OPEN

The Protective Effects of Soft Contact Lenses for Contact Sports: A Novel Porcine Model for Corneal Abrasion Biomechanics

Andrew Hou, M.D., Man Li Jin, M.D., and David Goldman, M.D.

Purpose: The aim of this study was to determine whether soft contact lenses provide protection for the corneal surface.

Methods: Fresh porcine eyes were inflated to intraocular pressures of 11 to 22 mm Hg and secured to a Styrofoam head. Newton meters affixed with artificial acrylic nails were placed at angles of 0°, 45°, and 90° from a porcine corneal surface. The force of impact was recorded at which corneal abrasions were induced. The experiment was repeated with Senofilcon A and Lotrafilcon A soft contact lenses placed upon porcine eyes.

Results: The mean forces required to induce a corneal abrasion with force at 0°, 45°, and 90° from corneal surface were 11 ± 5.09, 9.18 ± 2.76, and 7.72 ± 2.61 Newtons, respectively. With soft contact lens barrier, the maximum measurable force of 50 Newtons could not produce a corneal abrasion.

Conclusion: The force required to create corneal abrasions varies depending on the angle of the force vector. The use of contact lenses can withstand a minimum of five times the average force needed to create corneal abrasions.

Key Words: Abrasion—Contact lens—Trauma—Injury—Sports—Safety.

(*Eye & Contact Lens* 2022;48: 228–230)

Ocular sports injuries are a common cause of acute ophthalmologic visits to emergency departments worldwide. It is estimated in the United States alone, ocular sports injuries account for an average of 100,000 visits to medical professionals.[1] These injuries affect both children and adults, and these place significant burden to patients, caretakers, and the medical system.[1] Often, the cause of ocular sports injuries is the underutilization of protective eyewear. In children, anterior globe injuries are most common with 83% consisting of corneal abrasions.[2] In sports such as baseball and ice hockey where governing bodies mandate the use of face protection visors, the incidence of eye injuries has significantly declined.[1] However, this becomes more difficult in sports that do not currently require the use of such protections.

Kareem Abdul-Jabbar, one of the most dominant basketball players in the history of the sport was famous for wearing goggles. During his college career, he had a corneal abrasion in his left eye resulting in missing subsequent games.[3] During his professional career, he had another corneal abrasion, eventually experiencing recurrent corneal erosion syndrome. Unwilling to miss further games, he resorted to the use of protective goggles for the remainder of his career. Other professional basketball players such as James Worthy and Amare Stoudemire also wore nonprescription protective goggles after ocular injuries.[1]

METHODS

The study activities were submitted to the Henry Ford Health System Institutional Review Board (IRB). Activities described by the principal investigator involve research on fresh pig eyes. No human subjects or biospecimens are involved in this study. As such, the activities do not meet the definition of human subject research, as defined by the Common Rule. Therefore, this study does not require review by the Henry Ford Health Systems IRB.

No live animals were involved in this study. Research was performed on fresh-harvested porcine eyes. Freshly harvested porcine eyes were obtained through overnight shipping. The pig eye was placed in an upright configuration into a Styrofoam head mold. The eyes were infused with saline solution by means of the optic nerve to standardize the intraocular pressure (IOP) among the eyes. Intraocular pressure was measured using a tonometer (Reichert, Depew, NY) to be between 11 and 22 mm Hg to mimic normal IOP of a human eye. An acrylic artificial fingernail measuring 6 mm in width and 20 mm in length was securely attached to the end of a Newton meter to quantitatively measure the amount of force exerted on the eye. The Newton meter was pointed 0°, 45°, and 90° from the corneal surface as depicted in Figure 1.

Incremental amounts of force were applied to the pig eye until an epithelial defect was created. Fluorescein stain was used to assess the eye for an abrasion. This was repeated a minimum of 10 times for each angle of impact to obtain a statistically reasonable distribution of samples. The trial was repeated with two different types of soft bandage contact lenses placed on the pig eye. Silicone hydrogel polymer Senofilcon A Air Optix Night and Day (Alcon, Fort Worth, TX) and Lotrafilcon A Acuvue Oasys (Johnson & Johnson, New Brunswick, NJ) were tested.

From the Department of Ophthalmology, Henry Ford Hospital, Detroit, MI.

The authors have no funding or conflicts of interest to disclose.

Supported by Department of Ophthalmology, Henry Ford Hospital.

Presented as a poster at the American Society of Cataract and Refractive Surgery 2020 Annual Meeting (Virtual) under the name "Contact Lenses Offer Significant Protection from Traumatic Corneal Epithelial Abrasions."

Address correspondence to Man Li Jin, M.D., Department of Ophthalmology, Henry Ford Hospital, 2799 West Grand Boulevard, Detroit, MI 48072; e-mail: jin.manli.92@gmail.com

Accepted January 8, 2022.

DOI: 10.1097/ICL.0000000000000894

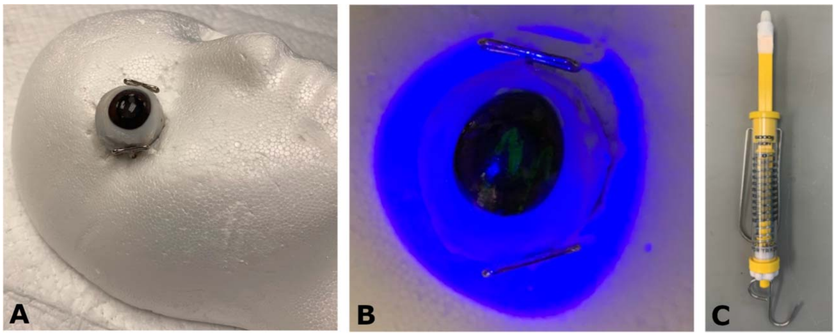

FIG. 1. Experiment setup. (A) Porcine eye secured to Styrofoam head. (B) Corneal abrasion highlighted with fluorescein staining. (C) Acrylic nail secured to the force applicator of the Newton meter.

Statistics

Two-Sample *t* tests were used to compare the force needed to create a cornea abrasion in the 0° group to the force needed in the 45° group and 90° group. The *t* tests were corrected using the Bonferroni correction method.

RESULTS

The mean force required to induce corneal abrasion in a porcine eye with force at 0°, 45°, and 90° to the corneal surface was 7.72 ± 2.61, 9.18 ± 2.76, and 11 ± 5.09 Newtons, respectively, as seen in Figure 2. Effect size was 0.54 between the 0° group and 45° group and 0.80 between the 0° group and 90° group.

The mean IOP for all eyes was 16.06 ± 3.36 mm Hg. These data show the eye is more vulnerable to corneal abrasions when the force is applied tangential to the surface of the cornea ($P=0.0012$). In addition, there was no association between IOP and force needed to create an abrasion. In the contact lens groups, the maximum measurable force of 50 Newtons could not create any corneal abrasions at any direction of force with Senofilcon A lens ($P<0.001$) or Lotrafilcon A lens ($P<0.001$) (Fig. 3).

DISCUSSION

For many athletes, it is difficult to enforce the use of eye protection if their sport's governing body does not mandate it. In a survey of more than 1,000 Australian squash players, 92% did not wear eye protection despite 71% understanding that safety glasses would decrease their risk of eye injuries.[4] In addition, athletes requiring corrective eyewear may find glasses uncomfortable when physically active. Glasses may also distort their peripheral vision or affect the magnification of small objects.[4]

Soft contact lenses have historically been used to enhance epithelial healing and control pain from ocular surface disease. It has been routinely used after refractive surgery to accelerate healing and prevent erosions. Compared with traditional hydrogel lenses, silicon hydrogel bandage contact lenses offer a higher degree of oxygen permeability and allow for extended use. Senofilcon A and Lotrafilcon A, both silicon hydrogel bandage contact lenses, have been shown to enhance epithelial healing and reduce postoperative discomfort after photorefractive keratectomy.[5]

This study has shown that contact lenses can withstand a minimum of five times the average force needed to create corneal abrasions. Although further research is needed to evaluate the translation of these results in humans, the data suggest that contact lenses may add a layer of protection from ocular injury. It is important to note that the authors of this study are not recommending the use of contact lenses as a substitute for protective eyewear, nor are we recommending the prophylactic use of contact lenses for athletes with no refractive error. Further studies are needed to elucidate these protective properties when used in real-life situations in the setting of contact sports.

As a counterargument, there is a myriad of literature regarding the hazards of contact lens wear, particularly in unsanitary conditions and with contact lens overwear.[6] Refractive surgery, as an alternative, has long-term satisfaction in the quality of vision when compared with contact lens wearers.[7] However, for high physical contact athletes comfortable and careful with their contact lenses, it may provide an extra protective barrier to corneal abrasions that refractive surgery would eliminate.

Although these findings suggest the potential protective benefits of contact lens wear on ocular trauma, there are discernible limitations. This study used fresh porcine eyes, which possesses a much thicker cornea compared with a human eye. The mean thickness of the porcine cornea measures approximately 666 μm,[8] whereas the epithelium has an average thickness of 80 μm.[9] Acknowledging the

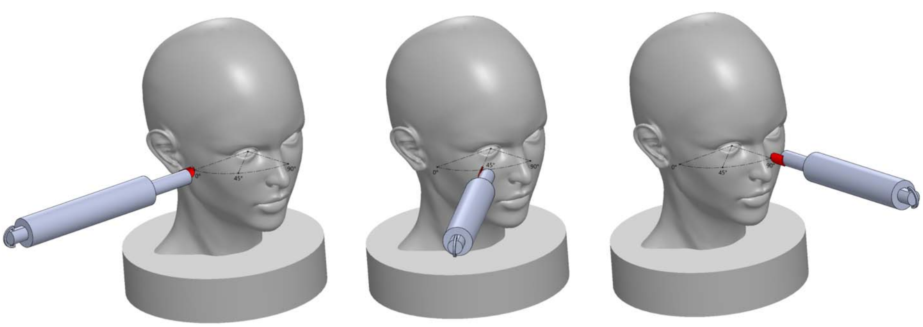

FIG. 2. Directions of impact. (*Left*) Impact at 0° from corneal surface. (*Center*) Impact at 45° from corneal surface. (*Right*) Impact at 90° from corneal surface.

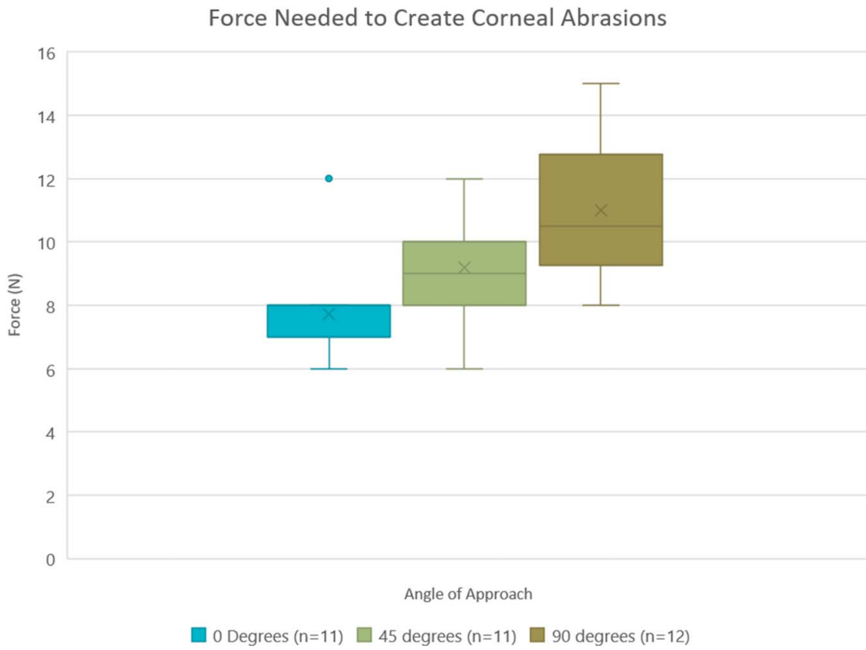

FIG. 3. Average impact force to create abrasion.

differences between the porcine and human eyes anatomy, steps were taken to simulate the human eye as much as possible. This included calibrating the IOP to normal human eye ranges and ensuring freshness of the porcine eyes (eyes were harvested within 24 hrs of experiment). Although contact lenses may be able to protect from corneal abrasion, there may be no protection from higher forces that may cause hyphema, retinal detachments, ruptured globes, or other intraocular injuries. It is important to add that contact lenses provide no added protection for periocular injury to the eyelids or orbital bones. For many athletes who are susceptible to high velocity blunt forces, the use of approved head and eye protection remains paramount.

The key message to be delivered is that eye protection for athletes is vital in preventing corneal abrasions. To find additional means of protection for the eyes would be widely beneficial, protecting millions of athletes around the world.

REFERENCES

1. Goldstein MH, Wee D. Sports injuries: An ounce of prevention and a pound of cure. *Eye Contact Lens* 2011;37:160–163.
2. Nelson LB, Wilson TW, Jeffers JB. Eye injuries in childhood: Demography, etiology, and prevention. *Pediatrics* 1989;84:438–441.
3. Basketball Goggles. Kareem Abdul-Jabbar: The greatest goggles in NBA history; 2011. Available at: https://basketball-goggles.com/2011/02/14/kareem-abdul-jabbar-the-greatest-goggles-in-history/. Accessed March 25, 2020.
4. Cass SP. Ocular injuries in sports. *Curr Sports Med Rep* 2012;11:11–15.
5. Razmjoo H, Abdi E, Atashkadi S, et al. Comparative study of two silicone hydrogel contact lenses used as bandage contact lenses after photorefractive keratectomy. *Int J Prev Med* 2012;3:718–722.
6. Sauer A, Greth M, Letsch J, et al. Contact lenses and infectious keratitis: From a case-control study to a computation of the risk for wearers. *Cornea* 2020;39:769–774.
7. Price MO, Price DA, Bucci FA Jr, et al. Three-year longitudinal survey comparing visual satisfaction with LASIK and contact lenses. *Ophthalmology* 2016;123:1659–1666.
8. Faber C, Scherfig E, Prause JU, et al. Corneal thickness in pigs measured by ultrasound pachymetry in vivo. *Scand J Lab Anim Sci* 2014;35:39–43.
9. Sanchez I, Martin R, Ussa F, et al. The parameters of the porcine eyeball. *Graefes Arch Clin Exp Ophthalmol* 2011;249:475–482.