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Ocular Trauma Scores in paediatric open globe injuries

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ABSTRACT

Background/aims To assess the predictive value and the applicability of Ocular Trauma Score (OTS) for paediatric injuries.

Methods Retrospective case series of 71 open globe injuries in children less than 18 years of age with a minimum follow-up period of 1 year. The variables of the OTS, the Paediatric Penetrating OTS (POTS), lens injuries and anterior versus posterior segment injuries were analysed for their predictive values in terms of visual outcome. The applicability and the predictive values of OTS and POTS as a whole were then evaluated.

Results Initial visual acuities, retinal detachments, wound locations ($p < 0.001$ each), lens injuries ($p = 0.001$), posterior segment injuries ($p = 0.002$), traumatic cataracts ($p = 0.010$), hyphaema ($p = 0.011$) and vitreous haemorrhages ($p = 0.026$) had significant impacts on visual outcome. The application of OTS proved difficult, as the presence of a mild degree of a relative afferent pupillary defect (RAPD) could not accurately be evaluated in all of our patients. Calculating the OTS without evaluation of RAPD renders it easily applicable for the initial examinations while remaining significantly prognostic ($p < 0.001$). The predictions of the POTS correlated with the actual final visual acuities ($p < 0.001$), but several POTS variables (ie, iris prolapse, age, organic injuries and delay of surgery > 48 h) had only limited impacts on visual outcome.

Conclusions The OTS has a high predictive value for visual outcome after open globe injuries in children, even without evaluation of RAPD.

INTRODUCTION

Of all ocular injuries, 22%–52% are estimated to occur in children^{1 2} and are a major cause of monocular blindness in this age group.³ To guarantee unambiguous communication regarding ocular injuries, the Birmingham Eye Trauma Terminology⁴ has been established. This terminology defines open globe injuries as ocular trauma with at least one full-thickness wound of the eye wall (cornea or sclera). Four subgroups allow precise distinction: (1) penetrating injuries have at least one entrance wound, but no exit wound (figure 1); (2) intraocular foreign body injuries are penetrating injuries in which a foreign body remains inside the globe; (3) perforating injuries have both an entrance and an exit wound; and (4) ruptures are contusions in which the eye wall yields at its weakest point.

Prognoses for open globe injuries have improved tremendously in the last decades.^{1 5} Modern surgical techniques and anti-infective treatment now facilitate good final visual acuities of 20/40 or

better for 56% of children and 49% of adults with serious eye injuries according to the United States Eye Injury Registry.⁵ Of those individuals affected, only 9% of children and 14% of adults end up with no light perception (NLP) after the injury.⁵

The Ocular Trauma Score (OTS) (table 1) is a tool for the prediction of visual outcomes after ocular trauma and is based on over 2500 patient records from the United States Eye Injury Registry.⁶ Both children and adults are registered in this database. The prognostic value of the OTS for injuries in adults is widely recognised. However, the applicability of the OTS for injuries in children has recently come under discussion. Some investigations attest a good predictive value,^{7–10} whereas others report limitations.^{11 12} Unver *et al.*,¹¹ in a retrospective analysis, report significantly lower NLP and 20/200 to 20/50 ratios and significantly higher light perception (LP) to hand movements (HM) ratios in their patient collective compared with OTS predictions. Additionally, the parameter relative afferent pupillary defect (RAPD) could not be evaluated in several cases. The authors declare that their case series was rather small and demand further investigations. Acar *et al.*¹² could not calculate the OTS for their patients, as they could not evaluate the RAPD in most cases. Thus, they established a separate score for paediatric ocular trauma, the Paediatric Penetrating OTS (POTS, table 2). This score is based on data from penetrating open globe injuries in children ranging in age from 0 to 15 years. Five POTS groups have been delineated (see table 2) to characterise injury severity.

It is not yet clear if the POTS can be applied for all types of open globe injuries, including ruptures, perforations and intraocular foreign body injuries.⁴



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Figure 1 Metallic foreign body on the surface of the lens.

Table 1 The OTS—calculation and probability of visual outcome

Calculation of the OTS						
Initial visual factor		Raw points				
A. Initial visual acuity category		NLP=60 LP to HM=70 1/200 to 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. Afferent pupillary defect		-10				
Probability of visual outcome						
Raw score sum	OTS-Score category	NLP (%)	LP/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

HM, hand movements; LP, light perception; NLP, no light perception; OTS, Ocular Trauma Score.

Thus far, an evaluation of the POTS has not been undertaken, with the exception of a comment that proposes a comparison of the OTS and the POTS.¹³

Table 2 The Paediatric Penetrating Ocular Trauma Score: 5-50 raw points are assigned to each parameter and added up to define five prognostic groups: Group 1 (≤45 points), Group 2 (46-64 points), Group 3 (65-79 points), Group 4 (80-89 points) and Group 5 (90-100 points)

Variables	Raw points
Initial visual acuity	
NLP	10
LP/HM	20
CF	30
0.1-0.5	40
0.6-1.0	50
Age	
0-5	10
6-10	15
11-15	25
Wound location	
Zone I	25
Zone II	15
Zone III	10
Concomitant eye pathologies	
Iris prolapse	-5
Hyphaema	-5
Organic/unclean injury	-5
Delay of surgery >48 h	-5
Traumatic cataract	-10
Vitreous haemorrhage	-20
Retinal detachment	-20
Endophthalmitis	-30

0.1≅20/200; 0.5≅20/40; 0.6≅20/33; 1.0≅20/20.

CF, counting fingers; HM, hand movements; LP, light perception; NLP, no light perception.

In this paper, we evaluate the applicability and predictive value of both of these scores for open globe injuries in children.

METHODS

This analysis was performed according to the Declaration of Helsinki and has been approved by the Ethical Committee of the Medical University of Graz.

Children with open globe injuries operated upon in the Department of Ophthalmology of the Medical University of Graz were identified via searching the computerised institutional database and the archives. For our retrospective study, we analysed the medical records of all 104 children who were operated upon between 1 September 1992 and 31 July 2011. Children were defined as individuals younger than 18 years of age in accordance with the United Nations Committee on the Rights of the Child. Injuries were classified in accordance with the Birmingham Eye Trauma Terminology System⁴ and the Ocular Trauma Classification Group.¹⁴

Patients were excluded (n=33) if no initial visual acuity or no follow-up of at least 1 year was available or if they underwent primary surgery in other hospitals.

The OTS and POTS parameters analysed for their impacts on visual outcome included initial visual acuity, globe rupture, endophthalmitis, perforation of the globe, retinal detachment, age, wound location (I=cornea, II=anterior 5 mm of the sclera, III=posterior to zone II, as defined by the Ocular Trauma Classification Group¹⁴), iris prolapse, hyphaema, organic injury object, delay of surgery >48 h, traumatic cataract and vitreous haemorrhage. All POTS and OTS parameters were routinely assessed, except for the RAPD. The presence or absence of light reaction was recorded for most of the patients, whereas the presence of a mild degree of a RAPD could not be evaluated in the majority of our patients. In addition to the pre-existing score parameters, lens injuries and posterior versus anterior segment injuries were included in the analysis. The influences of all of these parameters on final visual acuity were explored using non-parametric methods (the Mann-Whitney U-test and the Kruskal-Wallis test).

The initial and final visual acuities were categorised into five groups based on either the OTS (1=NLP, 2=LP to HM, 3=1/200 to 19/200, 4=20/200 to 20/50, 5=≥20/40) or the POTS (1=NLP, 2=LP/HM, 3=counting fingers, 4=0.1 to 0.5, 5=0.6 to 1.0). For comparison of initial and final visual acuity scores, the Wilcoxon rank-sum test was used.

The applicability of the OTS and the POTS as a whole was assessed. Additionally, a modification of the OTS that was calculated without the inclusion of the RAPD was evaluated. As a consequence, at maximum, a possible change of one score category could occur. The POTS was calculated and evaluated both for the age group for which it was originally designed (0-15) and for our entire patient collective (0-17). The χ^2 test and Spearman's rank correlation coefficients were used to evaluate the predictive values of the OTS and POTS. A p value of <0.05 was used to indicate statistical significance. All p values are regarded in an explorative sense. Normally distributed parameters are reported as the means and SDs. The statistical analysis was performed using the statistical software SPSS V20 (SPSS Inc., Chicago, Illinois, USA).

RESULTS

Of the 104 children with open globe injuries, the initial and final visual acuities were available for 71 children (55 (77.5%) boys and 16 (22.5%) girls), with a mean patient age of

10.3 years (SD±4.7). The median follow-up was 36 months (range 12–204 months).

The median OTS category of visual acuity was 1/200 to 19/200 at the initial examination and improved to ≥20/40 at the last individual follow-up (tables 3 and 4, $p<0.001$). In total, 56 (78.9%) children recovered to a better category of vision or remained in the best category, 12 (16.9%) remained unchanged and 3 (4.2%) deteriorated.

Analysis of the OTS score parameters indicated that initial visual acuity (as defined by the OTS, table 3) and retinal detachment predicted worse visual outcomes ($p<0.001$). Furthermore, the parameters globe rupture, endophthalmitis and globe perforation were associated with lower median categories of final visual acuity (table 3).

POTS parameter analysis indicated that initial visual acuity (as defined by POTS, table 3), wound location, retinal detachment, hyphaema, traumatic cataract and vitreous haemorrhage were significantly associated with worse visual outcomes. For iris prolapse, we observed a marginal significance ($p=0.058$). In 70.3% of the children without and 53.1% of those with an iris prolapse, a good visual acuity (highest category of final visual acuity) was achieved. The other parameters (age, organic/unclean and delay of surgery) were not significantly predictive of outcome. Additionally, lens injuries and injuries of the posterior segment (parameters that were not included in the OTS and POTS scores) were significantly linked with worse visual outcomes ($p<0.001$).

Regarding the predictive value of the scores as a whole, the adapted OTS without RAPD had a high predictive value (Spearman's correlation: $r=0.60$, $p<0.001$). The percentages of final visual acuities predicted by the original OTS were comparable with the outcomes measured in our patient collective. No significant differences were noted between observed and predicted frequencies in any visual acuity category ($p<0.05$, table 4).

The POTS as a whole significantly correlated with visual outcome for children in the age range of 0 to 15 years (the age group for which it is originally designed, Spearman's correlation: $r=0.54$, $p<0.001$) and for our 0–17-year-old patients (Spearman's correlation: $r=0.56$, $p<0.001$, table 4). However, the predictive value of the first two score groups was low (table 4).

DISCUSSION

Open globe injuries range among the most severe eye injuries,^{9 12} but their prognoses are very heterogeneous and depend on certain injury characteristics.

The clinical findings that are predictive for worse visual outcome are similar when paediatric open globe injuries are compared with investigations including adults: initial visual acuity,^{10 15–18} retinal detachment,^{8 15–17 19} posterior wound location,^{8 15 18–20} globe rupture,^{1 8 15 17 18 20} endophthalmitis,^{15 17 19 21 22} globe perforation,^{17 18 21} hyphaema¹⁵ and injuries of the posterior segment.²³ Lens injuries or traumatic cataracts are prognostic in several studies^{17 18 24} but are not prognostic in others.^{19 21} There are also different findings for the prognostic value of vitreous haemorrhage: some authors report a prognostic value^{8 17–20} while others do not.¹⁵ There are various statements about the prognostic relevance of young age. Some authors report a worse outcome in children <5 years of age^{8 25} while others do not.¹⁹ In our study, there was no difference between younger and older children, but we admit that our patient collective is too small to reach clarity concerning to what extent amblyopia influences visual outcome in young

children with open globe injuries. A large case series with a homogenous occlusion protocol would be necessary to further explore this question.

Table 3 Predictive value of the evaluated parameters

	N	Per cent	Median FVA	p Value
OTS—Score parameter*				
IVA, n=71				
NLP	4	5.6	1	<0.001
LP to HM	21	29.6	4	
1/200 to 19/200	13	18.3	5	
20/200 to 20/50	16	22.5	5	
≥20/40	17	23.9	5	
Globe rupture, n=71				
No	67	94.4	5	–
Yes	4	5.6	2.5	
Endophthalmitis, n=71				
No	69	97.2	5	–
Yes	2	2.8	3	
Perforating injury, n=71				
No	69	97.2	5	–
Yes	2	2.8	2.5	
Retinal detachment, n=69				
No	58	84.1	5	<0.001
Yes	11	15.9	2	
POTS—Score parameter†				
IVA, n=71				
NLP	4	5.6	1	<0.001
LP to HM	21	29.6	4	
Counting fingers	13	18.3	4	
0.1–0.5	21	29.6	5	
0.6–1.0	12	16.9	5	
Age, n=71				
0–5	13	18.3	4	0.590
6–10	24	33.8	5	
>10	34	47.9	5	
Wound location, n=71				
Zone I	41	57.7	5	0.001
Zone II	10	14.1	5	
Zone III	20	28.2	3.5	
Concomitant pathologies‡				
Iris prolapse, n=69				
No	37	53.6	5	0.058
Yes	32	46.4	5	
Hyphaema, n=66				
No	41	62.1	5	0.011
Yes	25	37.9	4	
Organic/unclean, n=60				
No	42	70	5	0.475
Yes	18	30	5	
Delay of surgery >48 h, n=69				
No	61	88.4	5	0.102
Yes	8	11.6	5	
Traumatic cataract, n=69				
No	46	66.7	5	0.010
Yes	23	33.3	4	
Vitreous haemorrhage, n=67				
No	54	80.6	5	0.026
Yes	13	19.4	4	

Continued

Table 3 Continued

	N	Per cent	Median FVA	p Value
Further parameters*				
Lens injury, n=69				
No	38	55.1	5	0.001
Yes	31	44.9	4	
Segment, n=71				
Posterior	28	39.4	4	0.002
Anterior	43	60.6	5	

*OTS groups of median FVA: 1=NLP; 2=LP/HM; 3=1/200 to 19/200; 4=20/200 to 20/50; 5=>20/40.

†POTS groups of median FVA: 1=NLP; 2=LP/HM; 3=counting fingers; 4=0.1–0.5; 5=>0.6.

FVA, final visual acuity; HM, hand movements; IVA, initial visual acuity; LP, light perception; NLP, no light perception; OTS, Ocular Trauma Score; POTS, Paediatric Penetrating OTS.

As far as the pre-existing scoring systems are concerned, their applicability is limited in open globe injuries in children.

As a whole, POTS is significantly predictive. Apart from initial visual acuity, its constituting variables can easily be assessed during either the initial examination or surgery under general anaesthesia. However, we can attest to the weakness of prognostic power among single score parameters, as the four parameters, age (0–5, 6–10, >10), iris prolapse, organic injuries and delay of surgery >48 h, are not significantly linked with final visual acuity among our patients.

Additionally, the predictive value of the score categories 1 and 2 is low. In all, 10 of 19 children (53%) who were classified as score Group 1 and 16 of 19 children (84%) classified as Group 2 ended up with final visual acuity scores in the best two groups of visual acuity (table 4). In contrast, only one child (20%) classified as an OTS category 1 had a final visual acuity of 20/200 or better, whereas four out of five (80%) children in this category ended up with visual outcomes of HM or worse (table 4).

Another advantage of the OTS is that it only requires six parameters, in contrast to the POTS, where calculations

incorporating 11 parameters are necessary. All of these parameters (except for the RAPD, which we could not accurately evaluate) had impacts on the final visual acuity scores among our children. Initial visual acuity and retinal detachment were significantly predictive. The pathologies of globe rupture, perforation and endophthalmitis occurred too seldom to be suitable for statistical testing of significance, but the median final visual acuities of patients with these pathologies were 2 and 2.5 categories worse (table 3).

Injured children might show too poor compliance for an accurate determination of a mild degree of a RAPD, and bilateral injuries pose additional challenges.^{9 11 12} Considering the pharmacological effects of analgesics on the pupils, evaluations under general anaesthesia are often impossible. The inclusion of RAPD would have resulted in a lower predicted visual acuity in some cases. Hence, our results suggest that final visual acuity in our patients might be slightly better than would have been predicted by the original OTS. However, as shown above, the presence or absence of the RAPD can produce no more difference than one OTS score category. Calculating an adapted version of the OTS without the RAPD renders easier applicability while remaining highly prognostic.

Our results indicate that the OTS is a reliable prognostic tool for paediatric open globe injuries, even if the RAPD cannot be evaluated precisely.

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Table 4 Final visual acuity outcomes based on OTS and POTS

OTS	Final visual acuity category (OTS)					Total
	NLP	LP—HM	1/200–19/200	20/200–20/50	≥20/40	
1	3 (60%)	1 (20%)	0 (0%)	1 (20%)	0 (0%)	5
2	1 (16.7%)	1 (16.7%)	2 (33.3%)	1 (16.7%)	1 (16.7%)	6
3	1 (3.4%)	1 (3.4%)	2 (6.9%)	8 (27.6%)	17 (58.6%)	29
4	0 (0%)	0 (0%)	0 (0%)	3 (20%)	12 (80%)	15
5	0 (0%)	0 (0%)	0 (0%)	1 (6.2%)	15 (93.8%)	16
Total	5 (7%)	3 (4.2%)	4 (5.6%)	14 (19.7%)	45 (63.4%)	71
POTS group	Final visual acuity category (POTS)					Total
	NLP	LP—HM	CF	0.1–0.5	≥0.6	
1	5 (26.3%)	2 (10.5%)	2 (10.5%)	5 (26.3%)	5 (26.3%)	19
2	0 (0%)	1 (5.3%)	2 (10.5%)	5 (26.3%)	11 (57.9%)	19
3	0 (0%)	0 (0%)	0 (0%)	6 (33.3%)	12 (66.7%)	18
4	0 (0%)	0 (0%)	0 (0%)	0 (0%)	11 (100%)	11
5	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (100%)	4
Total	5 (7%)	3 (4.2%)	4 (5.6%)	16 (22.5%)	43 (60.6%)	71

CF, counting fingers; HM, hand movements; LP, light perception; NLP, no light perception; OTS, Ocular Trauma Score; POTS, Paediatric Penetrating OTS.

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