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Original Research Article

EPIDEMIOLOGICAL PROFILE, CLINICAL SPECTRUM, AND OUTCOMES OF PEDIATRIC OCULAR TRAUMA: A RETROSPECTIVE STUDY

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ABSTRACT

Background: Pediatric ocular trauma is a major cause of acquired visual impairment and blindness among children, particularly in low-resource settings. Understanding its epidemiology and clinical profile is essential for improving outcomes and guiding preventive strategies. The objective is to evaluate the epidemiological patterns, types of injuries, management modalities, and visual outcomes in pediatric patients presenting with ocular trauma to a tertiary care center.

Materials and Methods: A retrospective study was conducted over one year (February 2024 to February 2025) at the Department of Ophthalmology in a tertiary care centre, including all children aged 0 to 16 years presenting with ocular trauma. Data were collected on demographics, mode and place of injury, clinical findings, management (medical/surgical), and pre- and post-treatment visual acuity. Statistical analysis included descriptive statistics and chi-square testing to assess associations between management type and outcomes.

Results: Out of 60 pediatric patients, 75% were male, with the highest incidence (40%) observed in the 11–16-year age group. Most injuries occurred at home (45%), with blunt trauma from wooden sticks being the most common cause (20%). Medical management was employed in 35% of cases, while 65% required surgical intervention. Post-treatment, the proportion of children with visual acuity of 6/6–6/12 increased from 15% to 40%. Although not statistically significant ($p = 0.0643$), surgically managed cases had a trend toward poorer outcomes.

Conclusion: Pediatric ocular trauma is largely preventable, with domestic environments being a common source of injury. Early diagnosis and timely intervention significantly improve visual outcomes. Public education and structured trauma care protocols are vital for reducing the burden of childhood ocular injuries.

Keywords: Pediatric ocular trauma; Visual acuity; Eye injury; Blunt trauma; Ocular surgery; Childhood blindness.

INTRODUCTION

Ocular trauma in children remains a significant global public health concern and is among the leading causes of acquired visual impairment and monocular blindness in the pediatric population. It accounts for approximately 8–14% of all ocular injuries across age groups and represents a substantial portion of preventable childhood blindness, especially in low- and middle-income countries where access to timely ophthalmic care may be limited.[1] Pediatric ocular trauma not only compromises visual development but also imposes long-term psychological, educational, and economic burdens on affected children and their families.[2]

The anatomical and physiological characteristics of a child's eye, such as thinner sclera, more elastic tissues, and limited communicative ability, make it

uniquely vulnerable to injury and subsequent complications.[3] Moreover, children are naturally more active, inquisitive, and often lack awareness of environmental hazards, predisposing them to trauma in various settings, including the home, playground, school, and roads.[4]

The spectrum of ocular trauma in children ranges from superficial injuries like subconjunctival hemorrhage to severe globe-threatening injuries such as corneal lacerations, traumatic cataract, retinal detachment, and endophthalmitis.[1] The visual prognosis largely depends on the severity of the injury, time to presentation, appropriateness of intervention, and adherence to follow-up care. Delayed management, particularly in cases requiring surgical intervention, may result in irreversible visual loss, amblyopia, or even enucleation.[5]

There is a paucity of recent and region-specific data from tertiary care centers in India that comprehensively analyze the clinical profile, management strategies, and visual outcomes of pediatric ocular trauma.

Therefore, the present study was conducted to evaluate the epidemiological characteristics, types of injuries, clinical presentation, treatment modalities, and visual outcomes of pediatric ocular trauma cases presenting to a tertiary care center over a one-year period. Understanding the local patterns of injury and their outcomes can help in formulating targeted preventive strategies, awareness campaigns, and evidence-based clinical protocols for better pediatric eye care.

MATERIALS AND METHODS

Study Design and Setting: This was a retrospective, hospital-based observational study conducted in the Department of Ophthalmology at a tertiary care referral center in South India. The study was conducted over a period of one year, from February 1, 2024, to February 28, 2025. It aimed to analyze the epidemiological profile, injury characteristics, management approaches, and visual outcomes of pediatric patients presenting with ocular trauma.

Ethical Approval: Ethical clearance for the study was obtained from the Institutional Ethics Committee. As the study involved retrospective analysis of anonymized patient data, the requirement for informed consent was waived in accordance with national ethical guidelines.

Study Population: The study included all pediatric patients aged 0 to 16 years who presented with ocular trauma, either to the outpatient department (OPD) or the emergency room (ER) of the hospital, during the designated study period. Pediatric trauma cases referred from peripheral centers, primary health centers, or private clinics were also included if complete records were available.

Inclusion Criteria

- Children aged 0–16 years
- Clinical diagnosis of ocular trauma based on patient history and ophthalmic examination
- First-time presentation during the study period
- Availability of complete clinical records, including at least one follow-up visit with documented post-treatment visual acuity

Exclusion Criteria

- Children with pre-existing ocular pathology not related to trauma (e.g., congenital cataract, retinoblastoma)
- Incomplete documentation or missing data on key variables such as vision or intervention
- Patients who were lost to follow-up or had follow-up of less than 2 weeks
- Ocular injuries secondary to iatrogenic causes (e.g., post-surgical complications)

Data Collection Procedure: Data were retrieved from the hospital's medical record section and electronic health database. A structured data extraction sheet was used to ensure consistency across all case entries. Demographic data such as age and sex were noted. Injury-related variables included place of injury (home, school, playground, road, workplace), mode of trauma (blunt trauma, penetrating injury, chemical/thermal burns, animal or human bite), laterality, and time of presentation. Clinical details included initial visual acuity, anterior segment findings (such as lid laceration, subconjunctival hemorrhage, corneal tear, hyphema, traumatic cataract, foreign body), and posterior segment findings (such as vitreous hemorrhage, retinal detachment, Berlin's edema, or choroidal rupture). Intraocular pressure values were recorded when available.

Classification and Management of Injuries: Management strategies were classified as either medical or surgical. Medical management included the use of topical and systemic antibiotics, corticosteroids, cycloplegics, anti-glaucoma agents, or antifungal/antiviral medications based on etiology. Surgical management involved procedures such as repair of lid or canalicular lacerations, suturing of corneal or scleral tears, extraction of traumatic cataracts with or without intraocular lens implantation, anterior vitrectomy, and globe salvage or evisceration procedures, where indicated. Each case was followed until visual and anatomical stabilization was achieved or until the last follow-up visit during the study period.

Classification of Visual Acuity: For analytical purposes, visual acuity was grouped based on World Health Organization (WHO) visual impairment criteria:[6]

- 6/6 to 6/12: Normal to mild visual impairment
- 6/18 to 6/60: Moderate visual impairment
- <6/60 to PL+ (Perception of Light positive): Severe visual impairment
- NPL (No Perception of Light): Complete blindness

The best-corrected visual acuity (BCVA) post-treatment was recorded as the final outcome parameter.

Primary and Secondary Outcome Measures

- **Primary outcome:** Functional visual recovery as assessed by change in visual acuity pre- and post-treatment
- **Secondary outcomes:** Type and mechanism of injury, time to presentation, treatment modality, complications, and anatomical integrity at follow-up

Statistical Analysis: All data were coded and entered in Microsoft Excel (Office 365), and further analysis was conducted using Python (version 3.10) and associated libraries such as Pandas, NumPy, SciPy, Matplotlib, and Seaborn. Descriptive statistics, including frequencies and percentages, were used to summarize demographic variables, injury characteristics, and outcomes. Cross-tabulations were created to explore associations between management type and outcomes. The chi-square test was used to determine the statistical significance of associations. A p-value of less than 0.05 was considered statistically significant. Visual tools including bar graphs and heatmaps were used to enhance the presentation and interpretation of the data.

RESULTS

As shown in [Table 1], the majority of pediatric ocular trauma cases (40%) occurred in the 11–16 years age group. Males were more frequently affected than females, accounting for 75% of the cases, suggesting a strong male predominance likely due to greater participation in outdoor activities.

Table 1: Demographic Distribution.

Variable	Category	Frequency (n)	Percentage (%)
Age Group	0–5 years	6	30.0
	6–10 years	6	30.0
	11–16 years	8	40.0
Sex	Male	15	75.0
	Female	5	25.0

[Table 2] highlights that home was the most common place of injury (45%), followed by playground (25%). Regarding the mode of trauma, wooden stick injuries were the most frequent (20%), followed by road traffic accidents (15%) and blunt trauma (15%). A considerable proportion (30%) fell under miscellaneous causes, indicating varied injury sources.

Table 2: Distribution of Place and Mode of Injury.

Variable	Category	Frequency (n)	Percentage (%)
Place of Injury	Home	9	45.0
	Playground	5	25.0
	Road	3	15.0
	School	1	5.0
	Workplace	1	5.0
Mode of Injury	Wooden Stick	4	20.0
	RTA	3	15.0
	Blunt Object	3	15.0
	Falls	2	10.0
	Dog Bite	1	5.0
	Burn	1	5.0
	Others	6	30.0

[Table 3] presents the relationship between type of management and outcome. Among those treated medically, no cases worsened, and the majority showed improvement (66.7%). Conversely, over half (50%) of surgically treated children had worsened outcomes, pointing toward a correlation between injury severity and need for surgical intervention.

Table 3: Type of Management vs. Outcome

Management Type	Improved (n)	Stable (n)	Worsened (n)	Total (n)
Medical	4	2	0	6
Surgical	3	4	7	14
Total	7	6	7	20

The impact of treatment on visual outcomes is summarized in Table 4. Post-treatment, there was a significant increase in children achieving 6/6–6/12 vision (from 15% to 40%) and a decrease in NPL cases (from 25% to 15%). These findings reflect the potential for functional visual recovery following prompt and appropriate management.

Table 4: Visual Acuity Before and After Treatment

Vision Category	No. of Eyes Pre-treatment (%)	No. of Eyes Post-treatment (%)
6/6–6/12	3 (15%)	8 (40%)
6/18–6/60	5 (25%)	4 (20%)
<6/60–PL+	7 (35%)	5 (25%)
NPL	5 (25%)	3 (15%)

Finally, [Table 5] reports the results of the chi-square test assessing the association between management type and outcome. Although the association did not reach statistical significance (p = 0.0643), the trend indicates that surgically managed cases had poorer outcomes, likely due to greater injury complexity.

Table 5: Chi-Square Test for Management Type vs. Outcome

Chi2 Statistic	Degrees of Freedom	P-Value	Significance
5.49	2	0.0643	Not Significant

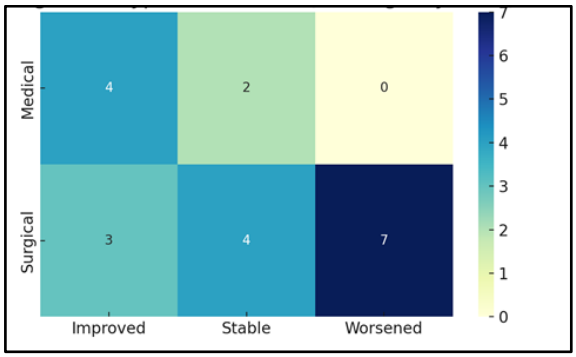

Figure 1: Heatmap of Management Type vs. Outcome

The heatmap visually displays the distribution of outcomes across medical and surgical management, showing a higher frequency of worsened outcomes in surgically managed cases [Figure 1].

DISCUSSION

Pediatric ocular trauma represents a critical yet underrecognized public health issue, accounting for a significant proportion of acquired visual impairment and blindness in children. The current retrospective study analyzed the demographic distribution, causative factors, clinical spectrum, management modalities, and visual outcomes of pediatric ocular trauma cases at a tertiary care center in South India. Our findings provide important insights into injury patterns in a regional context and underscore the importance of early recognition, appropriate intervention, and sustained follow-up in mitigating long-term visual morbidity.

Demographic Profile: In our study, boys were disproportionately affected, comprising 75% of the total sample. This male preponderance is consistent with multiple prior reports from both developing and developed countries.[7] The higher incidence among boys may be attributed to behavioral factors such as increased involvement in outdoor play, more aggressive play patterns, and greater exposure to unsupervised environments. Furthermore, our age-wise distribution revealed that the majority of injuries (40%) occurred in children aged 11 to 16 years. This is consistent with findings from studies by Maurya et al. and Khatry et al., which reported that ocular trauma is more frequent in school-aged children and adolescents due to increased engagement in unsupervised physical activities, outdoor sports, and reduced parental supervision during this developmental period.[8,9] Children in this age group are more physically active, tend to participate in sports, and may also begin to engage in part-time vocational activities, all of which increase the risk of ocular trauma.

Place and Mechanism of Injury: Home was identified as the most frequent setting for ocular injuries (45%), followed by playgrounds (25%). These findings are comparable to studies from low- and middle-income countries where domestic environments are often not child-proofed.[8,9] Despite the general perception of home as a safe space, our study reinforces that the home is a significant locus of preventable pediatric injuries. Inadequate supervision, hazardous tools within reach, and unsafe play practices contribute substantially to the risk.

The leading mode of injury in our study was blunt trauma with wooden sticks (20%), followed by road traffic accidents (15%), blunt objects (15%), and falls (10%). In our study, blunt trauma emerged as the most common mechanism of injury among pediatric patients, primarily caused by wooden sticks, balls, or other household objects. This finding aligns with global trends in pediatric ocular trauma. A five-year retrospective study conducted in Lithuania by Puodžiuvienė et al. reported that blunt trauma accounted for 40.3% of ocular injuries in children, making it the most prevalent mechanism in their cohort.[1] The predominance of blunt injuries may be attributed to children's natural engagement in vigorous activities, including sports and unsupervised play, as well as their lack of hazard awareness and physical coordination. These types of injuries are often associated with anterior segment damage such as hyphema, corneal edema, and traumatic cataract, which were frequently observed in our study as well. Although the severity of such trauma varies, the potential for permanent visual impairment underscores the importance of preventive strategies, including better supervision, protective eyewear during sports, and childproofing of home environments.[10] In our study, sports-related ocular injuries were notably prevalent among older children and adolescents, particularly those involving balls and sticks. This observation aligns with findings from a comprehensive 23-year analysis by Miller et al., which examined pediatric sports- and recreation-related eye injuries treated in US emergency departments. The study reported that children aged 10 to 14 and 15 to 17 years had the highest rates of eye injuries, with basketball (15.9%) and baseball/softball (15.2%) being the most common sports associated with these injuries. The increased participation in organized sports and recreational activities during adolescence, coupled with the use of projectiles like balls and sticks, contributes to the heightened risk of ocular trauma in this age group.

These findings underscore the importance of implementing preventive measures, such as the use of appropriate protective eyewear and education on safe play practices, to mitigate the risk of sports-related eye injuries among older children and adolescents.[9] The relatively high frequency of RTA-related injuries in our study reflects the growing exposure of children to vehicular environments and underlines the necessity for better enforcement of road safety measures, particularly use of restraints and pedestrian education for children.

Clinical Spectrum and Laterality: In our study, we observed a diverse range of anterior and posterior segment injuries among pediatric patients. The most commonly encountered anterior segment injuries included corneal lacerations, hyphema, and traumatic cataracts. These findings are consistent with those reported by Kayaarslan et al., who identified similar anterior segment manifestations in their cohort of pediatric ocular trauma cases. Posterior segment injuries in our study ranged from vitreous hemorrhage to retinal detachment. Such posterior segment involvements are also highlighted in the literature as significant contributors to visual morbidity following ocular trauma in children.[12]

Furthermore, the majority of injuries in our cohort were unilateral, a pattern that aligns with global trends in pediatric ocular trauma. For instance, a study conducted in São Paulo, Brazil, reported that 94.81% of pediatric ocular injuries were unilateral. Despite affecting only one eye, unilateral injuries can have profound implications on binocular vision development and educational performance, especially in younger children. The loss of vision in one eye can lead to challenges in depth perception and visual coordination, which are critical for learning and daily activities.[13]

Timing of Presentation: Prompt presentation to a healthcare facility is critical in preventing permanent damage in ocular trauma. In our cohort, while some children presented on the same day, a substantial number had delayed presentations, ranging from several days to weeks. Delayed presentation has been strongly associated with poor visual outcomes in various studies, primarily due to the progression of inflammatory or infectious sequelae and missed therapeutic windows for surgical intervention.[14,15] Barriers to early care-seeking in our context may include lack of awareness, distance from tertiary centers, economic constraints, and reliance on traditional or home remedies.

Management and Outcomes: In our study, 65% of the cases required surgical intervention, while 35% were managed medically. Among those treated medically, 66.7% showed visual improvement, whereas only 21.4% of surgically managed cases showed improvement, with over 50% resulting in worsened outcomes. These findings highlight that the need for surgical intervention often reflects the severity of trauma and that more invasive injuries naturally carry a poorer prognosis despite timely and appropriate surgical care.[16]

The most common surgical procedures performed included corneal tear repair, lid and canalicular laceration repair, and cataract extraction with or without intraocular lens implantation. Globe reconstruction and management of traumatic endophthalmitis were also reported in more complex cases. Literature consistently supports early primary repair for open-globe injuries, with best results achieved when performed within 24 hours.[10,17] However, in resource-limited settings or in cases of late presentation, optimal surgical timelines are often difficult to maintain.

Visual Acuity Outcomes: The primary outcome measure in our study was post-treatment visual acuity. Prior to treatment, only 15% of children had normal to mild impairment (6/6–6/12), whereas after treatment, this figure increased to 40%, indicating a substantial functional recovery in many cases. The proportion of children with no perception of light (NPL) decreased from 25% to 15%, reflecting the anatomical salvage and partial functional improvement achieved in some severe cases. This trend aligns with previous findings that highlight the importance of prompt diagnosis, access to surgical expertise, and structured rehabilitation in improving visual prognosis.[10]

Nonetheless, approximately 35% of children remained within the moderate to severe impairment categories post-treatment. This underscores the irreversible nature of some injuries and the critical need for preventive measures. The high burden of long-term visual disability in children has implications not only for quality of life but also for academic performance, psychosocial development, and economic productivity in adulthood.[15]

We performed a chi-square test to explore the association between management type and clinical outcome. Although the test did not reach statistical significance ($\chi^2 = 5.49$, $p = 0.0643$), there was a clear trend suggesting worse outcomes in surgically managed patients. The lack of statistical significance may be attributed to the small sample size and heterogeneous injury types. However, our finding is consistent with the hypothesis that injuries requiring surgical management are generally more severe and, therefore, have poorer visual prognosis.[18]

Our results are broadly consistent with previous Indian studies conducted in both rural and urban settings. A study by Shah et al. from Gujarat emphasized that delayed presentation was a major contributor to poor outcomes, particularly in cases of traumatic endophthalmitis among children, where initial injury severity compounded by late intervention led to guarded visual prognoses.[19] Similarly, Bhattacharyya et al. from a tertiary center in Delhi reported that home-related injuries were the most frequent source of pediatric ocular trauma and highlighted the importance of timely surgical repair in minimizing long-term complications.[20] These findings mirror the trends observed in our cohort,

where the majority of injuries occurred at home and surgical cases demonstrated worse outcomes—often reflective of delayed care and increased injury severity.

Internationally, studies from China, Egypt, and Nepal have further corroborated these observations. In the Chaoshan region of China, Cao et al. identified a strong male predominance, high frequency of unilateral injuries, and a clear link between common childhood activities and injury causation, emphasizing the preventable nature of many incidents.[21] Kaçer and Kaçer, in a systematic review of pediatric ocular trauma, reported similar epidemiological patterns, reaffirming that most injuries could be avoided with proper supervision and safety measures.[1] In Nepal, Dulal et al. also documented a high burden of unilateral, preventable ocular injuries among boys, with outcomes heavily influenced by the timing of care and availability of ophthalmic services.[22]

These consistent findings across both Indian and international literature emphasize the universality of pediatric ocular trauma risk factors and highlight the critical need for early intervention, parental education, and systemic improvements in trauma care pathways.

Implications for Practice and Policy: Our findings have several implications for clinical practice, policy formulation, and community outreach. Firstly, routine health education programs should emphasize home safety, especially for caregivers of children under 10 years. Protective gear and safety standards in sports equipment must be enforced in schools and recreational centers. Road safety education tailored for school-going children and strict adherence to helmet and seatbelt use should be promoted.

From a healthcare systems perspective, improving the availability and accessibility of ophthalmic emergency care, especially in rural areas, can reduce the time to presentation and optimize outcomes. Integration of ocular trauma training in pediatric emergency medicine and primary care curricula may also enhance early recognition and referral. Furthermore, rehabilitation services including low vision support and psychosocial counseling should be made accessible for children who suffer permanent visual impairment.

Limitations

This study is not without limitations. As a single-center, retrospective analysis, it may be subject to selection bias and may not capture all trauma cases in the region. The sample size, though reflective of actual burden, may limit the generalizability of the findings. Additionally, variability in documentation of injury mechanisms and follow-up duration across cases could affect the accuracy of visual outcome assessments.

Despite these limitations, the study offers valuable epidemiological insights and a framework for planning future multicentric prospective studies. Longitudinal follow-up assessing the functional, educational, and psychological impact of pediatric ocular trauma would further enrich our understanding and response to this issue.

CONCLUSION

In conclusion, pediatric ocular trauma continues to pose a serious threat to child vision health in India. This study highlights that most injuries are preventable, commonly occur at home, and disproportionately affect boys and adolescents. Early intervention, particularly within the first 24 hours, remains a critical determinant of visual outcome. Future efforts should be directed toward community-level prevention, improved access to pediatric ophthalmic care, and development of trauma registries for long-term monitoring and research.

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