (BCVA), relative afferent pupillary defect (RAPD) and associated lesions. In addition to the type, zone and size of injury, we also recorded the time, day, month and place of injury. In cases where urgent surgical management was necessary, we collected the type of procedures.

We converted the initial BCVA into logMAR. Then, we divided them into five groups:

- No light perception
- Light perception or hand motion
- Visual acuity of counting fingers or better and >1.00 logMAR
- 0.30 logMAR <visual acuity ≤1.00 logMAR
- 0.30 logMAR or better.

We used the following definitions and classifications to determine the type of globe injury and the zone of injury:

- Definitions of ocular traumatology terms and the classification of eye injuries were based on the Birmingham Eye Trauma Terminology[7]
- The classification of zones of injury was based on the ocular trauma classification system. When structures of more than one zone were injured, the zone of injury was defined by the most posterior involvement.[8]

The severity of ocular trauma was based on the ocular trauma score (OTS) and the pediatric OTS (POTS): from each record, whenever possible, we calculated the OTS, as defined by Kuhn *et al*.[9] We also calculated the POTS, as defined by Acar *et al*.[10]

The follow-up period was 6 months. For each patient, data were collected on short-term complications, defined as those occurring within the first 3 months following the injury, and long-term complications, defined as those occurring after 3 months. In addition, the final BCVA was measured at 6 months postinjury.

Similar to the initial BCVA, we converted the final visual acuities into logMAR and divided them into the same five groups as the initial BCVA.

Prognosis evaluation was based on the final visual acuity. We defined the following prognostic factors: age, gender, place of injury, time of injury, month of injury, day of the injury, mechanism of injury, time between injury and consultation, length of hospitalization, initial visual acuity, type of injury (OGI vs. CGI), size of injury (only for OGI), zone of injury, associated lesions, type of urgent surgical procedure, short-term complications, long-term complications, type of management (surgical vs. nonsurgical), and severity of the ocular trauma: OTS and POTS.

For each prognostic factor, we calculated the number of eyes for the following final visual acuities:

- Worse than 1.00 logMAR (poor visual outcome)
- Of 1.00 logMAR or better (good visual outcome).

For each category of OTS and POTS, we calculated the number of eyes for each of the five groups of final visual acuities. Visual acuities were converted into logMAR. For each score (OTS and POTS), we compared our final BCVA with their respective final BCVA in the corresponding studies.[9,10] Then, we evaluated the level of agreement between our final BCVA using OTS and our final BCVA using POTS.

Data were collected using Microsoft® Excel® (Redmond, WA, USA) and then analyzed using IBM® SPSS® Statistics, version 23 (Armonk, NY, USA). Statistical significance was

considered at $P < 0.05$. The Shapiro–Wilk test was used to test for normality. The Chi-squared test was employed to compare the final visual acuities between the two groups for different prognostic factors. The unpaired *t*-test was used to compare our five groups of final visual acuities with those of the OTS and the POTS. We used the Cohen's kappa coefficient to evaluate the agreement between our five groups of final visual acuities in OTS and POTS. Since the last two columns in the final visual acuity prediction tables are different for each score, we changed them in the POTS prediction table, to make them similar to those in the OTS (patients with a final visual acuity of 0.3 logMAR or better were included in the last column). This was done to facilitate statistical analysis. Depending on the value of the Cohen's kappa, the strength of agreement varied from "no agreement" to "perfect agreement".

Results

We retrospectively evaluated the records of 3226 children younger than 16 years of age. We included 422 eyes (398 children) with pediatric ocular trauma [Figure 1]. Twenty-four (6.03%) children had bilateral injuries.

The results of descriptive statistics are summarized in Table 1.

Age ranged from 6 months to 14 years and a half, with a mean age of 7.95 years. Males were predominantly injured with a sex ratio (males to females) of 5.32. The overall most common place of injury was home (*n* = 127 eyes, 30.09%). In CGI, the predominant place of injury was street (*n* = 101 eyes, 31.46%), while it was home (*n* = 48, 47.52%) in OGI. The most common time of injury was from 9 a.m. to 7 p.m. (*n* = 191, 74.90%). Most pediatric ocular injuries occurred on weekends (194, 45.97%). The monthly distribution followed a bimodal distribution with most injuries occurring in March (*n* = 55, 13.03%) and July (*n* = 59, 13.98%). Most children with pediatric ocular trauma consulted our emergency department more than 24 h following the injury (*n* = 144, 56.47%). The length of hospital stay was predominantly <7 days (*n* = 164, 81.59%), with a mean of 5.2 days.

In CGI, the four most common mechanisms of injury were fall (*n* = 74, 23.05%), fist (*n* = 69, 21.50%), nail (*n* = 61, 19%), and stone (*n* = 59, 18.38%), whereas in OGI, the four most common mechanisms of injury were tree branch (*n* = 22, 21.78%), glass (*n* = 21, 20.79%), knife (*n* = 14, 13.86%), and metallic object (*n* = 13, 12.87%).

Our sample included 321 eyes with CGI (76.06%) and 101 eyes (23.94%) with OGI. The most common type of injury in CGI was contusion (*n* = 208, 64.79%), while it was penetrating injury (*n* = 74, 73.26%) in OGI. The size of injury was predominantly <5 mm (*n* = 41, 48.80%) in OGI. Zone I was the most common zone of injury (*n* = 281, 66.58%) in both CGI and OGI. Hyphema was the predominant associated lesion (*n* = 89, 27.73%) in CGI [Figure 2], while it was corneal laceration (*n* = 49, 48.51%) in OGI [Figure 3]. Globe laceration

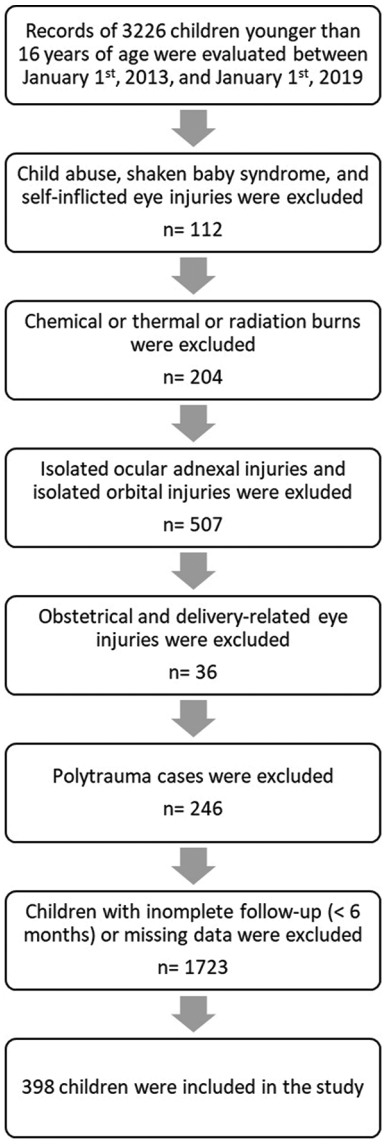

Figure 1: Flowchart depicting the exclusion and inclusion criteria

repair was the most commonly performed urgent surgical procedure (*n* = 101, 23.93%).

Overall, the three most common short-term complications by order of frequency were cataract (*n* = 75, 17.77%), early ocular hypertension (*n* = 19, 4.5%), and infectious keratitis (*n* = 14, 3.32%), whereas the two least common were early retinal detachment (*n* = 7, 1.66%) and endophthalmitis (*n* = 6, 1.42%).

Endophthalmitis was exclusive to OGI. The mechanism of injury was a metallic IOFB in three eyes, a tree branch in two eyes, and a fragment of glass in one eye. The delay between trauma and endophthalmitis ranged from 2 to 7 days. The causal organism was identified in only one eye, which was due to *Streptococcus viridans*. Management included empiric systemic antibiotics and topical fortified antibiotics. Intravitreal injections of antibiotics (vancomycin and ceftazidime) and/or antifungals were associated with the topical and systemic routes. In five eyes, pars plana vitrectomy was necessary, and

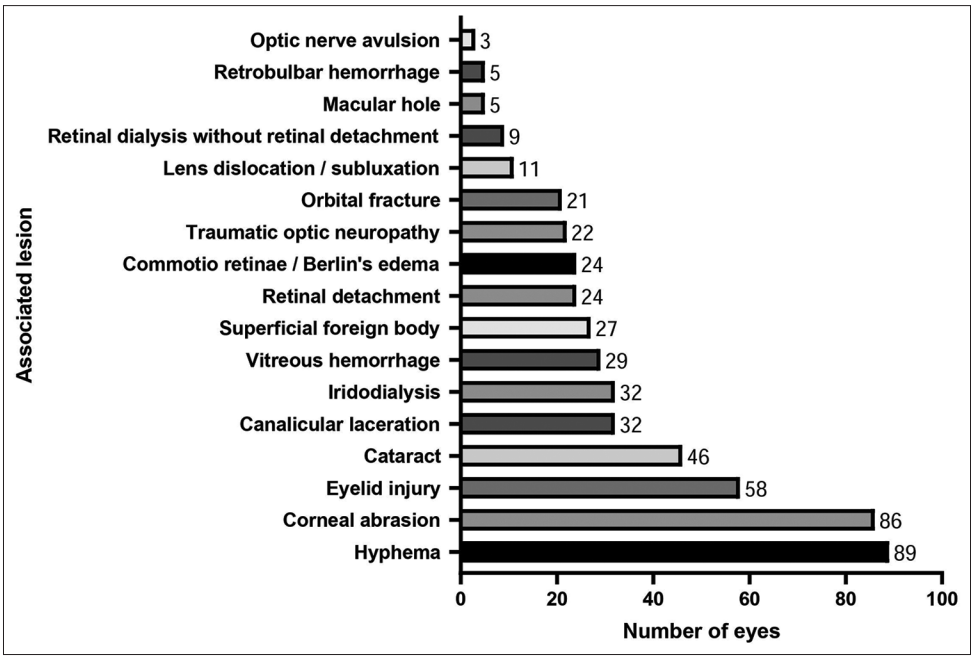

Figure 2: Distribution of associated lesions in closed-globe injuries

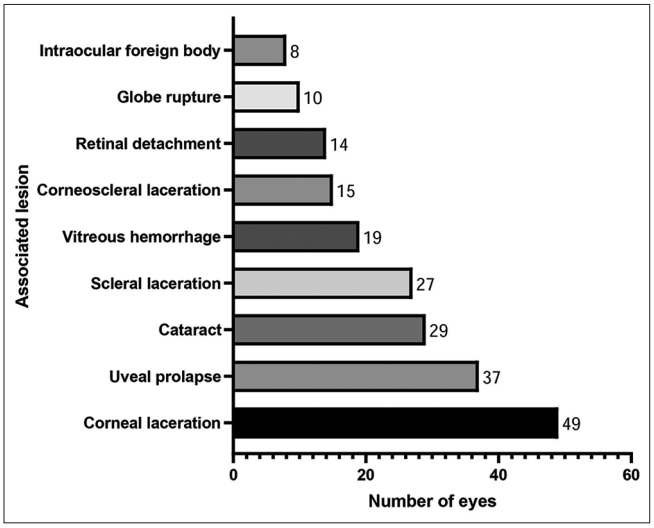

Figure 3: Distribution of associated lesions in open-globe injuries

it was performed before 14 days in all five cases. The final BCVA was 1.00 logMAR or worse in all of them (mean = 1.6 logMAR).

The three most common long-term complications by order of frequency were amblyopia (n = 98, 23.22%), astigmatism (n = 89, 21.09%), and corneal opacity (n = 74, 17.54%). The overall management was predominantly surgical (n = 246, 58.29%).

The visual acuity (initial and final) was not possible in 50 eyes. In both CGI and OGI, the most common initial BCVA was 0.3 logMAR or better (n = 178, 47.85%), while the least common initial BCVA was no light perception. Amblyopia was already present in 13 (3.08%) eyes, before the injury. The most common final BCVA was 0.3 logMAR or better irrespective of the type of injury (n = 191, 45.26%). In both CGI and OGI, the most common final BCVA was ≤0.3 logMAR, while the least common was no light perception.

OTS could not be calculated in 50 eyes where the initial visual acuity could not be measured. However, POTS was calculated in all 422 eyes, as it bypasses the initial visual acuity. The most common OTS group [Figure 4] was OTS 3 (n = 148, 39.78%), and the most common POTS group [Figure 5] was POTS 2 (n = 183, 43.36%).

Statistically significant prognostic factors found in our study are summarized in Table 2.

We found a statistically significant association between the final BCVA in our study and the final BCVA in both the OTS (P = 0.001) and the POTS studies (P = 0.003). We found a moderate agreement (Cohen's kappa coefficient = 0.56) between OTS and POTS regarding the distribution of the final BCVA.

Discussion

This 6-year retrospective study evaluates the epidemiological profile of pediatric ocular trauma in a major tertiary center in Tunisia. To our knowledge, this is the only Tunisian study that included both CGI and OGI.[11-13]

Similar to our findings, most studies reported a mean age from 7 to 10 years of age with male predominance.[11,14] These findings might be explained by the fact that these children, particularly boys, are engaged in more outdoor activities that are injury prone and the fact that adult supervision is more lenient compared to younger children. In our study, bilateral

Table 1: Summary of descriptive statistics

Main characteristics	*n* (%)
Number of patients (eyes)	398 (422)
Age (years)	
Mean	7.95±4.22
Range	0.5–14.5
0–6	201 (50.50)
7–12	117 (29.40)
13–15	80 (20.10)
Sex ratio (males to females)	5.32
CGI	321 (76.06)
Most common: Contusion	208 (64.79)
OGI	101 (23.94)
Most common: Penetrating injury	74 (73.26)
Previous ocular conditions	
Amblyopia	13 (3.08)
Congenital glaucoma	2 (0.47)
Keratoplasty	1 (0.24)
Leber hereditary optic neuropathy	1 (0.24)
Most common mechanism	
In CGI	Fall (23.05)
In OGI	Tree branch (21.78)
Most common place of injury	
Overall	Home (30.09)
In CGI	Street (31.46)
In OGI	Home (47.52)
Most common initial visual acuity	
Overall	Better than 0.4 logMAR (42.18)
In CGI	Better than 0.4 logMAR (46.11)
In OGI	Better than 0.4 logMAR (29.7)
Most common final visual acuity	
Overall	Better than 0.4 logMAR (45.26)
In CGI	Better than 0.4 logMAR (52.02)
In OGI	Better than 0.4 logMAR (23.76)
Time from injury to consultation (h)	
≤24	111 (43.53)
>24	144 (56.47)
Length of hospitalization (days), mean	5.2±4.2
<7	164 (81.59)
≥7	37 (18.41)

CGI: Closed-globe injury, OGI: Open-globe injury

injuries occurred in 6% of eye injuries. The predominant mechanisms of these injuries were firecrackers in CGI and glass in OGI. Bilateral ocular injuries were most likely related to the mechanism of trauma.

As reported by other studies, we found home to be the most common place of injury.[11,14] These findings might suggest that these children would not have been under a sufficient supervision. Most injuries in our study occurred in July and March, which correspond to the holidays. Differences with other studies could be explained by different holiday periods.

Several studies found that children were seen in the hospital within 24 h following the injury.[11,15,16] Two studies in Nigeria and India[17,18] reported a delay of consultation of more than

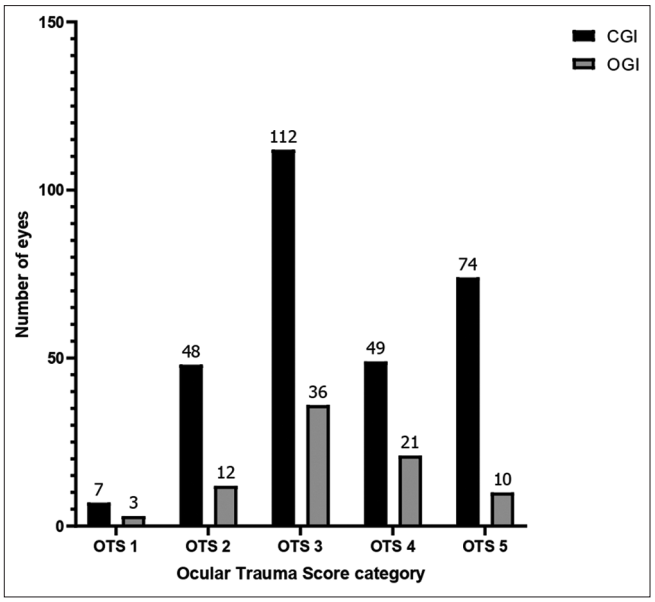

Figure 4: Distribution of ocular trauma score categories by type of injury OGI: Open-globe injury, CGI: Closed-globe injury, OTS: Ocular trauma score

24 h. In our study, slightly more than half of the children were seen more than 24 h after the injury. This delayed consultation could be explained by the downplay of injuries by the child or difficulties communicating the injury to the parents. Moreover, financial constraints could delay the consultation, particularly when the injury gives the impression of being minor.

We had one child with keratoplasty before ocular trauma. A study by Rehany and Rumelt[19] reported the vulnerability of eyes with prior keratoplasty to trauma, emphasizing the importance of prevention. Reporting previous ocular conditions is important when considering the prognosis of the ocular injury in addition to the medicolegal considerations.

Several studies reported OTS groups 2 and 3 as the most common.[18,20-24] Similarly, in our study, the predominant OTS group was 3. As reported in other articles, we found POTS 2 as the most common POTS group.[24-26]

In this study, we found that an initial BCVA worse than 1 logMAR was significantly associated with a poor visual outcome, while an initial BCVA of 1 logMAR or better was significantly associated with a good visual outcome. Singh *et al*.[23] found that the initial visual acuity was the best predictor for the final visual outcome, while the type of injury was the third best predictor (after the initial visual acuity and the size of injury). Similar to other authors,[27,28] this study found that OGI had a more severe visual prognosis. Singh *et al*.[23] also reported that the zone of injury was the fourth best predictor of final visual outcome. Comparable to several studies,[11,29,30] we uncovered zone III to be significantly associated with poor visual outcome.

Various studies[11,24,30] revealed that hyphema and a shallow anterior chamber were predictive of a final visual acuity

worse than 0.3 logMAR. In our study, hyphema and uveal prolapse were associated with poor prognosis. Similar to Malek *et al*.,[11] we showed that cataract was associated with poor visual outcome.

Posterior segment involvement might imply a severe injury. Two studies[11,30] reported that retinal detachment and RAPD were predictive of poor visual outcome. We found that retinal detachment and traumatic optic neuropathy were associated with poor visual outcome. All 22 children with traumatic optic neuropathy in our study had a unilateral injury with decreased visual acuity and a RAPD. These findings emphasize the importance of the initial posterior segment evaluation which should be performed after assessment for a RAPD.

Several investigators[11,16,24,29,30] showed that retinal detachment, endophthalmitis, and posttraumatic cataract were associated with poor visual outcome, whereas in our study, only endophthalmitis was associated with poor visual outcome. Majority of these articles included only OGI, while in our study, most children with cataract or retinal detachment had CGI. This could explain the association of these short-term complications with poorer visual outcome in these studies. Although Mansouri *et al*.[31] included only young adults in

Table 2: Summary of statistically significant prognostic factors

Prognostic factor	Poor visual outcome (*P*)	Good visual outcome (*P*)
Length of hospital stay	≥7 days (0.02)	<7 days (0.02)
Delay to consultation	>24 h (0.0001)	≤24 h (0.0001)
Initial BCVA	NLP (0.0003)	1.0–0.3 logMAR (0.0001)
	HM or LP (0.01)	≤0.3 logMAR (0.0001)
	CF or >1 logMAR (0.01)	
Type of injury	OGI (0.001)	CGI (0.0004)
Size of injury (for OGI)	5–10 mm (0.01)	<5 mm (0.02)
	≥10 mm (0.006)	
Zone of injury	Zone III in OGI (0.032)	Zone I in CGI (0.0001)
		Zone I in OGI (0.0001)
Associated lesions in CGI	Hyphema (0.02)	Vitreous hemorrhage (0.002)
	Cataract (0.006)	
	Retinal detachment (0.0004)	
	Traumatic optic neuropathy (0.049)	
Associated lesions in OGI	Uveal prolapse (0.01)	
	Cataract (0.04)	
	Vitreous hemorrhage (0.02)	
	Corneoscleral laceration (0.03)	
	Retinal detachment (0.03)	
	Globe rupture (0.01)	
	IOFB (0.03)	
Urgent surgical procedures	Laceration repair (0.001)	
	Pars plana vitrectomy (0.007)	
	Cataract surgery (0.04)	
	IOFB extraction (0.03)	
Short-term complications	Infectious keratitis (0.002)	Cataract (0.02)
	Endophthalmitis (0.001)	Early ocular hypertension (0.04)
		Early retinal detachment (0.02)
Long-term complications	Corneal opacity (0.001)	Astigmatism (0.04)
	Synechiae (0.03)	
	Glaucoma (0.01)	
	Phthisis bulbi (0.001)	
	Amblyopia (0.03)	
Management	Surgical management (0.0001)	Nonsurgical management (0.0001)
OTS	OTS 1 (0.01)	OTS 3 (0.0001)
	OTS 2 (0.002)	OTS 4 (0.0001)
		OTS 5 (0.0001)
POTS	POTS 1 (0.0001)	POTS 2 (0.0001)
		POTS 3 (0.0001)
		POTS 4 (0.0001)
		POTS 5 (0.0001)

OGI: Open-globe injury, CGI: Closed-globe injury, IOFB: Intraocular foreign body, BCVA: Best-corrected visual acuity, NLP: No LP, LP: Light perception, HM: Hand motion, CF: Counting fingers, OTS: Ocular trauma score, POTS: Pediatric OTS

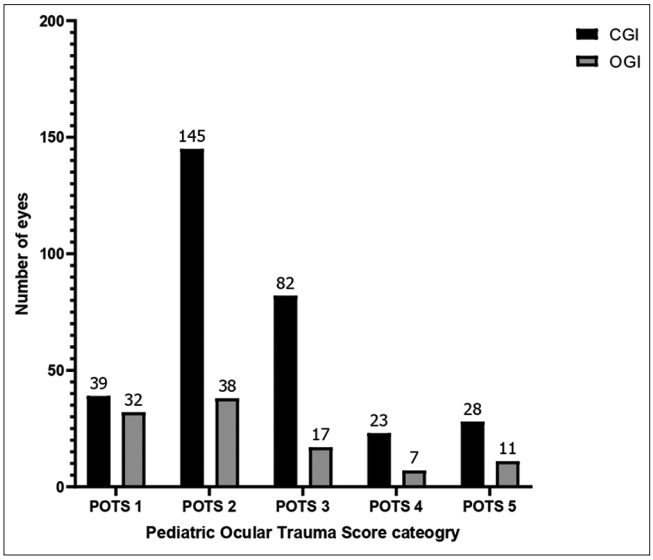

Figure 5: Distribution of pediatric ocular trauma score categories by type of injury. OGI: Open-globe injury, CGI: Closed-globe injury, POTS: Pediatric ocular trauma score

their study, their mean postoperative BCVA (1.7 logMAR) following pars plana vitrectomy for endophthalmitis was close to ours (1.6 logMAR).

Following the initial management of ocular lesions, aggressive amblyopia therapy should be promptly indicated. One study[32] reported that early initiation of amblyopia therapy within 3 months of OGI may improve visual outcomes, independent of the type of injury. Another study[33] recommended amblyopia therapy following corneal laceration repair, despite corneal opacity in the visual axis.

As reported by other authors,[11,30] we also found OTS groups 1 and 2 to be associated with poor visual outcome.

Malek *et al*.[11] revealed that POTS 1 and POTS 2 were both associated with poor visual outcome, whereas we only discovered POTS 1 to be associated with poor visual outcome.

We found a Cohen's kappa coefficient of 0.56 (moderate agreement) between the two scores. This value falls between those reported in studies by Dursun *et al*.[34] and Morgan and Kasahara.[35]

Both OTS and POTS seem to be good predictors of the final visual outcome in pediatric eye injuries.[34,35] However, many authors found OTS to be relatively superior to POTS.[11,36-38] We recommend using one of them to estimate the final visual outcome, depending on the availability of the initial visual acuity.

Our study had multiple limitations, particularly its retrospective nature. We tried to address potential selection and information biases by excluding children with missing data and incomplete follow-up. In addition, our study was monocentric, and the follow-up period was relatively short.

Despite these limitations, our study had several strengths, primarily the sample size and the inclusion of both CGI and OGI. Moreover, we studied multiple prognostic factors and calculated POTS in addition to the OTS while evaluating their level of agreement.

Notwithstanding the great progress in the treatment of ocular trauma and its complications, prevention should always be the centerpiece of trauma management. Preventive strategies[39] of pediatric ocular trauma revolve around four elements: policies and legislation, personal eye protection, education, and national eye injury registers. Legislation and policies should be aimed at eliminating ocular hazards. When elimination of ocular hazards is not possible, eye protection should be strongly considered a preventive measure for pediatric ocular trauma. In one-eyed children, eye protection should be recommended in any situation in which there is a risk of eye injury. Polycarbonate was considered almost universally as the material of choice for eye protection.[40] Education is the mainstay of pediatric eye injury prevention. It should not only target the parents but also children as they lack the ability to detect and avoid ocular hazards. National eye injury registers should be implemented to follow epidemiological trends and to identify the risks of pediatric ocular trauma. Data should be used to assess the effectiveness of preventive strategies and eventually implement more effective preventive measures.

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Conflicts of interest
There are no conflicts of interest.

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