


ORIGINAL RESEARCH

Globe trauma associated with falls at Australian tertiary centres

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Abstract

Objective: Falls frequently cause globe and adnexal trauma, particularly in the elderly. The morbidity decreases confidence, independence and quality of life. We aimed to improve the understanding of fall-related globe and adnexal trauma and the involvement of ophthalmology at two tertiary trauma centres.

Methods: A retrospective medical record review was conducted at Royal North Shore Hospital and Royal Prince Alfred Hospital of patients admitted with fall-related globe and/or adnexal trauma between January 2015 and December 2019. International Classification of Disease Tenth Revision codes were used to identify patients for inclusion. Medical records were reviewed to extract data on demographics, trauma, ocular examination and referrals to ophthalmology.

Results: From January 2015 to December 2019, 346 patients, 186 were female (54%) and median age 76 years (interquartile range 24 years), were admitted to Royal North Shore Hospital and Royal Prince Alfred Hospital with fall-related globe and/or adnexal trauma.

One hundred and twenty-five (36%) suffered globe trauma with 48 (14%) classified as severe. Patients over 65 years old had at least three risk factors contributing to falls. Alcohol and illicit substances were involved in 20% of falls and occurred predominantly in younger populations. There were significantly more patients with globe trauma if orbital/mid-facial fractures were present (55% *vs* 36%, $P < 0.001$).

Conclusion: Fall-related globe and adnexal trauma were more common in the elderly. Alcohol and illicit substances have a role in falls in younger populations. Thorough ocular assessment is required especially in mid-facial/orbital trauma to exclude globe trauma. Further, research is required to determine the effect of fall prevention strategies in preventing globe trauma.

Key words: *accident, adnexal trauma, elderly, fall, globe trauma, trauma.*

Introduction

Falls occur frequently in the elderly, greater than 30% of people aged over

Key findings

- Peak age of patients with fall-related globe and adnexal trauma was greater than 75 years.
- In younger populations, falls were most commonly associated with alcohol and illicit substances.
- Patients presenting with mid-facial or orbital fractures were more likely to have globe trauma.

65 years reported a fall in the preceding 12 months with 50% being recurrent fallers.¹ The elderly often have multiple risk factors predisposing them to falls, such as impaired cognition, polypharmacy, reduced balance and poor lower limb strength.^{1–4} Chronic diseases such as Parkinson's disease, ischaemic heart disease, chronic obstructive pulmonary disease and depression can further increase the risk of falls.^{1,3,5,6} In younger adults, falls are highly influenced by the consumption of alcohol and illicit substances,⁷ as they increase the likelihood of risk-taking behaviours and accidents.^{8,9} Pre-ambulant children can also be at greater risk of falls while developing their coordination and strength.^{10,11}

The risk of trauma is increased in the elderly due to the frequency of falls and underlying comorbidities.^{1,2} Ten percent of falls in the elderly cause serious trauma, such as fractures, head and globe injuries.^{1,3,12} In elderly populations, falls are one of the greatest causes of globe and adnexal trauma,^{4,13} and a frequent cause of unilateral blindness.¹⁴ If the fall does

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Accepted 3 August 2023

not cause injury, the psychosocial impact from loss of confidence often leads to decreasing activity, independence and quality of life.^{1,2,5,6,12} Moreover, elderly patients with globe trauma are at risk of nursing home admission and institutionalisation.³

Lee *et al.* conducted a 10-year review of globe trauma associated with falls from standing-height in the elderly at a trauma centre in Melbourne, Victoria, Australia.¹⁵ Apart from the present study, there has been minimal research into specific fall-related globe and/or adnexal trauma across all age groups and in other locations in Australia.

To investigate the epidemiology and aetiology of globe and adnexal trauma caused by falls across all age groups, we performed a retrospective case series at two tertiary referral hospitals in Sydney, New South Wales (NSW), Australia. In addition, we aimed to determine the ophthalmology input in the acute assessment of these patients.

Methods

A retrospective medical record review was conducted of patients with fall-related globe and/or adnexal trauma from two tertiary hospitals, Royal North Shore Hospital (RNSH) and Royal Prince Alfred Hospital (RPAH), in Sydney, NSW, Australia, between January 2015 and December 2019. The catchment for these hospitals included metropolitan Sydney, central and northern regional NSW.

Using the International Classification of Disease Tenth Revision codes, hospital diagnostic and procedural coding data were searched to identify patients (Appendix S1). Inclusion criteria were patients admitted to either hospital after suffering globe and/or adnexal trauma resulting from a fall. Globe trauma was defined as an injury to the globe or optic nerve and adnexal trauma as injury to the orbital contents, orbit, eyelids and surrounding soft tissue.¹⁶ Patients were classified by age with children aged 18 years and below, adults above 18 years and the elderly over 65 years. Patients with a mechanism of injury aside from falls and elective admissions bypassing emergency were excluded.

Medical records were reviewed to confirm fall-related globe and/or adnexal trauma, and to extract demographic data, risk factors for falls, ocular examination and specialist ophthalmology referral. The medical record review was conducted by a single abstractor who was not blinded to the study aims and used a standardised abstraction form.

Ocular examinations were classified as 'no examination' if no ocular examination was documented, a 'gross examination' if there was a short description of the appearance of the globe and periorbital area, while a 'thorough examination' included documentation of the visual acuity, extra ocular movements, pupils, and anterior segment examination. An 'unwitnessed fall' was defined as a fall that occurred without being seen by others. The length of time before patients were found following the fall was recorded and the term 'long lie' was used if patients were found at least 2 hours after the fall.¹⁷

A high-energy mechanism of injury was defined as a mechanism that resulted in a large amount of kinetic energy being transferred to the patient such as fall down a flight of stairs. A low-energy mechanism of injury was defined as a mechanism that caused a small amount of kinetic energy being transferred to the patient such as fall from standing-height.¹⁸

Patients' injuries were classified using the Globe and Adnexal Trauma Terminology Survey.¹⁹ Internal globe injuries, lamellar lacerations to the eye, open globe injuries (OGIs) and injuries to the optic nerve were further classified as severe globe injuries, due to the increased risk of vision loss from these injuries.^{20,21}

Multisystem trauma was defined as injury to two or more areas of the body.²² The severity of the multisystem trauma was classified by retrieval services and emergency staff according to the accident and subsequent injuries.^{22,23} At RNSH and RPAH, trauma presentations meeting criteria, such as fall from greater than 5 m, penetrating injuries and spinal cord injury, activated a trauma call which mobilised a multidisciplinary team to provide emergent management.²²

Statistical analysis

Statistical analysis was performed using Jamovi software, Version 1.6^{24,25} (Jamovi, Sydney, NSW, Australia). Descriptive analysis of the data was used to describe continuous data utilising mean (standard deviation [SD]) or median (interquartile range) dependent on the distribution of the data. The categorical data were reported using counts and proportions and compared with χ^2 -tests.

Results

A search of the medical records at RNSH and RPAH using International Classification of Disease codes yielded 890 patients. All duplicates were removed and patients with no globe or adnexal trauma, elective admissions and patients who sustained trauma from another mechanism of injury other than falls were excluded (Fig. 1). Three hundred and forty-six patients were admitted to RNSH and RPAH with globe and/or adnexal trauma resulting from a fall between January 2015 and December 2019 (Table 1).

Demographics

The mean age of patients was 70 years (SD 21 years), with a range of 3 months to 101 years, and the majority of patients ($n = 186$, 54%) were female. Two hundred and fifty-two (73%) patients were aged over 65 years, with the highest number of patients being greater than 75 years (Fig. 2).

Three hundred and eight (89%) patients initially presented to either RNSH or RPAH, 38 (11%) were transferred from other hospitals. The reasons for transfer from other hospitals included facial burn, multisystem trauma and ophthalmology referral for severe globe trauma.

One hundred and six (30%) patients sustained multisystem injury.

Data on the injury

One hundred and ninety-four (56%) patients had had a fall within the home, such as tripping on carpet, stairs, uneven floors or cords. There were 41 unwitnessed falls and of these

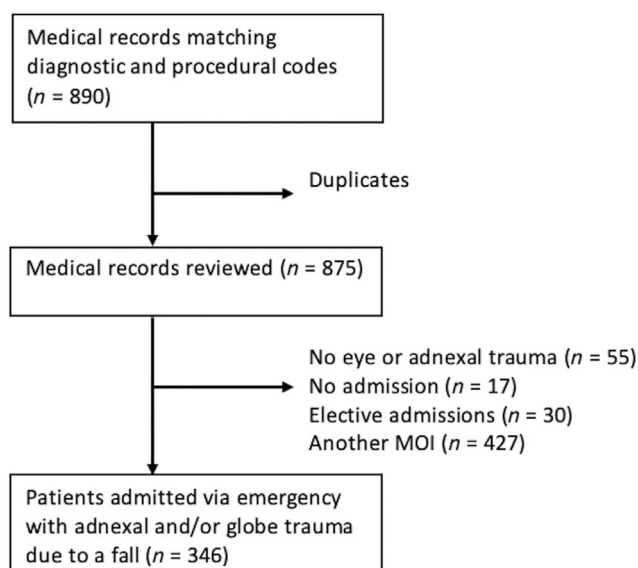


Figure 1. Patients with globe and adnexal trauma examined according to the inclusion and exclusion criteria to determine patients with fall-related globe and adnexal trauma. MOI, mechanism of injury (n = 346).

TABLE 1. Demographic data of patients admitted with adnexal and/or globe trauma due to a fall (n = 346)

Characteristics	
Mean age [range]	70 ± 21 years [3 months to 101 years]
Sex (mean age)	Male 160 (67 ± 22 years) Female 186 (73 ± 20 years)
Age categories (years), n (%)	
0–10	3 (1%)
11–18	4 (1%)
19–35	26 (8%)
36–65	61 (18%)
66–85	164 (47%)
86–105	88 (25%)
Side of injury, n (%)	
Left	168 (49%)
Right	158 (46%)
Bilateral	20 (5%)
Initial hospital of presentation, n (%)	
RNSH	175 (51%)
RPAH	133 (38%)
Metropolitan hospital	27 (8%)
Rural hospital	8 (2%)
Other tertiary hospital	3 (1%)
Alcohol or illicit drugs, n (%)	70 (20%)

RNSH, Royal North Shore Hospital; RPAH, Royal Prince Alfred Hospital.

patients, 13 had no memory of the fall due to illness and/or cognitive impairment. Ten (3%) patients had a ‘long lie’ after the fall, with one patient lying on the floor for 2 days before being found. The ‘long lie’ patients lived alone were elderly and had numerous comorbidities.

The most common risk factor for a fall was age over 65 years. Multiple risk factors for falls were present in patients, with all elderly patients having at least three risk factors contributing to their fall. Polypharmacy and chronic disease were other common risk factors (Table 2). Twelve falls were due to syncope secondary to postural hypotension, arrhythmias or recent change in medication. Most of the patients under the age of 65 years did not have a pre-existing risk factor for falls, apart from five patients who suffered from chronic alcohol abuse.

Alcohol and illicit substances were involved in 20% of falls, predominantly in younger populations. The mean age of patients admitted with an alcohol-related fall was 56 years (range 15–86 years), illicit substance-related falls was 50 years (range 42–57 years) and for both alcohol and illicit substance 40 years (range 22–57 years). Alcohol-related falls mostly occurred at home (n = 29, 41%) or while walking from a local restaurant or licenced venue (n = 24, 34%).

Adnexal trauma

The most common adnexal injury was periorbital haematoma which occurred in 336 (97%) patients. Mid-facial/orbital fractures occurred in 110 (32%) patients with the following associations; falls from a standing-height (11%) when the point of impact was directly to the mid-facial area; and high-energy injuries such as fall from greater than 2 m (4%) or falling down stairs (4%). Sixty-one (55%) patients with mid-facial/orbital fractures had globe trauma and 25 (23%) were classified as severe globe trauma. Table 3 details the data on the globe and adnexal trauma.

Globe trauma

One hundred and twenty-five (36%) patients suffered globe trauma with

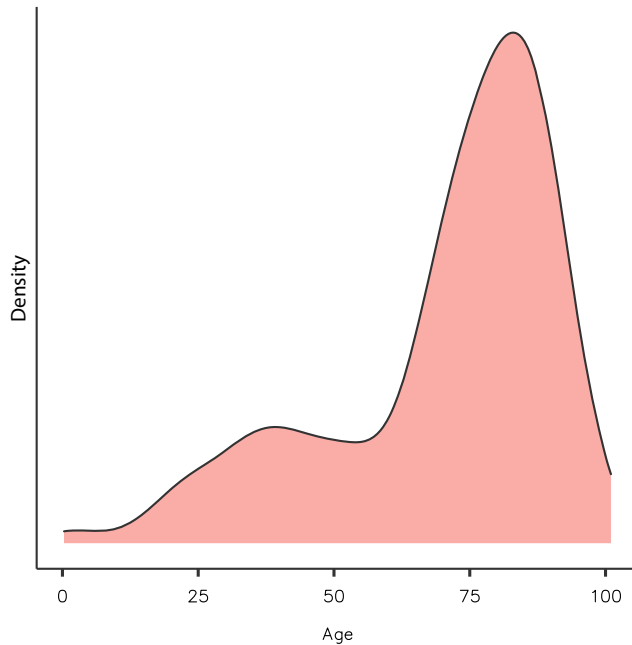


Figure 2. Distribution of age of patients with globe and/or adnexal trauma from a fall ($n = 346$, median 76 years, interquartile range 24 years).

TABLE 2. Intrinsic associations with falls in patients with globe and/or adnexal trauma ($n = 346$)

Intrinsic associations	n (%)
Age >65 years	252 (73)
Chronic disease	165 (48)
Polypharmacy/high-risk medications	144 (42)
Impaired cognition	56 (16)
Poor balance/gait/strength	48 (14)
History of falls	36 (10)
Visual impairment	34 (10)
Alcohol/substance abuse	29 (8)

48 (14%) classified as severe. Sixty-four patients injured their right eye, 54 injured their left and in six the injuries were bilateral. There were 25 OGIs, 24 ruptured globes and one penetrating laceration. Three of the ruptured globes occurred along previous surgical wounds such as post-cataract surgery and corneal transplants. The OGIs carried poor visual prognosis as all injured eyes had a final visual acuity less than 6/60.

There was no significant difference in the rate of globe trauma (39% *vs* 32%, $P = 0.203$) or severe globe

trauma (13% *vs* 15%, $P = 0.608$) between males and females. Significantly more patients with mid-facial/orbital fractures had globe trauma compared to patients with no mid-facial/orbital fractures (55% *vs* 36%, $P < 0.001$). Severe globe trauma occurred at similar rates in patients with and without orbital/mid-facial fractures (23% *vs* 14%, $P = 0.07$).

Of the 106 patients with multi-system trauma, all patients had adnexal trauma, 42 (40%) had globe trauma with 12 (11%) patients with globe trauma classified as severe. Ten

patients had a mechanism of injury and/or injuries necessitating a trauma call. Six of these trauma call patients had comorbid globe trauma, including one patient with severe globe trauma.

Management

All patients were initially reviewed by emergency staff. Eighty-nine (26%) patients had a thorough eye examination documented by emergency staff, 157 (45%) had a gross examination documented and for 100 (29%) there was no examination documented.

When globe trauma was diagnosed by emergency staff, 58% of patients had had a thorough eye examination documented. When only adnexal injuries were diagnosed, 205 (92%) patients had had a gross examination or no eye examination documented (Fig. 3). Challenges complicating the initial examination of patients included delirium, cognitive impairment, intoxication, non-English speaking backgrounds and altered levels of consciousness.

Ophthalmology was referred 122 (35%) patients by emergency medical staff. Reasons for referral included suspicion of globe trauma, abnormal visual acuity or comorbid mid-facial/orbital fracture. One hundred and fifteen (94%) patients referred were seen by ophthalmology within 24 hours in the ED or in the clinic. Of the patients referred to ophthalmology, 82 (67%) had a thorough eye examination documented by emergency staff. Of the 125 patients with globe trauma, 88 (72%) patients were referred to ophthalmology by the emergency staff at presentation including 45 (92%) patients with severe globe trauma. Seventy-two (65%) patients with mid-facial/orbital fractures were referred to ophthalmology.

There was one patient with globe trauma where the diagnosis was delayed. The patient presented from a nursing home after a fall with head strike. They were reviewed by emergency medical staff and no referral to ophthalmology was made, the patient was then discharged. The patient represented to emergency 2 days later complaining of eye pain and abnormal vision. A referral to ophthalmology was made on representation and the

TABLE 3. Adnexal and globe injuries occurring from falls (n = 346)

Adnexal and globe injuries	n (%)
Periorbital haematoma	321 (97)
Orbital/mid-facial fracture	110 (16)
Laceration to lids or adnexa	36 (10)
Open globe injury	25 (7)
Internal eye injury	25 (7)
Corneal trauma	15 (4)
Retro orbital haematoma	8 (2)
Optic nerve injury	3 (1)

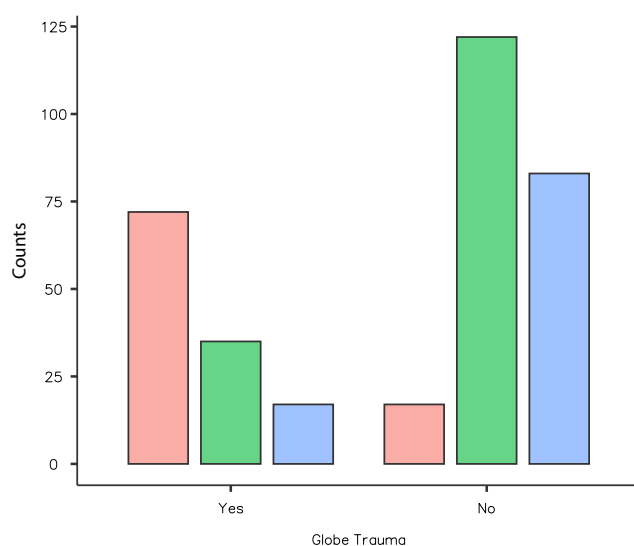


Figure 3. Type of ocular examination in the presence of globe trauma occurring from falls (n = 346). Ocular examination: (■) thorough examination; (■) gross examination; (■) no examination.

patient was found to have a subconjunctival haemorrhage and epithelial defect.

Discussion

Our study demonstrated the spectrum of fall-related globe and adnexal trauma from 346 patients admitted to RNSH and RPAH between January 2015 and December 2019. The majority of patients were elderly and had at least three aspects contributing to their falls. Adnexal trauma was more common than globe trauma (100% vs 36%, respectively), with 97% of patients suffering periorbital haematomas. Of the 125 patients who

suffered globe trauma in 48 (14%) the globe trauma was classified as severe. A mechanism of injury involving a greater impact, for example a fall from a height, was associated with more severe adnexal injuries, such as mid-facial/orbital fractures. If the patient had mid-facial/orbital fractures, they were more likely to have globe trauma than patients without orbital/mid-facial fractures. When severe globe trauma was present or suspected in the acute examination, emergency staff referred the patient for ophthalmology reviews.

The majority of patients with fall-related globe and/or adnexal trauma were elderly and had the fall occur

in the home. This is consistent with previous literature where falls by the elderly in the home were overrepresented.^{26–29} Additionally, we found that patients most often had at least three risk for falls such as age, chronic disease and polypharmacy. For younger patients in our study, alcohol was the most frequent contributor to falls. Consequently, for elderly patients presenting with a fall medical review is recommended and in young patients a drug and alcohol history should be taken to identify any underlying risks contributing to their falls.

From 2014 to 2022, the NSW government legislated an amendment to the Liquor Act, colloquially referred to as the 'lockout laws', restricting the service of alcohol to certain time periods in inner Sydney. The 'lockout laws' followed community outcry on alcohol-related injuries and violence. During this period, there was a sustained reduction of alcohol-related serious injury and assaults presenting to St Vincent's Hospital located in inner Sydney.^{9,30} Although, from 2010 to 2020 the rate of alcohol-related hospitalisations across NSW increased from 440.1 to 502.9 per 100 000, and alcohol-related falls were the second most common reason for alcohol-related hospitalisation.^{8,31,32} RNSH and RPAH are located approximately 5 km from the central business district (CBD) of Sydney and receive patients and referrals from inner Sydney. We found that alcohol was involved 20% of the fall-related globe and adnexal trauma, however, only four of the patients were injured in the CBD area and the remaining occurred in the patients' local area outside the CBD. The role of alcohol in trauma is important to identify as alcohol management plans can have a role in preventing globe trauma.^{8,32}

In the 110 patients with mid-facial/orbital fractures, there was a higher proportion of globe trauma compared to those without these fractures. Our findings are consistent with Guly *et al.* who conducted a retrospective analysis of a Trauma Audit Research Network database from England and Wales between 1989 and 2004. They found the risk of globe trauma for patients with facial fractures was 6.7 times greater compared to patients with no

facial fracture.^{33,34} Likewise, Poon *et al.*²⁰ in their review of globe trauma occurring in the context of multisystem trauma found that mid-facial/orbital trauma significantly increased the risk of globe trauma. Poon *et al.* recommended that patients with such fractures should be referred for ophthalmology review. Concerningly, only 65% of patients in our study with mid-facial/orbital fractures were referred for ophthalmology review. Our data highlights the association of globe trauma with mid-facial/orbital fractures has remained stable over time. Further education is required on the importance of thorough ocular examinations and referral for specialist ophthalmology reviews in these patients.^{20,33,35} The development of readily available clinical tools may be useful for acute emergency staff when assessing these patients. Moreover, preventative measures are needed to decrease the incidence of severe trauma.

Only 26% of our patients had a thorough ocular examination documented at presentation with most of these occurring in patients with suspected globe trauma. For the remaining patients, a gross examination or no examination was performed, raising the concern for delays in the diagnosis of globe trauma. Notably, one of our patients had a delay in diagnosis of their globe trauma; the injury was diagnosed following representation to hospital. Challenges for emergency staff when assessing patients after trauma include barriers such as language, intoxication, delirium and cognitive impairment.^{36,37} Given these challenges, it is vital to perform a thorough ocular examination as patients may be unable to effectively convey symptoms such as decreased vision, diplopia or scotomas.^{4,13} Utilising simple tools such as a Snellen chart on a smartphone, support of family members and re-examination by more experienced staff may be useful to prevent delays in diagnosis and missed injuries.^{13,38}

Similar to our study, Lee *et al.* found that globe trauma can result from low-impact falls emphasising the need for thorough ocular examination even in seemingly innocuous circumstances.¹⁵ We also found that in younger populations, falls were commonly

associated with alcohol and illicit substances. Additionally, there were few patients with alcohol-related falls from Sydney's CBD which may have been influenced by the 'lockout laws' in place at the time. Our study provides recent data on the spectrum of globe and adnexal trauma resulting from falls in all ages admitted to two trauma centres. We highlight the need for high index of suspicion of fall-related globe trauma, due to the frequency of falls presentations and significant morbidity that can result.

Limitations

The present study was limited by its retrospective design and descriptive analysis as missed injuries, incomplete documentation and incorrectly coded admissions may introduce selection bias. There was a risk of referral bias as RPAH and RNSH are both tertiary trauma centres and patients were admitted. This may have led to an overrepresentation of patients with more severe injuries as minor globe and adnexal trauma can be managed in low acuity hospitals and outpatient settings. Similarly, very few children were identified in the study as severe trauma in Sydney is typically referred directly to specialist paediatric hospitals. To gain a contemporaneous overview of fall-related globe trauma clinical registries could be used to gather more comprehensive data.³⁹ The International Globe and Trauma Epidemiology Study (IGATES) registry has been established as an international platform that could be used to collect such data^{16,40} including globe trauma from all patient presentations, clinic reviews and hospital admissions. This comprehensive database of injuries would minimise the introduction of bias seen in retrospective medical record reviews such as incorrectly coded patients, missed or delayed diagnoses.

Conclusion

Elderly patients were most commonly affected by fall-related globe and adnexal trauma. In the young, alcohol and illicit substances have a role in such injuries. A thorough ocular examination is vital to diagnose globe trauma following a fall, with mid-facial/orbital

fractures increasing the risk of globe trauma. Utilising specialist ophthalmology assessment can aid emergency staff in diagnosing globe trauma. Further, research is required to determine the effect of falls prevention strategies including alcohol management plans in preventing globe trauma.

Acknowledgement

Open access publishing facilitated by The University of Sydney, as part of the Wiley - The University of Sydney agreement via the Council of Australian University Librarians.

Author contributions

CB, AKH, CLF and SW were involved in conceiving the study. CB collected and analysed the data. CB wrote the first draft of the manuscript. CB, AKH, CLF and SW reviewed and edited the manuscript and approved the final version of the manuscript.

Competing interests

None declared.

Data availability statement

All data generated or analysed during the present study are included in this article [and/or] its supplementary material files. Further enquiries can be directed to the corresponding author.

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Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Appendix S1. International Classification of Disease (Tenth Revision) diagnostic and procedural codes to identify globe trauma.