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Latin American Journal of Ophthalmology

Review Article

Ocular Trauma Score revisited – Making sense of it all

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Received : 26 April 19
Accepted : 03 July 19
Published : 04 December 19

DOI
10.25259/LAJO_8_2019

Quick Response Code:

ABSTRACT

Globe injuries, a component of ophthalmic trauma, are a serious and preventable cause of monocular blindness typically affecting children and young adults. Visual outcome is generally unpredictable as it depends not only on anatomical structural damage but also on functional recovery, which is based on individual patient, operating surgeon, and other risk factors. There are no classifications, investigations, or treatment guidelines that are internationally standardized and practiced. As there are numerous controversies and variability of practice standards, we herewith review existing literature related to the relevance and practice of the Ocular Trauma Score to highlight validated and effective predictive models in adult ocular trauma and also in the pediatric population. Its applicability in various situations and proposed guidelines may help clinician to predict visual outcome following mechanical ocular trauma and also help audit outcomes when predicted outcomes are not achieved.

Keywords: Ocular trauma, Classification of ocular trauma, Ocular Trauma Score, Pediatric Ocular Trauma Score

METHODS AND LITERATURE REVIEW

All the possible literature relevant to the management of ocular trauma was searched on Cochrane database for eyes and vision group and Medline (1970–2018), EMBASE, and metaRegister for clinical trials.

INTRODUCTION

Trauma is the leading cause of monocular preventable blindness in the developed world, although few studies have uniformly and consistently addressed the problem of trauma in developing nations and rural areas.[1] Combined with adnexal injuries, the eyelids, the lacrimal system, and the orbit, ophthalmic trauma is a major cause of morbidity with permanent structural, functional, esthetic, economical, and psychosocial consequences both in adults and children.[2,3]

While mechanical injuries are the most commonly encountered, well-studied, and of relevance to the discussion in this manuscript, other injuries include chemical, thermal, and ionizing radiation. The spectrum of ophthalmic trauma includes ocular injuries, ocular adnexal injuries (eyelid, lacrimal, and orbital structures), and orbito-facial injuries (cranio-orbital and orbitofacial fractures and soft tissue injuries). Ocular trauma is encountered in 13–16% of all systemic injuries[4-7] and as high as 83% in patients with head injuries[4-7] warranting the need for a formal evaluation by ophthalmologists in all head injuries and suspect cases in systemic injuries.

The spectrum of ophthalmic trauma includes ocular injuries, ocular adnexal injuries, i.e., eyelid, lacrimal, and orbital, and orbitofacial injuries (cranio-orbital, orbitofacial, and soft tissue injuries). Ocular trauma is encountered in 13–16% of all systemic injuries[4,5] and as high as 83% in patients with head injuries[4] warranting the need for formal evaluation by ophthalmologists in all cases of head injuries and suspect cases in systemic injuries.

The etiology of ocular injury vastly differs between urban and rural areas and among various geographical regions around the world and is worthy of investigation.[8-10] Common causes of mechanical ocular trauma include road traffic accidents and motor vehicle accidents including direct impact with steering wheels, windshield and windows and also airbags, assault, industrial accidents and other occupational injuries, falls, domestic accidents especially in children and women and sports injuries.[10,11] Other less frequent but potentially serious causes include firecracker injuries,[7] guns, and finally, terrorism-related injuries. Common risk factors for ocular trauma include children (domestic accidents), youth (sports and violence), adult males (industrial accidents, violence, and assaults), alcohol consumption, and the elderly (falls).

Globe injuries have been variably and often incorrectly mislabeled over the centuries. The first major attempt to address this and introduce a standardized terminology was with the introduction of the Birmingham Eye Trauma Terminology (BETT). Taking into account the nature of the injury, integrity of the ocular coats, internal disruption, and the presence of intraocular foreign bodies, two broad classifications along with part from a formal classification into closed- and open-globe injuries, may then be classified into closed- and open-globe injuries. A broad classification of globe injuries includes closed- and open-globe injuries with terminologies, as shown in Table 1®.[12]

Presentation may be varied and may include corneal abrasions, foreign bodies and lacerations, anterior segment injuries such as traumatic iritis, micro- and macroscopic hyphema, sphincter ruptures, iridodialysis and angle recession, traumatic cataracts, and lens subluxation/dislocation resulting in phacodonesis. Posterior segment injuries include vitreous hemorrhage, vitreous base avulsion, retinal tears, detachment and dialysis, and choroidal ruptures. Other vision-threatening consequences include direct and indirect optic nerve injuries (traumatic optic neuropathy), optic nerve avulsion, and orbital compartment syndrome.

Development of strategies for the prevention of injuries in each region justifies the need for knowledge of the causes. In eye injuries, the victims, their families, and the society bear a large, potentially preventable burden.[13,14] Preventable measures include adoption and use of personal protective equipment, wearing seatbelts in automotive, wearing helmets and shatterproof face shields, sports goggle in contact sports, and the routine dispensing of polycarbonate spectacle lenses in children and active adults. Despite the controversy of airbag-related ocular injuries,® their life-saving property alone well justifies their use. Even in developed countries, where adequate education and industrial laws have been promulgated, preventable ocular injuries are still a major concern.[15] Thus, a universal education, adoption, and enforcement of the routine and appropriate protective eyewear with appropriate targeting of resources toward preventing eye injuries may reduce this burden.

Ocular trauma is neglected discipline in many parts of the world, because of poor infrastructure and untrained workforce, with highly variable and often unpredictable outcomes. General ophthalmologists and junior ophthalmologists are often first line to manage ocular trauma, and very commonly, they are not specifically and well trained in the initial assessment and management of complex injuries. Most importantly, all forms of mechanical ocular trauma were universally deemed to have a guarded visual prognosis, thereby not only lowering expectations of both patients and treating physicians but also reducing accountability and responsibility to deliver the best possible care. Risk factors for poor prognosis following ocular trauma are several and include extremes of age: children <5 years of age, elderly, blunt injuries causing globe ruptures,[3] blast injuries, penetrating injuries with intraocular foreign bodies and contamination,[16-20] poor visual acuity and traumatic cataract at presentation,[11,21] presence of relative afferent pupillary defect (RAPD), and delayed repair.[22-24] Although globe injuries are ideally repaired as soon as possible as soon after addressing life-threatening injury, it has been shown that expertise of the surgical team makes a huge impact on the final outcome. Surgical repair by a dedicated ocular trauma team with meticulous and proper techniques, even in patients with bare or no light perception[25] by trained and experienced specialists, especially in high-risk injuries, followed by follow-up surgeries as and when indicated for consequences such as traumatic cataract, dislocated lens, persistent vitreous hemorrhage, endophthalmitis, and retinal detachment, has a better outcome,[25] justifying the need to develop dedicated integrated ophthalmic trauma units globally.[26]

An example of a visually significant consequence of ophthalmic trauma is traumatic cataract.[1,10,11] Various methods have been established for evaluating visual outcomes in eyes with cataracts due to trauma,[10,11,22,27,28] but damage to surrounding ocular tissues may compromise the visual gain in eyes after surgery. Traumatic cataracts often have poor visual outcomes in children due to amblyopia and recurrent inflammation.[11,29] Thus, the success rate may differ significantly between eyes with traumatic versus non-traumatic cataracts.[30]

Numerous attempts to categorize the severity of trauma in general and specifically ocular and ophthalmic trauma

Table 1: Estimated probability of follow-up visual acuity category at 6 months.

Raw score sum	OTS score	NPL (%)	PL/HM (%)	1/200–19/200 (%)	20/200–20/50 (%)	≥20/40 (%)
0–44	1	73	17	7	2	1
45–65	2	28	26	18	13	15
66–80	3	2	11	15	28	44
81–91	4	1	2	2	21	74
92–100	5	0	1	2	5	92

NPL: Nil perception of light; PL: Perception of light; HM: Hand movements

have been made over the decades. In patients with head and neurological injuries, the advent of the Glasgow Coma Scale (GCS)[31] has radically changed the approach to assessment, prognostication, and management*. In its original form and subsequently revised/modified form, it has become an important tool for first responders to assess brain function and consciousness with global impact not only in assessing patients at presentation but also during recovery and guide various forms of intervention. A further modification was the Revised Trauma Score which incorporated the GCS along with blood pressure and the respiratory rate.[32]

Likewise, the Abbreviated Injury Scale (AIS) is an anatomically based consensus-derived global severity scoring system that classifies each injury in every body region according to its relative severity on a six-point ordinal scale – from Minor to Maximal*. The Injury Severity Score is based on the AIS and is based on the body region(s) affected with the face and eyes as an important component.[4,5]

A major advance in the classification and terminology in ocular trauma was the standardized classification of ocular trauma.

Subsequently, a multicenter collaborative study proposed the Ocular Trauma Classification System by Pieramici *et al.* in 1997.[33] The International Ocular Trauma Classification Group has defined Zone III injuries as those extending beyond 5 mm of the limbus [Figure 1].[1] Based on the justification given by the Ocular Trauma Classification Group, they have arbitrarily taken it as 5 mm as injuries in that zone may not extend into the pars plana and hence any injury not involving Zone III or pars plana region are predicted to have favorable prognosis.[34]

A significant advance in the assessment and prognostication of outcomes of globe injuries was the Ocular Trauma Score (OTS) proposed by Kuhn *et al.* in 2002 which was developed to provide more accurate information about visual prognosis. Based on a detailed study of 2500 cases of globe injuries from both the Hungarian Eye Injury Registry and the United States Eye Injury Registry and having studied more than 100 variables, six specific variables that can be easily and clinically determined were highlighted as the most important to predict outcomes for visual acuity following

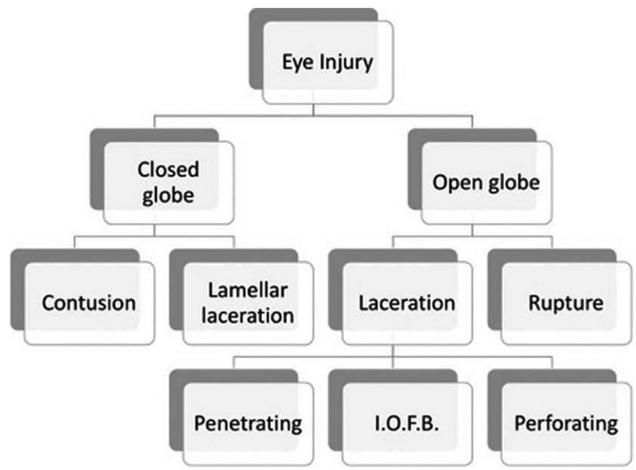

Figure 1: Birmingham eye trauma terminology system (BETTS).

optimal management.[12] This has been the single and most widely known ocular trauma prognosticating tool although, despite its simplicity, is not universally practiced or enforced by health-care institutions and required by health-care networks. It is unclear, however, from the original publication whether pediatric injuries were included in the data analysis leading to the OTS.

The Ocular Trauma Score

Raw scores calculated using Table 1 depending on presenting vision then score didected according clinical conditions as per Table 2. OTS was then matched to the same predicted outcomes using the same ranges as per OTS.[16]

The introduction of the BETT System (BETTS) in 2004 was the next major step in the assessment and categorization of various forms and consequences of mechanical ocular trauma,[5] thereby standardizing descriptions, management and assessing outcomes from various centers and also making it possible to understand and compare visual outcomes following medical and surgical management of closed- and open-globe injuries, respectively. While the most studied of ocular trauma consequence was traumatic cataract,[7] other consequences such as vitreous hemorrhage, endophthalmitis, and retinal detachment have been far less studied.[12]

Table 2: Computational method for deriving the OTS score.

Initial visual factor	Raw points
A. Initial raw score (based on initial visual acuity)	NPL=60 PL or HM=70 1/200–19/200=80 20/200 to 20/50=90≥20/40=100
B. Globe rupture	−23
C. Endophthalmitis	−17
D. Perforating injury	−14
E. Retinal detachment	−11
F. RAPD	−10

Raw score sum=sum of raw points. OTS: Ocular Trauma Score, RAPD: Relative afferent pupillary defect

VALIDATION OF OCULAR TRAUMA SCORE (TO BE COMBINED WITH THE TEXT BELOW OF THE REVIEW OF LITERATURE)

Perhaps, the greatest benefit of the OTS is its use as a reference point when auditing surgical results of cases due to mechanical trauma. It can provide useful pointers to guide service redesign in order to maximize outcomes. When managing ocular trauma sustained during the Afghanistan and Iraq wars, it became apparent that improved surgical provision and techniques were not improving outcomes from the worst injuries (shrapnel injuries). To counter this, the enforced use of combat eye protection reduced the incidence and severity of eye injuries significantly. In this case, the OTS was used to highlight the problem to policymakers in an irrefutable form to which they responded. Overall, it remains a useful system that allows communication between clinicians regardless of experience, specialties, and geographical location, enabling them to efficiently plan, manage, and monitor the full range of ocular injuries due to mechanical trauma.

Similar to the BETTS, the OTS model covers the description of both open- and closed-globe eye injuries. It is easy to use, as the six predictive factors (A to F) are readily assessed, and it can give realistic expectations of the visual potential of an open-globe injury.[15,20]

HIGHLIGHT AND EXPAND ON EACH OF THESE STUDIES BELOW TO SHOW VALIDATION OF OTS

OTS is validated in case of combat injuries and deadly weapons.[35]

Firecracker injuries, Penetrating injuries and intraocular foreign bodies[36-39] in patients with facial fractures[38] Traumatic cataracts in adults as well as in children.[22,23] Siderosis bulbi (and Forensic medicine by various authors.

Ocular trauma validated in various ethnic and geographical regions China[40] New Zealand,[41] Pakistan,[42] Turkey,[43] Afghanistan[44] Value and simplicity even among non-ophthalmologists.

OCULAR TRAUMA SCORE AND PEDIATRIC OCULAR TRAUMA SCORE

The OTS has been shown to be equally beneficial in pediatric ocular injuries. The value of the OTS for predicting visual outcomes following surgery in children with traumatic cataracts has been validated in several studies across the globe.[21,28]

A positive correlation was demonstrated even in the absence of documentation of RAPD in children.

Lesniak, *et al.*[19] reported no significant differences between the final visual acuities and the visual acuities predicted by OTS in children. Sharma proposed that the OTS calculated at the initial examination may be of prognostic value in children with penetrating eye injuries.[20]

Oiticica-Barbosa and Unver validated OTS in the pediatric population prospectively and found useful.[23]

Acar *et al.*[45] reported the validity of OTS in open-globe injuries in the pediatric population.[24,46-50]

The author published a report that OTS is a valid predictor for visual outcome in children following surgeries of 354 traumatic cataracts in children.[22]

Despite the reported benefits and value of OTS in children, there are several implications on their use in children. Some of these include inability to assess the presence and severity of RAPD and the potential development of amblyopia in younger children. Strabismus, refractive errors, or ocular opacity can result in amblyopia in children. If the possibility of amblyopia is not included in the score, then the predictive accuracy of OTS may be compromised. The authors have hence incorporated this into the OTS to derive a mathematical model for the Pediatric OTS (POTS). The aim of this study was to validate our proposed mathematical model and to compare the predictive value of POTS with OTS for assessment of outcome in children with traumatic cataract.[25,29]

There are very few reports comparing predicted and achieved visual acuities prospectively.

There are reports of validation of OTS in the pediatric age group with contradictory results. Many of them are retrospective studies and smaller sample size.[25,45-50]

Reports from India validated OTS with 787 cases of traumatic cataract.[20]

Two of the important factors in calculating the OTS, initial visual acuity and RAPD, are very difficult to obtain in a child after trauma, especially in the younger age group, rendering the OTS inaccurate even if possible. The value of the OTS in pediatric patients from the age of 2 years was assessed recently by two Turkish groups, but the conclusions reached by each were opposing, adding to the controversy.[24,25] A new POTS was published recently with the purpose of refining the prognostic accuracy in children where initial vision is not accurate.[24]

Similar to many other series in pediatric trauma, it lacks the statistical power of the OTS due to relatively small sample size and its predictive power remains untested.

Comparison of OTS and POTS has been done in an article by Shah *et al.* and found in POTS is more accurate in cases of children, comparison done using Area Under the Receiver Operating Characteristics (AUROC).[23]

Morgan *et al.* reported a comparison of OTS and POTS in case of open-globe injuries in children and found no superiority of any model.[28]

Zhu L reported a comparison of OTS and POTS in case of penetrating injuries and concluded POTS as a more robust model.[38]

Limitations of the OTS

There are drawbacks to using any simplified system. It does not include associated injuries that have a bearing on the outcome of the mechanical injury, such as chemical, electrical, and thermal ocular injuries, nor does it include significant facial and ocular adnexal injuries. It does not factor in results from ancillary tests including X-ray, computed tomography, or ultrasound "B" scans that inform the examination of the eye, especially where there is no view of the posterior segment. The clinician must interpret these other clinical and investigational findings to help refine the prognosis predicted by the OTS.

While the OTS has been extensively used and reportedly beneficial, there is a 1-in-5 chance that the score may be wrong, so its use to justify primary enucleation is hazardous. It is better to use the OTS as a guideline in order to make informed treatment decisions. Thesis especially trauma of the post-trauma patient with bare or no light perception and severe ocular injury. While in the years past such patients underwent primary ocular evisceration or enucleation, it has now been showed in several series that meticulous repair followed by additional procedures when indicated may salvage some of these eyes – structurally (globe preservation) and functionally (vision restoration).

Additional uses of the OTS

Other predictive models such as the Classification and Regression Tree (CART) have also been proposed for predicting the visual outcome based on an initial examination (2007). The regression tree analysis has also been tried, albeit in smaller studies but has not yet been validated.

While the OTS has been more widely studied and used as it is dedicated to mechanical ocular injuries, the latter, although promising, as it includes factors related to ocular adnexal injuries, has not shown to be of great predictive value and thus much less commonly used. Moreover, the direct application of the OTS in children has also been a subject of debate with modifications proposed by various authors from around the world. Comparative studies for OTS and regression tree have been reported with more prognostic accuracy using OTs.[8,9,10] Schmidt *et al.* have reported excellent predictive model for open-globe injuries.[18]

More recently, the BAsic SEverity Score for Common OculaR Emergencies was reported by Bourges *et al.* Unlike previous scoring systems which were designed for mechanical ocular trauma, this study was based on a variety of ophthalmic emergencies (subconjunctival hemorrhage, post-operative endophthalmitis, and ocular trauma) where a group of ophthalmologists and researchers rated the severity of 86 common ocular emergencies using a Delphi consensus method. The ratings were attributed on a 7-point scale throughout a first-round survey. Then, the experts were provided with the median and quartiles of the ratings of each item to re-evaluate the severity levels being aware of the group's first-round responses. The final severity rating for each item corresponded to the median rating provided by the last Delphi round. Results, which is not very popular and not validated.[8]

COMPARATIVE STUDIES

Lima-Gomez Hans and Unver[23,24] reported estimates for a 6-month visual prognosis, but some of the variables required evaluation by an ophthalmologist.

Using the OTS, 98.9% of the eyes in the general population could be graded in a trauma room. Knyazer[30] reported the prognostic value of the OTS in Zone 3 open-globe injuries.

Mao *et al.* reported that OTS predictor is a useful tool.[46] Sobaci reported OTS relevance in deadly weapon-related open-globe injuries.[35] Meng and Hernández reported the relevance of OTS in open-globe injuries along with zone of injury.[40,47]

Page and du Toit also reported other than OTS presenting visual acuity which is an important predictor.[48,49]

There are few studies where OTS is validated with a particular situation such as IOFB and retinal detachment.

Yaşa reported the value of OTS in case of open-globe injuries with intraocular foreign bodies.[36]

Gervasio studied a combination of open-globe injuries and facial fractures.[39]

Ustaoglu *et al.* also reported the relevance of OTS along with presenting vision and zone of injury.[41,43,50]

Islam reported the relevance of OTS in case of open-globe injuries during combat.[42]

Yu Wai Man studied a comparison of various predicting models by comparing OTS and regression tree analyses. Both the OTS and CART had high predictive accuracy, but the OTS had higher prognostic accuracy and could be used in counseling patients and in management decision-making.[16,17,28,51]

One limitation of the study is that while POTS is more specific and sensitive in case of higher raw scores, it does not predict outcomes as accurately with lower raw scores. In such cases, the OTS can be utilized to give more accurate predictions of the outcome.[24]

Two of the important factors in calculating the OTS, initial visual acuity and RAPD, are very difficult to obtain in a child after trauma, especially in the younger age group, rendering the OTS inaccurate even if possible. The value of the OTS in pediatric patients from the age of 2 years was assessed recently by two Turkish groups, but the conclusions reached by each were opposing, adding to the controversy.[25,26]

The review addresses the validity and applicability of OTS POTS and others but will be important to stratify which have OTS has greater applicability in the general population and POTS have limited applicability, which needs to be improved. We should develop an ideal ocular (+ adnexal) trauma scoring system which we should be working together on a global basis and be validated.

Despite it being proposed several decades ago, till date, the OTS is good and accurate predictive model may be used to predict visual outcome in all types of mechanical eye injuries.

OTS also has good predictive value in case of the pediatric age group, but POTS is better for this purpose for higher scores. OTS may be used for lower score value.

Craig Hospital Score may be used for ocular movements.

Other models also provide accurate predictive information but less user-friendly.

SUMMARY

OTS is good and accurate predictive model may be used to predict visual outcome in all types of mechanical eye injuries. Value and adoption to the model is beyond doubt.

OTS also has good predictive value in case of the pediatric age group, but POTS is better for this purpose. Early assessment, life stabilization, early primary intervention by dedicated trained teams, subsequent additional intervention as indicated.

CONCLUSION

All regions of the world and all nations with both low- and high-volume traumas will be advised to have dedicated ophthalmic trauma centers of excellence with integrated ophthalmic trauma units, have dedicated ophthalmic trauma teams, and routinely adopt the current standard of OTS guidance, which are to be developed by the International Trauma Registry like I GATES study and participate in it to develop ideal scoring system.[26]

Other models also provide accurate predictive information but less user-friendly.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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How to cite this article: Shah M, Sundar G, Shah S. Ocular Trauma Score revisited – Making sense of it all. Lat Am J Ophthalmol 2019;2:4.