Ocular trauma does not receive adequate attention in many areas globally owing to poor infrastructure, untrained human resources, and variable outcomes. General ophthalmologists are the first-line health workers treating this eye condition, but they are not particularly trained. Thus, the first assessment is performed by a relatively untrained team.[1]

Pediatric ocular trauma might result in life-long visual disability, thus posing a burden to the health-care system and society.[2] In children, open-globe injury is regarded as the most severe eye trauma caused by the penetration of a sharp object.[3] To optimize outcomes, careful evaluation and timely treatment are vital in open-globe injury. Precise visual prognosis is a key challenge in eye trauma treatment in pediatric cases. Parents frequently question physicians whether their children would become blind or can see again. Different scoring methods available for ocular trauma evaluation can help health-care providers appropriately predict vision-related outcomes. The Ocular Trauma Score (OTS) is one such generic instrument used to evaluate outcomes. In this scoring methodology, visual acuity (VA) is estimated by subtracting raw points for five diagnostic findings from initial VA.[4] However, the OTS demonstrated a low accuracy in children owing to its inability to obtain accurate VA; thus, instruments should be developed specifically for pediatric patients.[5–9] The Pediatric penetrating OTS (POTS) involves the exclusion of the initially calculated VA and afferen-t pupil defect serving as prognostic factors and the inclusion of wound location and age as new variables.[9] However, POTS’s drawback that it is less effective in high-risk trauma cases has been reported.[10–14]

Ocular trauma can result in the development of cataracts.[1] Various methodologies can be employed to determine vision-related outcomes in cataracts caused by trauma or other factors.[8] However, in those with traumatic cataracts, damage caused to adjacent ocular tissues can possibly reduce visual gain following surgery. This phenomenon can result in different rates of success between patients with and without traumatic cataracts. Moreover, the vision-related outcomes of pediatric traumatic cataract cases are often unsatisfactory owing to recurrent inflammation and amblyopia.[6]

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The Birmingham Eye Trauma Terminology System (BETTS) provides standardized definitions for ocular trauma.[9] These definitions can be employed to compare vision-related outcomes after operation for traumatic cataract and identify determinants that can predict the aforementioned outcomes. Most studies investigating the vision-related outcomes of traumatic cataracts[6] have included a small sample size or were designed as case studies.

The toddlers/infant OTS (toddlers OTS [TOTS]) was recently designed for children aged <6 years with open-globe injury resulting from trauma. In line with the POTS, the TOTS does not rely on VA and is beneficial for prognosis prediction in US toddlers and infants.[11,12]

**Methods**

**Patients**

This prospective cohort study was approved by the Drashti Netralaya Ethics committee (Ref-Drashti Netralaya/2020/13). All procedures followed the tenets of the Declaration of Helsinki and its amendments.

We included all patients aged <6 years who had traumatic cataracts resulting from ocular trauma and presented at the Drashti Netralaya between January 2011 and December 2020. We excluded children with a follow-up duration of <6 months. We reviewed patients’ electronic medical records. Data retrieved included demographic factors, ocular trauma characteristics and clinical data in the pretested online format, VA at the final follow-up, and existence of concomitant ocular disease. Information for the following additional signs and ocular comorbidities used to calculate scores was collected: hyphema, iris organic/unclean injury, prolapse, detachment of the retina, vitreous hemorrhage, traumatic cataract delay of >48 h for surgery, and endophthalmitis.

**Score calculations and statistical analyses**

We determined the OTS by using the standard table of raw points and points deducted according to comorbidities by converting them into different OTS categories.

Furthermore, the POTS was determined following the method reported by Acar et al.[13] and Shah et al.[14] We assigned raw points to the VA calculated at presentation. Additional points were added or subtracted for wound location, age, and any of the eight concomitant eye conditions. For patients with missing information regarding initial VA in medical records, the following equation was adopted for trauma score calculation: VA = 2 × (age + zone) – corresponding pathologies.

We stratified open-globe injuries into three anatomical zones based on their location: zone I (those confined to the limbus and cornea), zone II (those located 5 mm posteriorly to the limbus), and zone III (if the wound was extended to the macula and optic nerve posteriorly to zone II).[15] The range of the resulting score was from 1 (low prognosis) to 5 (favorable prognosis).

The following injury-related characteristics were evaluated to determine the TOTS: wound size >6 mm, existence of hyphema, cataract or lens damage, choroidal detachment, and detachment of the retina. These characteristics were assigned 1, 1, 1, 2, and 1 point, respectively, and zones II and III were assigned 1 and 2 points, respectively.[14] We considered the injury as having low (favorable) prognosis and high (poor) prognosis risk if the sum of points was 0 or 1 and ≥ 2, respectively.[14]

The OTS categories 1–5 and POTS 1–5 were calculated according to vision improvements. We compared the results of OTS categories 1–5 with those of TOTS categories 5–1, and the results of POTS categories 1–5 with those of TOTS categories 5–1 by using Fisher’s exact test and Student’s t test with 95% confidence intervals (CIs). A P value of < 0.5 was considered significant.

The receiver operating characteristic (ROC) curves comparing the TOTS with the OTS and the POTS with the TOTS for all categories were plotted to examine their specificity and sensitivity.

To perform statistical analysis, POTS and OTS categories 2–5 were all merged into the low-risk category corresponding to the TOTS category 1. The scoring methods’ predictive values were examined through a comparison of final and predicted VA by using Fisher’s exact test of independence; the sample t test was performed to evaluate its association [Table 1]. Specificity and sensitivity with 95% CIs were calculated using the ROC curve for each score. P value of < 0.05 indicated significance.

**Results**

Of 1630 traumatic cataract cases included, 457 (28%) and 1173 (72%) were female and male patients, respectively. Furthermore, 681 (41.8%) were pediatric cases.

We studied 124 patients aged <6 years; among them, 44 (35.41%) and 74 (64.5%) were female and male patients, respectively [Table 2]. Furthermore, the patients’ mean and median ages were 4.6 ± 1.29 and 5 years, respectively. Among 124 patients, 29 (23.4%) and 95 (76.6%) had closed-globe and open-globe injuries, respectively. The pre- and post-vision differed significantly. The outcomes of open-globe injury did not differ significantly from those of closed-globe injury (P = 0.162). Moreover, children aged <2 years had significantly poorer outcomes.

The number and percentage of cases with POTS, OTS categories 1–5, and TOTS categories 5–1 (more to less severe) were determined.

The difference among OTS, TOTS, and POTS categories was nonsignificant [Table 3].

No significant difference was noted between the low-risk TOTS categories and the merged 2–5 categories of POTS (P = 0.241 and 0.241, respectively) [Table 2].

Sensitivity and specificity for TOTS compared to OTS and POTS are displayed in Table 4 and Fig. 1 (for merged low-risk categories) and Fig. 2 (for individual categories).

**Discussion**

This study investigated the applicability and validity of TOTS, OTS, and POTS in patients aged from 0 to 6 years. The findings indicated the higher applicability of OTS than the POTS in all the categories of severity.
The OTS provides a more accurate prediction of vision-related outcomes. Nevertheless, the inclusion of children in a database of >2500 patients with severe eye injury based on which the score was formulated remains unclear.\[6,7\]

Although studies have employed regression tree, its validity is not evaluated. Compared with regression tree analysis, the OTS provided a highly accurate prognosis prediction.\[9-11\]
A study developed a predictive model for open-globe injuries. Another study developed the Basic Severity Score for Common Ocular Emergencies for examining the severity status of 86 common eye conditions by using the Delphi method. In this methodology, the severity was rated using a scale (7 points) in the first round of the survey. The final severity of each item was determined according to the median ratings obtained in the final Delphi survey. However, this score is not used widely and remains to be validated.

Politzer et al. developed the Craig Hospital Eye Evaluation Rating Scale (CHEERS) to investigate the severity and frequency of deficits in eye movements in traumatic brain injury patients.

Lesniak and Bauza found that in pediatric patients, the final calculated VA did not significantly differ from the VA predicted with the OTS. Sharma suggested that the initially calculated OTS might predict the prognosis of pediatric penetrating eye injury patients. However, Unver indicated the limitation of OTS in predicting vision-related outcomes in pediatric cases.

Several studies have prospectively validated the OTS in children.

Hossain, Uysal, and Tok have indicated that the OTS exhibited high validity in pediatric open-globe injury cases.

The OTS could predict vision-related outcomes after operation in 354 traumatic cataract patients. However, the likelihood of amblyopia should be considered in children. Refractive errors, strabismus, and ocular opacity can result in amblyopia. Not including amblyopia while calculating the scores can reduce OTS’s prediction accuracy. Therefore, we considered amblyopia in the OTS calculation for establishing a model for the POTS. We validated this model and compared prediction accuracy between the OTS and POTS for evaluating outcomes in pediatric traumatic cataract patients.

A study conducted in India validated the OTS in 787 traumatic cataract individuals.

Because of the difficulty in obtaining Relative Afferent Pupillary Defect (RAPD) and initial VA, two crucial factors for OTS calculation in pediatric trauma patients, particularly younger children, the calculated OTS would be inaccurate. Two studies conducted in Turkey calculated the OTS for children; however, these studies reported contradictory findings. The POTS was recently developed for prognosis prediction in children whose initial vision findings were inaccurate.

In children, the POTS was more accurate than the OTS, as indicated by the area under ROC (AUC).

The accuracy of POTS and OTS in examining the prognosis of open-globe injuries in pediatric cases was similar.

Zhu found that POTS was more robust than the OTS in examining penetrating injuries.

The findings of regression analysis revealed that both OTS and regression tree analysis were robust in predicting prognosis; however, the OTS demonstrated a greater accuracy. Thus, the OTS could be employed to counsel patients and make treatment-related decisions.

This study examined the scoring methods’ applicability and validity. The OTS, but not the POTS, demonstrated increased applicability in the general population. Future studies should examine TOTS’s applicability.

To our knowledge, no study has compared the validity among the TOTS, POTS, and OTS.

| Variable 1 | Variable 2 | P   |
|-----------|-----------|-----|
| OTS1      | TOTS5     | NA  |
| POTS1     | TOTS5     | NA  |
| OTS2      | TOTS4     | 0.035 |
| POTS2     | TOTS4     | 0.374 |
| OTS3      | TOTS3     | 0.242 |
| POTS3     | TOTS3     | 0.242 |
| OTS4      | TOTS2     | 0.090 |
| POTS4     | TOTS2     | 0.090 |
| OTS5      | TOTS1     | 0.065 |
| POTS5     | TOTS1     | 0.065 |

| Test category | Area under ROC curve | Inference                      |
|---------------|----------------------|--------------------------------|
| ROC OTS POTS higher risk versus TOTS higher risk | 0 | TOTS is less relevant |
| ROC OTS2 POTS2 versus TOTS4 | 250 | More sensitive and specific |
| ROC OTS3 POTS3 versus TOTS3 | 833 | More sensitive and specific |
| ROC OTS5 POTS5 VS TOTS1 | 500 | Less sensitive and specific |

Table 2: Age and sex distribution

| Age group in years | Sex | F | M | Total |
|--------------------|-----|---|---|-------|
| 0-2                |     | 4 | 5 | 9     |
| 3-6                |     | 40| 75| 115   |
| Total              |     | 44| 80| 124   |

Table 3: Comparative study of OTS, POTS, and TOTS for various trauma score categories

| Test category | Area under ROC curve | Inference                      |
|---------------|----------------------|--------------------------------|
| ROC OTS POTS higher risk versus TOTS higher risk | 0 | TOTS is less relevant |
| ROC OTS2 POTS2 versus TOTS4 | 250 | More sensitive and specific |
| ROC OTS3 POTS3 versus TOTS3 | 833 | More sensitive and specific |
| ROC OTS5 POTS5 VS TOTS1 | 500 | Less sensitive and specific |

Table 4: Study of sensitivity and specificity of different trauma categories (area under curve)
In line with BETTS, the OTS could be easily used to evaluate both closed-globe and open-globe eye injury. The examination of six factors (A–F) for prediction that is required for OTS calculation is relatively easy. The OTS could accurately predict vision-related outcomes in open-globe injury. However, a one in five risk of obtaining an incorrect score exists; thus, this score should not be employed to plan the primary treatment procedure. The OTS should be adopted for making treatment-related decisions.\textsuperscript{[2,30]} The TOTS and POTS exhibited limitations in those with poor prognosis.

Read et al.\textsuperscript{[31]} developed a new prognostic score. Patients aged 0–6 years with open-globe injury exhibit specific risk factors indicating poor outcomes. The score calculated using our algorithm did not rely on VA acuity, and thus can be beneficial for prognosis prediction in younger children.

**Conclusion**

TOTS, as a novel predictive score, is more reliable than the POTS, but less specific and sensitive in high-risk (OTS-1 and POTS-1) cases. TOTS can be employed to examine outcomes in toddlers in whom vision check-up is not possible on presentation.

**Synopsis:** Toddlers Ocular Trauma Score is calculated based on the clinical findings and not on the presenting vision, and is tested for sensitivity and specificity for prediction, in comparison with Pediatric Ocular Trauma Score and Ocular Trauma Score.

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**Conflicts of interest**

There are no conflicts of interest.

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