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ORIGINAL ARTICLE

Association between paediatric eye injuries, later academic success and social performance

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ABSTRACT

Aim To investigate an association between eye injury and later academic and social performance.

Methods A retrospective longitudinal study of taking measurements multiple times was conducted including all severe eye injuries admitted during 2011-2017 at the main regional clinic to investigate changes in academic success and social inclusion before and after an injury. Parents/caregivers were surveyed asking questions on academic performance, and community/social involvement. In 2023 data on employment status were obtained. Kappa (κ) and non-parametric Wilcoxon signed-rank test for multiple comparisons were used. For association of employment status and post-injury visual acuity Fisher score was tested.

Results The total sample for assessing social inclusion and academic success was 36 and 25 children, respectively. In the following academic year κ agreements decreased from 0.88 ($p<0.001$) comparing pre-injury with a one-year post to 0.5106 ($p<.0001$) in the second year and 0.4750 ($p=0.003$) in the third, suggesting a deteriorating trend. A comparison of academic success before injury to two and three years after injury showed the trend significantly worsening with time ($p=0.005$, and 0.003, respectively). No association between an eye injury and social inclusion, as well as between employment and final visual acuity was noticed.

Conclusion Our findings suggest no association between social inclusion, employment, and eye trauma, while in later years academic success may be more impacted by the eye injury. Due to eye injury unpredictability in childhood age, both an informed and supportive climate environment at home and school is essential to minimize deleterious responses to eye trauma.

Keywords: childhood trauma, ocular, academic achievement, social engagement

INTRODUCTION

Trauma is the event that includes physical, mental, sexual, and medical adverse events or violence in any natural or human-made setting (1). Severe paediatric injuries hold several times higher risk of residual functional impairment, observed in around 60% of hospitalized cases in the U.S. (2).

Eye injuries in children can occur during various recreational activities, or while doing chores at home or school where family control is reduced. Studies of detailed injury mechanisms indicate that even slight modifications to usual routines can increase children's injury risk, like wearing mother's shoes, which can cause stumbles and falls; helping whitewashing neighbour's house; falling on a sharp pencil, playing with a toy-gun or fireworks; and being bitten by domestic animals (3,4).

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The mean annual incidence of paediatric ocular injuries varies from 719 per 100,000 children in New Zealand (5); the prevalence of 15.6% in Australia (6), and 12.8% in India with tertiary level hospital treatment in 17.7% (7) cases was noticed. On average, 63,186 children were treated annually in the United States emergency departments for consumer product-related eye injuries (8). Hospital eye injury admittance rate in children varies from 12% in Australia (6) or from 12.5% to 33.7% in Croatia (9). In the United Kingdom, Barry et al. reported visual acuity less than 6/60 with an incidence of 0.19 per 100,000 in children aged 16 years or less requiring inpatient or day-case admission (10).

Periods of visual impairment are likely to result in missed school and inability to engage in social activities. Consequences may include isolation from social groups and diminished ability to interact with peers. In addition to visual impairment, ocular injury, as a traumatic experience in general, can cause decreased concentration, memory problems, and impaired organizational abilities that reflect poorly on school performance and later academic success (11). However, in-depth analysis and literature on this topic are scarce. Publications usually investigate incidence, hospital admittance, risk factors, and visual prognosis (5,7,9). Further social, academic, or community impact of childhood eye trauma is limited in the current literature.

The aim of this study was to investigate the association between an eye injury and subsequent academic performance and social impact including later-adulthood employment to translate these findings into future interventions. Previous studies from Bosnia and Herzegovina lack in-depth publications on eye trauma implications in paediatric population.

PATIENTS AND METHODS

Patients and study design

A 12-year-long retrospective longitudinal study design of taking measurements multiple times was used to investigate changes in academic success and social inclusion before and after an eye injury, where an injury event was a hazardous risk factor. All patients (aged 0-18 years old) admitted at the Cantonal Hospital Zenica (the major trauma hospital of Zenica-Doboj Canton), between 2011 and 2017 due to any eye injury that required hospitalization were included. Eligibility criteria included all eye injury types and all injury intents, admitted for in-hospital treatment.

A total of 36 patients met the eligibility criteria. Patient demographic and clinical data were collected from the electronic Hospital Eye Injury Registry and as a part of previous study (2). Children's parents/caregivers were surveyed during 2018 and 2019. Details of the study and data collection were previously described in a study by Jovanovic et al. where retrospective case-crossover study was employed. Briefly, data were obtained three times: one case time point was at the time of injury, and two control time points one month before the injury, and a month before the survey using patients/caregivers surveying (2). The survey had three parts that included information about the patient, the injury, and questions on child's academic performance, level of community or social involvement, and social interaction level. The total response rate was 100%. Data distribution did not show differences based on the mode of data collection.

Exclusion criteria for statistical analysis on the academic success were: the case the parent could not objectively report, academic record from the diploma or graduation certificate due to any cause, and a patient (a child) was older than 18 years old in the second year of the follow up period without entering college, meaning that the academic path ended with high school.

In 2023, hospital electronic records for all 36 patients who met eligibility criteria were screened again for updates on employment data and employment type based either on their self-reported employment or health insurance-related data.

Patient consent was obtained from the caregivers or parents as part of hospital admittance informed consent.

The protocol was reviewed and approved by the Institutional Review Board of the Cantonal Hospital Zenica on 31 March 2016 (20/1-2-3081/8) being compliant with the Helsinki Declaration.

Methods

In all patients, age and clinical parameters (injury zone and final visual acuity on discharge) were assessed. Age was binned into three categories 0-6, 7-12, and 13-18 years. Injury Zone was classified into I, II, and III according to the Birmingham Eye Trauma Terminology (12). The final visual acuity was first classified into five categories that were binned into three: the first less or equal to L+P+, the second 0.3/60-5.5/60, and the third category 6/60 and higher. For preverbal children, visual acuity could not be assessed and the missing data were marked. Final visual acuity can be used as a proxy measure for the injury severity. The survey asked the same questions for the time before an injury occurrence and academic success one year, two years, and three years after an injury occurred in the settings without an injury.

Parents were asked to find academic record books and read cumulative grades (GPE) at the end of each year as an objective measure of success.

The level of social inclusion questions were asked at the same time as academic success was evaluated, but for different timeframes, i.e. for the period just before the

injury occurrence, one month before the injury, and during the last month before the survey was conducted. In order to obtain parents' objective stance on child's socialization level they were asked if the child was equally socialized before and after the injury, and if the child was less or more socialized. To avoid recall bias, parents were asked to name specific social activities before and after the injury, such as hobbies, sports, extra-curricular activities, spending time outside with friends, and volunteering in the community. All answers were recorded as "yes" or "no". Employment data were recorded as categorical yes/no data, and for this analysis, final visual acuity was coded and binned into two categories: good (0.1 and more), and poor (5.5/60 and less).

Statistical analysis

To compare events before and after the injury the Kappa (κ) (using individual information, measuring agreement proportion) and non-parametric Wilcoxon signed-rank test (using the mean, to test differences between two related groups) were used. Kappa ranges from -1 to +1, where 0 represents the random chance agreement and 1 represents a perfect agreement. Kappa is compared to percent agreement. The level of agreement increases with percentage, where less than 0 represents less than the chance agreement, 0.01-0.20 (0-4%) slight agreement; 0.21-0.40 (4-15%) fair agreement; 0.41-0.60 (15-35%) moderate agreement; 0.61-0.80 (35-63%) substantial agreement; and 0.81-0.99 (64-90%) an almost perfect agreement (13). Wilcoxon's signed-rank test shows three comparisons. As the number of comparison in this study was three, we used Bonferroni adjustment to control family-wise error rate, which resulted in the critical value $\alpha=0.05/3= 0.017$ (divided three times). The association between employment status and final visual acuity was obtained using the Fisher score test.

RESULTS

Out of the total sample size of 36 children, 25 were assessed for academic success as they were of school age at the time of injury, while 36 were evaluated for social inclusion.

Of 25 children assessed for academic success, eleven (44%) were between 7 and 12, and 14 (56%) were between 13 and 18 years old. Eye injury locations according to ophthalmology categorizations were Zone I in 14 (56%), Zone II in 7 (28%), and Zone III in 4 (16%) cases. In 22 (88%) children the final visual acuity was equal to or better than 6/60, in two (8%) it was ranged between 0.3/60 and 5.5/60, and one (4%) had only light perception and light projection or lower.

Over the three years of the academic success reporting, children aged ≥8 were excluded from the analysis, resulting in 24 children after the first, 23 after the second, and 19 after the third year of follow up. Two-thirds, 15 (65.2%) and 11 (57.8%) of the patients had no change ("the same") in their academic performance at two- and three years' post-injury, respectively. Seven (30.4%) and eight (42%) children had decreased ("worse") academic performance at two- and three years' post-injury, respectively, while one (4.3%) and zero patients had improved ("better") performance, respectively. In total, academic performance decreased in two (8.3%), seven (30.4%), and eight (42%) cases at one, two, and three years after the injury, respectively (Table 1).

The kappa agreement was decreased indicating a significant decline: in the following academic year kappa agreements decreased from 0.88 ($p<0.001$) comparing pre-injury with one-year post-injury to 0.5106 ($p<.0001$) in the second year and 0.4750 ($p=0.003$) in the third, indicating the deteriorating trend of academic success with subsequent years (Table 2).

No association between final visual acuity and academic success following all the follow-up years was found. Among 25 children, only 19 were included in the Wilcoxon signed-rank test because six children ended formal education period during the four years of the study period. Among these 19 children, no significant difference between academic success before the injury event and one-year following the event was detected ($p=0.079$). Comparing academic success before the injury to two years and three years after the injury, significant difference was found, being less than the assigned alpha=0.017 ($0.005706<0.017$, and $0.003328< 0.017$, respectively). This suggests that the difference between academic success before the injury and two years after the injury, as well as before the injury and three years after the injury was significant, showing a worsening trend in the frequency.

The total sample size for assessing social inclusion was 36 children at the time of injury. One child did not have data on the measured parameter to test if the eye injury affected the child's social inclusion, and 35 children were analysed, both school and non-school-age (Table 2).

Questions about social engagement were asked at the same time as academic success was evaluated, but for different timeframes, i.e., for the last month of the present time when the survey was conducted, seven (19%) of children's parents reported that they were less included in social activities compared to the time before the injury. Older children tended to stay included and active compared to younger children. A significant association only between final visual acuity and level of social inclusion after the injury was found, while age and injury zone showed no association.

When comparing inclusion and activity after the injury vs. before the injury, moderate agreement between different timeframes was found suggesting no association between eye injury and social inclusion ($\kappa=0.5455$; $p<0.0001$).

Comparing social inclusion before the injury to after the injury, at the injury to after the injury, and before the injury to the moment of the injury, no significant difference between the levels of social inclusion were found (using the Wilcoxon signed-rank test the two comparisons were tested with Bonferroni adjustment α=0.05/2=0.025).

In 2023, 24 patients were ≥18 years of age, and in total 23 patients had available data on their employment status. Fisher score did not show any association between unemployment status and final visual acuity (OR 0.2104, 95% CI: 0.003-4.87; p=0.25).

Table 1. Academic success changes of children and eye injury characteristics one, two, and three years post-injury

Academic success after an injury event	No (%) of patients in the group					
	Gender			Age (years)		
	Female	Male	p	7-12	13-18	p
After the 1st year*						0.482
Better	0	0	NA	0	0	
Same	6 (25)	16 (66.6)		11 (45.8)	11 (45.8)	
Worse	0 (0)	2 (8.33)		0 (0)	2 (8.33)	
Total	6 (25)	18 (75)		11 (45.8)	13 (54.2)	
After the 2nd year†						0.803
Better	0 (0)	1 (4.3)	0.716	0 (0)	1 (4.3)	
Same	5 (21.7)	10 (43.5)		6 (26.1)	9 (39.1)	
Worse	1 (4.3)	6 (26.1)		4 (17.4)	3 (13)	
Total	6 (26.1)	17 (73.9)		10 (43.5)	13 (56.5)	
After the 3rd year‡						0.657
Better	0 (0)	0 (0)	0.337	0 (0)	0 (0)	
Same	4 (21)	7 (36.8)		4 (21)	7 (36.8)	
Worse	1 (5.2)	7 (36.8)		4 (21)	4 (21)	
Total	5 (26.3)	14 (73.7)		8 (42.1)	11 (57.9)	

*Total number 24 (1 missing value); †Total number 23 (2 missing values); ‡Total number 19 (6 missing values)
NA, not applicable;

Table 2. Social inclusion changes of children eye and injury characteristics post-injury

Social inclusion after an injury event	No (%) of patients in the group								
	Age (years)			Injury Zone			Final Visual Acuity*		
	0-6	7-12	13-18	I	II	III	L+P+ or lower	0.3/60-5.5/60	6/60 or better
Included and active	0	1 (2.7)	2 (5.5)	2 (5.5)	1 (2.7)	0	0	1 (2.7)	2 (5.5)
Intermediate included and active	5 (13.8)	8 (22.2)	12 (33.3)	15 (41.6)	7 (19.4)	3 (8.3)	0	1 (2.7)	22 (61.1)
Non included and inactive	3 (8.3)	3 (8.3)	1 (2.7)	3 (8.3)	1 (2.7)	3 (8.3)	2 (5.5)	0	4 (11.1)
Total	8 (22.2)	12 (33.3)	15 (41.6)	20 (55.5)	9 (25)	6 (16.6)	2 (5.5)	2 (5.5)	28 (77.7)

*Total number 32 (3 missing values)

DISCUSSION

Previous studies showed that Attention Deficit Hyperactivity Disorder (ADHD) symptoms are associated with childhood trauma and injury occurrence, including penetrating eye injury (14, 15). Also, ADHD is a known risk factor for poor academic outcomes (15). Our results do not show a significant statistical difference in academic success between the time point before and after the eye injury, but frequency distribution showed a trend toward worsening academic success (worse academic success) with time (better academic success). Additionally, the kappa levels decreased in years following the injury (second and third year) from almost perfect to weak. Using a non-parametric test, the differences were significant between the time points before, in the second year, and in the third year after the injury where worsening of academic success was noted, suggesting that eye trauma may be associated with worsening academic success in time. However, to our knowledge, there are no previously published studies investigating the association between eye injury or trauma and academic performance.

Karaman et al. investigated the impacts of ocular trauma on mental health and children's and parents' quality of life (16) suggesting that eye trauma can be a risk for mental disorders that potentially may implicate academic performance. Weintraub et al. study looked at the Quality of Life (QOL) of retinoblastoma survival (17): retinoblastoma survivors usually have their eye(s) removed, which was not the case in any our patient. However, due to a limited number of studies reporting childhood eye injury data and visual acuity related to QQL, we compared Weintraub study that reported 63% of enucleation that can serve as a proxy for complete vision loss, and consequently lower QOL related to school among survivors and reduced emotional health among their parents compared to the age norms (17). The results of Weintraub et al. study differ from our results that showed no association between lower visual acuity and decreased academic success. However, a study from China (18) showed that students who had poor vision were more likely to perform better in mathematics compared to students with normal vision. Similarly, no association between amblyopia and employment in adulthood was reported (19), which converges with the results of our study showing no association between lower final visual acuity and later employment status in adulthood. Our data showed a moderate decrease in social inclusion following eye injury or trauma. In general, severe paediatric trauma, specifically penetrating injury, head injury, functional impairment at discharge and older age were associated with long-term functional impairment and decreased health-related quality of life (20).

Our study has several important limitations that may potentially decrease the generalizability of the results, with the small sample size being the most notable limitation. Recall bias is one of the major limitations of retrospective studies and could be problematic in the case of reporting the level of social inclusion; however, reporting for academic success was objective and based on the graduation records, which eliminated recall bias for this part of the study, and same as for the employment status. However, there are many contributing factors to high unemployment rates, which could impose differential bias. For social inclusion outcomes, although parents may recall well the year when the injury happened, it is possible that their memory was less accurate for the non-injury years, introducing possible outcome misclassification biases. Since the same questions were asked for three different time points (three years after the injury), the overreporting and underreporting were likely equally present in each of the time points. However, if under or over reporting was present, it was likely unintentional, thus introducing no differential misclassification bias that tends to underestimate the results of potential significance.

In conclusion, to our knowledge, this is the first published study to examine the association between eye trauma, academic success, social inclusion, and employment status related to visual outcome. Our findings suggest that a lack of association between social inclusion and eye trauma, as well as the association between eye injuries, does not lead to proximal decreases in academic success, but in later years, academic success may be more negatively impacted by eye injury. Childhood trauma can increase the risk of school failure, and unhealthy coping mechanisms may predispose a child to have a more or less severe response to trauma. For these reasons, identifying the association of eye injuries with social and school performance investigated in this study is the first necessary step in creating interventions like trauma-informed educational systems that support children with traumatic experiences yielding positive school performance and more successful academic.

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TRANSPARENCY DECLARATION

Competing interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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