Eye and Orbital Injuries in Sports

Jonathan A. Micieli, MD, CM, Michael Easterbrook, MD, FRCSC*

Although sports-related eye injuries are completely preventable they continue to occur, with serious consequences. Prevention is the most effective way to eliminate the significant morbidity and costs associated with sports-related eye injuries.1,2 However, for various reasons, including noncompliance with regulations, the lack of enforcement, or suboptimal legislation, these injuries continue to occur regularly.3–5 Eye trauma has significant consequences not only to the individual but also to society. There is a tremendous cost to care for and treat individuals who have sustained a sports-related injury and many experience permanent vision loss, which has profound effects on their lives.6 This article discusses the mechanisms, classification, and specific sports-related injuries that may occur to the eye and orbit. It ends with a brief discussion on eye protection and ocular motor function in concussion.

MECHANISM OF INJURY

Trauma to the eye may occur by blunt, penetrating, or perforating mechanisms. Blunt injuries refer to contusions or forces that strike an intact globe. Penetrating injuries occur when there is a single laceration to the eye causing an open globe, and perforating injuries occur when 2 full-thickness lacerations (entrance and exit) are present and are usually caused by a sharp object or missile.

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a Department of Ophthalmology and Vision Sciences, University of Toronto, 340 College Street, Suite 400, Toronto, Ontario M5T 2S8, Canada; b Department of Ophthalmology and Vision Sciences, University of Toronto, Suite 310, 790 Bay Street, Toronto, Ontario M5G 1N8, Canada*

E-mail address: michael.easterbrook@sympatico.ca

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• Eye injuries • Sports • Globe rupture • Eye protection

KEY POINTS
• Eye protection prevents serious eye injuries in sports.
• Certain findings on history or physical examination warrant urgent referral to an ophthalmologist.
• Irreversible blindness may occur after sports-related trauma.
The severity of an eye injury is correlated with the total impact force, the force onset rate, and the kinetic energy of an object.\textsuperscript{7} Experimental studies performed on human, monkey, and porcine eyes show that, after impact, the sclera expands equatorially, producing corneoscleral stress that can cause rupture of the eye.\textsuperscript{8,9} Computational models of the eye have been used to simulate a variety of impacts and analyze injury potential. An example of this is the Virginia Tech–Wake Forest University (VT-WFU) eye model, which is a finite element model that has been validated to predict globe rupture for blunt eye impacts.\textsuperscript{10} This model has shown that stresses in the corneoscleral shell exceeding 23 MPa and local dynamic pressures exceeding 2.1 MPa result in globe rupture.\textsuperscript{10} Other studies have shown that spherical projectiles (baseballs, BB pellets, paintballs, airsoft pellets) result in higher stresses and pressures in the eye compared with cylindrical projectiles (blunt impactor, aluminum, foam) and that peak stresses are located at the apex of the cornea, the limbus, or the equator of the globe.\textsuperscript{11} Models such as this can be used as predictive aids to reduce the burden and better understand the mechanisms of eye injury.

CLASSIFICATION OF INJURIES

Sports-related eye injuries can be classified using the Birmingham Eye Trauma Terminology (Fig. 1).\textsuperscript{12} This classification system uses the entire globe as the tissue of reference and has been endorsed by various societies of ocular trauma. In this system, an eye injury is first classified as either a closed globe injury or an open globe injury. Closed globe injuries can be further subdivided as either contusions (meaning there is no scleral or corneal wound) or lamellar lacerations (partial-thickness wounds of the eye wall). Open globe injuries are further divided into ruptures (full-thickness wound caused by blunt object) or lacerations (full-thickness wound of the eye wall caused by a sharp object). Lacerations can be penetrating, perforating, or involve an intraocular foreign body, which is a retained foreign body causing an entrance laceration.

ANATOMY OF THE EYE AND ORBIT

The eye or globe is not a true sphere. The radius of curvature of the cornea (8 mm) is smaller than that of the sclera (12 mm), giving it the shape of an oblate spheroid.\textsuperscript{13} The anteroposterior diameter of the globe is usually between 23 and 25 mm, with myopes (near-sighted individuals) generally having longer eyes than hyperopes (far-sighted individuals). The eye is divided into 3 main compartments: the anterior chamber, the

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\textbf{Fig. 1.} Classification of sports-related eye injuries. IOFB, intraocular foreign body. (Courtesy of Birmingham Eye Trauma Terminology; adapted from Kuhn F, Morris R, Witherspoon CD, et al. A standardized classification of ocular trauma. Graefes Arch Clin Exp Ophthalmol 1996;234(6):399–403; with permission.)