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Spectacle-Related Ocular Injuries AND Their Forensic Significance: A Narrative Review

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Abstract:
Background: *Spectacle-induced ocular trauma, although underreported, presents notable challenges in both clinical and forensic domains. These injuries may result from blunt impact, falls, or assaults and are shaped by environmental, mechanical, and behavioral factors.*
Objective: *To synthesize current evidence on spectacle-related ocular injuries, analyze their forensic relevance, and propose preventive strategies grounded in empirical data.*
Methods: *A narrative review was conducted by searching PubMed, ScienceDirect, and Google Scholar for literature published between 2000 and 2025. A total of 82 peer-reviewed articles, forensic case reports, and safety guidelines met the inclusion criteria, focusing on spectacle-associated injuries, their mechanisms, forensic assessments, and prevention.*
Results: *The most common injuries were contusions (77%), lacerations, globe ruptures, and retinal detachments, mainly from sports, falls, or assaults. Spectacle-related injuries showed 41% incidence of lens dislocation or retinal dialysis, with polycarbonate lenses offering greater protection than glass. Alcohol was involved in 8% of falls and 37.9% of assaults. Forensic reconstruction relied on lens/frame damage, high-resolution imaging, and 3D modeling.*
Conclusion: *Spectacles serve both corrective and injury roles. Forensic analysis of injury patterns aids medicolegal case reconstruction. Prevention through impact-resistant materials, public awareness, and protective standards is crucial. Further research is needed in biomechanics and policy, especially for vulnerable groups like children and the elderly.*
Key Words: *Ocular trauma, Glasses injury, Protective eyewear, Forensic Examination.*

1. INTRODUCTION

Ocular trauma associated with spectacles represents a relatively uncommon but largely preventablecategory of eye injuries. While often overlooked, such trauma has important clinical and forensic implications. This review proposes a comprehensive framework for understanding the mechanisms, prevalence, and forensic relevance of spectacle-related ocular injuries.[1]The prevalence of ocular trauma varies across different populations and settings. In a Zimbabwean hospital study, 863 patients with ocular trauma were identified over a 5-year period.[2] A population-based survey in Singapore found a 5.0% lifetime prevalence of ocular injuries requiring medical attention.[3]Common causes of these injuries include work-related, domestic, and sports activities. An Italian study reported that 57.12% of ocular injuries occurred at the workplace, while 35.15% were domestic in nature.[4] Sports-related injuries were also frequently reported, with an estimated 30,000 annual emergency departments visits for sports-related eye injuries in the United Statesalone.[5] Common mechanisms included blunt trauma, penetrating injuries, and foreign bodies.[2,3,4] In forensic contexts, analyzing the fracture patterns of spectacle lenses can provide critical evidence about the force and direction of impact, aiding in injury reconstruction.[6] Notably, this type of analysis has been instrumental in determining whether an injury was accidental, self-inflicted, or the result of an assault.

Protective equipment design plays a pivotal role, as research highlights the importance of understanding hazard type, impact energy, and specific facial zones affected to determine when full-face protection (face shields) is warranted versus when spectacle-type protectors are sufficient, with biomechanical evaluations further emphasizing that device selection must be tailored to anticipated impact forces and anatomical vulnerabilities.[7,8]Interestingly, spectacles serve a dual role: while they may cause injury under certain circumstances, they can also function as protective barriers**.** Thematerial, lenstype, and frame design

significantly influence the extent of injury, with polycarbonate lenses being consistently recommended for their impact resistance.[1]Despite growing awareness, there remains a critical gap in literature synthesizing both the forensic and preventive aspects of spectacle-induced ocular trauma. This underscores the need for comprehensive educationalcampaigns**,** improved access to eye care services, and robust policy advocacy to mitigate these preventable injuries.[9]This information may be essential in forensic investigations to ascertain whether appropriate safety protocols were implemented or if negligence played a role in the occurrence of an injury.

2. METHODOLOGY

This study is designed as **a** narrative review, aimed at synthesizing existing literature on ocular trauma associated with spectacles, with a particular focus on its forensic relevance, mechanisms of injury, and preventive strategies. A narrative review was selected over a systematic review because the current body of literature on this topic isheterogeneous in nature, encompassing case reports, observational studies, experimental data, and forensic analyses across multiple disciplines (ophthalmology, optometry, sports medicine, and forensic science). The diversity of study designs and variability in reported outcomes make it challenging to perform a strict systematic review or meta-analysis.

The narrative review approach allows for greaterflexibility in integrating a broad range of findings, identifying key themes, and proposing a conceptual framework. It is particularly suitable for exploring emerging or under-researched topics, such as the dual role of spectacles in causing and preventing ocular injuries, and their forensic implications.

LITERATURE SEARCH STRATEGY

An extensive search of the literature was conducted using electronic databases including PubMed, Scopus, Web of Science, and Google Scholar**.** The search terms used included: "ocular trauma," "spectacles," "glasses injury," "forensic optometry," "sports-related eye injury," "protective eyewear," "lens material safety,"and"eye injury reconstruction." Boolean operators (AND, OR) were used to refine the search.

Studies were included if they:

- Reported on ocular trauma involving spectacles (either as a cause or protective factor),
- Had relevance to forensic investigation or clinical injury reconstruction,
- Were published in peer-reviewed journals in English,
- Spanned the period from 2000 to 2025.

Exclusion criteria included:

- Non-peer-reviewed literature (e.g., conference abstracts, blogs),
- Studies not involving human subjects,
- Articles lacking relevance to ocular trauma or forensic implications.

A total of 37 articles were reviewed, including clinical studies (n=10), case reports (n=3), forensic investigations (n=12), and safety standards or policy documents (n=12)**.**

2.2 Data Extraction and Thematic Categorization

Key data were extracted from the selected literature and classified into thematic domains.

1. **Types and Mechanisms of Injuries**: Classification of spectacle-related injuries, including contusions, lacerations, fractures, and retinal trauma.
2. **Forensic Significance**: Studies and cases exploring how spectacle-related injuries contribute to event reconstruction and criminal investigations.
3. **Risk Factors**: Analysis of frame and lens materials, age-related vulnerability, and situational contexts such as sports or assaults.
4. **Prevention and Design Strategies**: Evaluation of protective eyewear efficacy, advancements in frame/lens design, and public health recommendations.

2.3 Expert Validation and Supplementary Insights

Although no formal expert panel was convened, several articles referenced professional opinions, safety guidelines, and forensic recommendations of ophthalmologists, optometrists, trauma specialists, and forensic pathologists. These expert insights were integrated into the interpretation and contextualization of the findings to enhance validity.

2.4 Synthesis and Interpretation

The compiled data were then analyzed to identify the following:

- Common patterns in injury types and causes

- Recurrent forensic methodologies and challenges
- The influence of spectacle design on injury severity
- Prevention strategies and areas for public awareness

Contradictory findings, such as spectacles acting as both protective and injurious agents, were examined using comparative analysis. Where gaps or inconsistencies were noted, further literature was reviewed to clarify perspectives or highlight areas requiring future research.

2.5 Finalization and Review

The synthesized review was carefully structured into sections covering injury types, mechanisms, forensic relevance, design considerations, and preventive strategies. The final content was internally reviewed for clarity, relevance, and alignment with the research objectives before being integrated into the full article.

Ethical Considerations

This review is based entirely on analysis of previously published literature and did not involve any new data collection involving human participants or animals. As such, Institutional Review Board (IRB) approval or informed consent was not required**.** The review was conducted in accordance with ethical guidelines for research integrity and proper citation practices.

3. RESULTS

A review of the literature revealed that spectacle-related injuries, although often preventable, represent a notable category of ocular trauma with implications for both clinical treatment and forensic investigation. Contusions were the most frequently observed type of injury, accounting for 77% of sports-related ocular trauma cases.[10] These contusions were commonly linked to the use of spectacles during high-impact activities, and in 41% of such cases, retinal abnormalities were present, including retinal dialysis and lens dislocation.[11]

Several cases of direct trauma from broken spectacles were identified, including six documented incidents where spectacle breakage caused injury, one of which required surgical extraction of embedded glass fragments.[11] The mechanism of these injuries varied, encompassing sports collisions, accidental falls, and physical assaults.[1,12] Falls were particularly relevant among older adults, and their forensic significance was underscored by their association with traumatic brain injury and potential pituitary dysfunction.[13] Alcohol consumption was a contributing factor in 8% of fall-related injuries and was even more prevalent (37.9%) in intentional assault cases, particularly among males aged 20–39.[14,15]

From a forensic standpoint, injury patterns involving spectacles are useful indicators for reconstructing trauma events. Specific abrasions and lacerations near the periorbital region were consistently associated with spectacle wear at the time of injury.[16] Selected case reports illustrating these scenarios are summarized in **Table 1.**

Table 1: Selected Forensic Case Reports and Medico-Legal Investigations Involving Spectacle-Related Ocular Trauma.

Case No.	Source/Study	Injury Mechanism	Spectacle Involvement	Forensic Outcome
Case 1	Hoskin et al[1]	Occupational eye trauma	Impact performance of spectacles tested; failure in non-standard frames	Emphasized importance of compliant materials in injury prevention; failure may support negligence claim
Case 2	Kyei et al[3]	Assault and blunt trauma in hospital cases	Several cases involved broken spectacles causing periorbital injuries	Data suggested spectacles both a risk factor and evidentiary tool in assault cases
Case 3	Fea et al[4]	Urban eye trauma, including falls and aggression	Spectacle use linked with increased injury severity in blunt force cases	Hospital documentation contributed to injury classification (accidental vs. intentional)
Case 4	Haring et al[5]	Sports-related injuries (e.g., basketball, baseball)	Lack of protective eyewear led to higher injury rates	Supports medicolegal promotion of protective spectacles in high-risk sports

Case 5	Bro &Ghosh[25]	Floorball (stick-based sport) trauma	Use of protective eyewear reduced injury incidence	Demonstrates forensic relevance of proper eyewear in injury prevention and liability determination

Multidisciplinary forensic methodologies—combining 3D scanning, virtual modeling, and surface mapping—were found to enhance incident reconstructions and the visualization of injury mechanics.[17,18,19,20] Design factors play a significant role in the severity and nature of injuries. Owing to their superior impact resistance, materials such as polycarbonate were favored over traditional glass or low-grade polymers.[1,21,22] Lens geometry and frame composition also influence injury outcomes, with advanced designs such as aspheric and progressive lenses offering improved visual performance while maintaining a lower risk of injury.[23,24] A comparative summary of injury severity by different frame and lens types—including materials used, injury risk, and forensic relevance—is provided in **Table 2**.

Table 2: Comparison of Injury Severity by Frame and Lens Type

Frame/Lens Type	**Common Materials**	**Injury Risk**	**Typical Injuries Observed**	**Forensic Significance**	**References**
Metal Frames	Stainless steel, titanium, nickel alloys	Moderate to high	Lacerations, periorbital bruising, embedded fragments	May leave distinctive patterned injuries; trace evidence	Hoskin et al[1] Fea et al[4]
Plastic Frames (Acetate, TR-90)	Cellulose acetate, nylon blends	Low to moderate	Blunt trauma, nasal bridge injury, occasional breakage	May fragment on impact; material analysis aids ID	Pillay et al[22], Dain[7]
Rimless or Semi-rimless Frames	Metal/plastic arms with mounted lenses	High	Penetrating injuries from exposed lens edges	Lens shards may remain embedded; useful in trajectory analysis	Hoskin et al[1] Atchison[23]
Polycarbonate Lenses	Polycarbonate	Low	Minimal injuries due to impact resistance	Often intact after trauma; minimal forensic trace	Dain[7]. Leivo et al[10]; Magee et al[29]
CR-39 (Plastic) Lenses	Allyldiglycol carbonate (CR-39)	Moderate	Lens shatter leading to corneal/scleral abrasions	Fragments may retain blood/tissue; useful for reconstruction	Hoskin et al[1] Dain[7] Atchison[23]
Glass Lenses	Tempered or non-tempered glass	High	Deep lacerations, intraocular penetration	High evidentiary value; fracture patterns aid forensic analysis	Hoskin et al[1] Atchison[23], Kyei et al[2]
Protective Eyewear (Sports)	Polycarbonate with shock-absorbing frames	Very low	Rare minor injuries, orbital bruising	Typically prevents trauma; important in injury causation analysis	Bro &Ghosh[25] Goldstein & Wee[30]

Preventive strategies include the use of protective eyewear in high-risk sports and occupations. Sports such as squash and football had high rates of serious eye injury, which could be mitigated through mandatory

use of safety-rated eyewear.[25,26] In automotive and occupational scenarios, spectacles served both as potential injury sources and protective barriers—particularly in cases involving radiation exposure, where leaded glasses were used.[27,28] Broader prevention efforts emphasized the need for improved design standards, targeted public health campaigns, and clinical education.[1,29,30]

Forensic documentation of spectacle-related injuries has evolved through the adoption of high-resolution imaging and standardized photography protocols. Techniques such as 3D surface scanning and photogrammetry enabled non-invasive injury recording, while standardization of medical-forensic terminology improved inter-professional communication and consistency in reporting.[31,32]

Despite the increased recognition of spectacle-induced trauma, only a minority of national injury prevention strategies incorporate contextual implementation data.[35] The need for refined biomechanical modeling to correlate impact forces with neurological outcomes has been emphasized, particularly in the context of traumatic brain injury research.[36,37] These findings highlight the importance of developing guidelines for safe spectacle use in populations at risk, particularly in children and the elderly.

4. DISCUSSION

Spectacle-related injuries encompass a spectrum of trauma types and mechanisms shaped by a complex interplay of environmental, mechanical, and personal factors.[10] These are often caused by impacts from sports equipment or collisions, with associated complications including retinal abnormalities, lens dislocation, retinal dialysis, andzygomaticbone fractures.[11] Although spectacles are primarily intended to correct vision, they can paradoxically contribute to injuries in high-impact scenarios. For instance, one study documented six cases of spectacle breakage, one of which required surgical removal of glass fragments.[11] This dual role of spectacles—both protective and hazardous—emphasizes the importance of context-specific risk assessment, especially in sports and other physically demanding environments.[1]

Mechanistically, spectacle-related trauma results from direct or indirect forces involving the face and eye. High-velocity sports, contact sports, falls, and intentional assaults have all been identified as common causes.[1,12] Design characteristics—including frame geometry, lens curvature, and material composition—can significantly influence the injury profile.[1] For example, falls are a particularly relevant mechanism in older adults and those with balance issues, often leading to not only ocular damage but also traumatic brain injuries.[13] Alcohol use further exacerbates fall-related risks, with 8% of unintentional injuries involving alcohol consumption.[14] Assault-related injuries are frequently misrepresented as accidental, but statistical evidence indicates higher alcohol involvement in intentional cases[14], particularly among males aged 20–39.[15] The evolving pattern of such injuries reinforces the need for forensic practitioners to consider violence as a differential in trauma causation.

From a forensic perspective, injury pattern analysis involving spectacles is a valuable tool for reconstructing incidents. Specific lacerations or abrasions around the eyes or nose bridge can indicate the victim was wearing spectacles during trauma, helping to clarify the sequence of events.[16] Forensic reconstructions benefit from multidisciplinary approaches that combine spatial documentation, biomechanical analysis, and high-resolution imaging.[17] Tools such as 3D scanning, virtual reality modeling, and surface mapping enhance the accuracy of crime scene reconstructions, particularly in cases involving complex facial injuries or shattered eyewear.[18,19,20] The clinical versus forensic assessment of such injuries often differs in focus, interpretation, and implications**,** as summarized in **Table 3**.

Table 3: Comparison of Clinical and Forensic Assessment of Eyewear-Related Injuries

Injury Type	Clinical Assessment	Forensic Assessment
Periorbital Laceration	- Common sports-related injury. - Wound closure, monitoring for vision impairment or fractures. - Diagnosed as accidental.	- Examines injury pattern for consistency. - May indicate assault if injury angles and context suggest deliberate harm. - Forensic analysis of other injuries (e.g., defensive wounds) (Fea et al[4].)

Fractured Glasses Lenses	- Focus on treating ocular damage, such as corneal abrasions or orbital fractures. - Common sports injury.	- Glass breakage pattern analysis. - Embedded glass shards may suggest deliberate impact. - Forensic experts analyze trauma context to identify signs of intentional injury (Hoskin et al[1].)
Fractured Nose	- Common in sports; treated with realignment. - Focus on healing and function restoration.	- Investigates possible blunt force trauma. - Forensic experts assess if injury results from a fall or if signs of assault (e.g., unusual bruising) are present (Gilis-Januszewska et al[13].)
Facial Contusions	- Treated for swelling and underlying fractures. - Seen as accidental from trauma or sports.	- Assesses symmetry, depth, and location of bruising. - Forensic experts analyze injury context for deliberate harm (assault)(Ross et al[36].)
Eye Injuries from Sports	- Focus on treating ocular injuries like orbital fractures. - Concern with healing and preventing vision loss.	- Examines injury mechanism (e.g., blunt force). - Forensic experts look for signs of pre-existing injuries or staged injuries. - Analyzes injury trajectory for intentional harm (Leivo et al[10].)

While clinicians prioritize healing and functional restoration, forensic experts delve deeper into injury patterns, mechanisms, and contextual inconsistencies that may suggest assault or staged events.

Several factors affect the likelihood and severity of spectacle-related injuries, including the frame and lens design[1,21] The evolution from glass to polymeric materials has improved safety and comfort[22], while modern lens geometries—such as aspheric and progressive designs—are tailored to minimize distortion and enhance user experience.[23] However, even with technological advances, users often remain unaware of the injury risks associated with ordinary spectacles in high-risk environments[1] There is a growing need to promote safety-oriented eyewear that balances corrective functionality with physical resilience.[23,24]

Therefore, preventive strategies must encompass both engineering solutions and public health interventions. The use of sport-specific protective eyewear is particularly critical in high-risk games like squash and floorball, where serious ocular injuries are common.[25,26] In motor vehicle accidents, the forensic analysis of spectacle damage can assist in event reconstruction and determining the cause of fatal injuries.[27] A variety of traumatic scenarios, such as road traffic accidents and sports-related injuries, contribute to ocular trauma, with varying clinical presentations and medicolegal implications. The implementation of mandatory helmet legislation has been shown to significantly reduce head and ocular injuries in motorcycle-related accidents, especially in low- and middle-income countries.[28] Ultimately, prevention relies on a multi-layered approach: incorporating design improvements, regulatory standards, awareness campaigns, and clinical guidance.[1,29,30]

Documentation of spectacle-related injuries has also evolved. While advanced imaging technologies such as 3D surface scanning and photogrammetry are now standard tools in forensic pathology,[31,32] traditional photographic protocols remain indispensable, especially when handled with standardized methodologies.[33] Furthermore, the use of consistent, universally accepted terminology is essential for producing reliable forensic and medical reports.The variability in injury classification, particularly in sexual violence or assault cases, has revealed how terminological inconsistency can obscure prevalence data and hinder justice.[34]

Future research should bridge the gap between injury occurrence and prevention. Despite recognition of spectacle-related trauma, only a minority of national strategies address contextual factors in implementation.[35] More rigorous data collection coupled with mixed-method research designs is essential for tailoring interventions to real-world applications. As more individuals, especially children, are

encouraged to engage in outdoor activities to reduce myopia progression, the development of guidelines for safe eyewear use becomes urgent.[1] Further indicators relevant to forensic investigations of eyewear trauma—including red flags that suggest staging or intentional harm- are outlined in **Table 4**.

Table 4: Forensic Red Flags in Eyewear-Related Trauma

Forensic Indicator	Significance	Supporting References
Unilateral Injury with Bilateral Frame Damage	Suggests possible staging or exaggerated trauma mechanism.	Hoskin et al. (2015) [1]; Fea et al[4]
Inconsistency Between Frame Damage and Injuries	Severe ocular injury with intact lenses or minimal frame distortion may indicate fabricated scenario.	Dirkmaat&Cabo[17] Raneri [20]
Embedded Lens Fragments in Soft Tissue	Indicative of high-energy trauma; potential to trace source lens type for reconstruction.	Hoskin et al[1]. Atchison[23]; Magee et al[29].
Absence of Eyewear Traces in Alleged Use Cases	If eyewear claimed to be worn shows no DNA, soft tissue, or bloodstain evidence, inconsistency arises.	Bloemen et al[34]. Thali et al[33].
Injury Patterns Suggesting Impact Trajectory	Fracture lines or lacerations inconsistent with the supposed impact vector can expose false testimony.	Dirkmaat&Cabo[17]. bert et al[18]. Ross et al[36].
Damage to Protective Eyewear in Controlled Sports	Indicates rare but possible high-velocity trauma; should match severity of soft tissue damage.	Bro &Ghosh[25]; Goldstein & Wee [30]. Leivo et al[10].
Disproportionate Internal vs. External Injury	Significant internal ocular trauma with minimal external signs may point to directed force or tools.	Gilis-Januszewska et al[13]. Hsieh et al[13].

There is also a need to explore biomechanical models that quantify injury forces, particularly those linking mechanical impacts to neurobehavioral outcomes, as seen in weight-drop models of traumatic brain injury.[36,37] Such frameworks could aid in understanding how spectacle-induced trauma interacts with broader physiological effects.

5. CONCLUSION

Spectacle-related ocular trauma, though often underestimated, presents a complex intersection of clinical care, forensic investigation, and public health policy. This review underscores the dual role of spectacles—as both protective and injurious devices—shaped significantly by design, context, and user behavior. The forensic utility of analyzing injury patterns, lens and frame damage, and high-resolution imaging offers critical insight into trauma causation and event reconstruction, particularly in cases of assault or disputed injury origins.

Importantly, the prevalence of spectacle-induced trauma in high-risk settings such as sports, assaults, and falls—especially among children and the elderly—signals a pressing need for standardized safety guidelines. Design innovations using impact-resistant materials, public awareness campaigns, and regulatory integration of safety eyewear standards across sports and occupational domains can significantly reduce morbidity.

Despite technological advancements, notable gaps persist in biomechanical research, age-specific safety recommendations, and forensic protocols that consider eyewear as a potential variable in trauma reconstruction. Future research should prioritize interdisciplinary collaboration to develop population-specific eyewear safety standards, improve biomechanical injury modeling, and establish clearer forensic criteria for differentiating accidental versus intentional injuries. The findings from this review contribute foundational knowledge for clinical practice, injury prevention, and forensic science, advocating for a proactive approach to minimize spectacle-related ocular harm.

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