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Case report

On-eye breakage and recovery of mini-scleral contact lens without compromise for the ocular surface

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ABSTRACT

Purpose: To report the on-eye breakage of a mini-scleral contact lens in a healthy cornea after being hit by a speeding object, without causing any severe corneal damage.
Case report: A 24-year-old Caucasian male involved in a clinical study reported the in situ breakage of a mini-scleral contact lens during motorbike maintenance. The patient reported eye redness and irritation that significantly decreased after all the pieces of the lens were recovered from the eye. Ocular examinations within 48 h showed absence of corneal damage other than superficial punctate keratitis inferiorly and no fragments of the lens were found in the conjunctival sac. The patient was wearing a 15.2 mm mini-scleral lens in a high Dk material. The evolution of rigid materials towards higher Dk values has resulted in a decreased hardness and modulus values, so these materials are more elastic when subjected to mechanical stress, which could be a beneficial aspect in absorbing the energy of an impact before breaking in pieces.
Conclusion: This case report shows that ScCL could have a protective effect to the corneal surface from the direct impact of a high-speed object. Mechanical material properties, wide supporting area and post-lens tear volume acted as protective factors helping to absorb and distribute the kinetic energy of the impacting object.

1. Introduction

The role of mini-scleral and scleral contact lenses (ScCL) for correction of irregular corneas with a wide range of etiologies and for ocular protection in cases of ocular surface diseases has been widely reported in the literature [1–4]. The excellent comfort, vision quality, centration and on-eye stability promoted by ScCL fittings comprise a series of advantages over other kind of contact lenses (CL). [5,6] These are the main reasons why practitioners are now prescribing ScCL beyond irregular corneas, namely to correct moderate to high refractive errors in normal corneas, accounting over 10% of the total ScCL fits [7].

Some concerns about the long term effects of ScCL wear have been raised, and the risk/benefit ratio of fitting ScCL in normal corneas is not well established [8]. To minimize the potential risks, like hypoxic stress of the cornea[8], ScCL are made of high oxygen permeability polymers which promote a better oxygen availability minimizing the corneal hypoxia [9]. However, these materials with higher Dk have a decreased hardness which is potentially related with the higher content of permeable monomers in the bulk of the material. As consequence, modern ScCL could hypothetically break more easily compared to PMMA thicker designs. When on-eye, ScCLs are entirely supported by the conjunctiva and sclera outside the corneal and limbal area [5]. Compared to other kind of CLs, a relatively thick liquid reservoir is trapped between the lens and the cornea, acting as protecting environment to avoid direct contact with the ScCL.

The following case report shows a 15.2 mm mini-scleral lens potentially acting as a protective shield to the cornea against the impact of a high-speed object and the safety procedures followed to ensure the recovery of the contact lens fragments, ocular health assessment and hypothesizing on the mechanical behavior of the contact lens during the impact.

2. Case report

A 24-year-old Caucasian male with a refraction of S + 3.75 = C −3.75 × 10° right eye (RE) and S + 3.75 = C −3.75 × 160° left eye

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(LE), participating in a mini-scleral lens clinical study reported the breakage of his right ScCL on eye during motorbike maintenance. The patient was bilaterally wearing mini-ScCL manufactured from Procornea (Eerbeek, Netherlands): the lenses were dispensed the day before the incident, so the subject was wearing the lenses just for one day. The technical details of the contact lens are presented in Table 1. The fitting of the contact lens on the dispensing visit is graphically presented in Fig. 1 depicting a central vault of approximately 370 μm after 30 min of lens wear (B). When first contacted the clinical investigator (R.A) he reported that 3 h before the lens broke after the impact of an object on his RE. The incident happened 6 h after ScCL application. He reported eye redness and irritation after the accident and confirmed to have recovered all pieces of the contact lens. He also reported a transient loss of vision after the impact what he attributed to the pieces of the contact lens floating on the eye. He further confirmed that vision was restored to normal levels and that discomfort was relieved after removal of all lens fragments.

Since the patient only contacted the clinical investigator on Friday night, 3 h after the incident and considering the relief of symptoms, normal visual perception, and patient's availability to attend the clinic, he was scheduled for a visit on Monday morning. The patient was also advised to report immediately in the event of worsening of vision, signs or symptoms and to go to a hospital emergency if necessary. Two days after the accident he showed no irritation or pain, while minor redness was persisting. Ocular examination showed absence of corneal damage other than superficial punctate keratitis in the inferior area (Fig. 2). It should be expected to see some conjunctival staining in the lens bearing points if the evaluation was done after the accident. However, since the patient was not wearing the lenses since the injury, the clinical investigator did not found any clinical differences in conjunctival health according to previous examinations. The ScCL was reconstructed from the pieces presented by the patient and apparently no fragments were observed (Fig. 3a), nor found in the conjunctival sacs.

By further investigating the accident, the object was determined to be a black rubber band with two metal square pieces attached to each end (Fig. 3b). The authors presume that one of the metal rings impacted the eye and lens when trying to pull the rubber band to fix a part of the motorbike he was repairing.

Table 1
Characteristics of the scleral contact lens.

Parameter	Value
Material	Boston XO (hexafocon A)
Dk	100 barrer
Central Thickness	400 μm
Diameter	15.2 mm
Back Optic Radius	8.20 mm
Power	+1.00 D (sphere)
Sagittal Depth	2.25
Refractive Index	1.425
Hardness	81/112 (Shore/Rockwell)
Density	1.27
Contact Angle	49

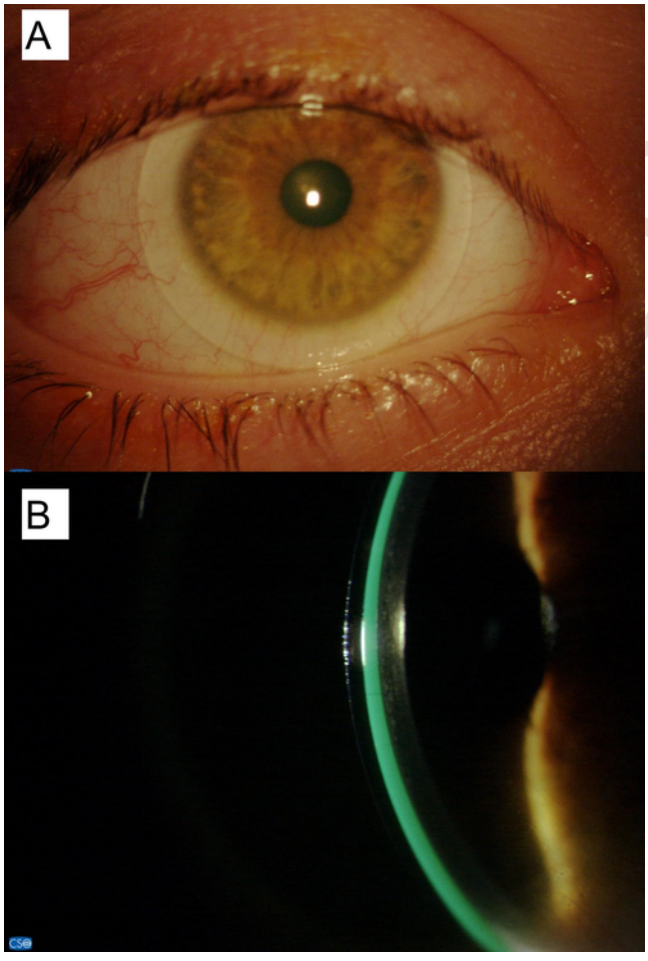

Fig. 1. Contact lens fitting at dispensing visit after 1 h of lens wear; (A) frontal view with absence of conjunctival blanching, (B) optical section with the slit lamp at central area at 16 x magnification.

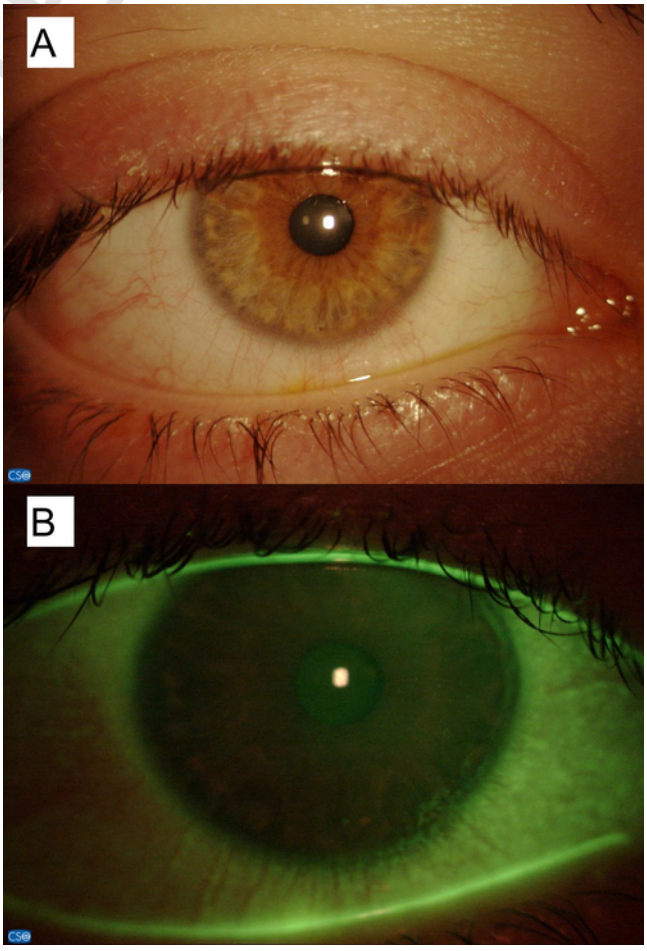

Fig. 2. Right eye of the subject 2 days after the accident; (A) increased redness in the inferior limbus, (B) positive fluorescein staining in the inferior area of the cornea.

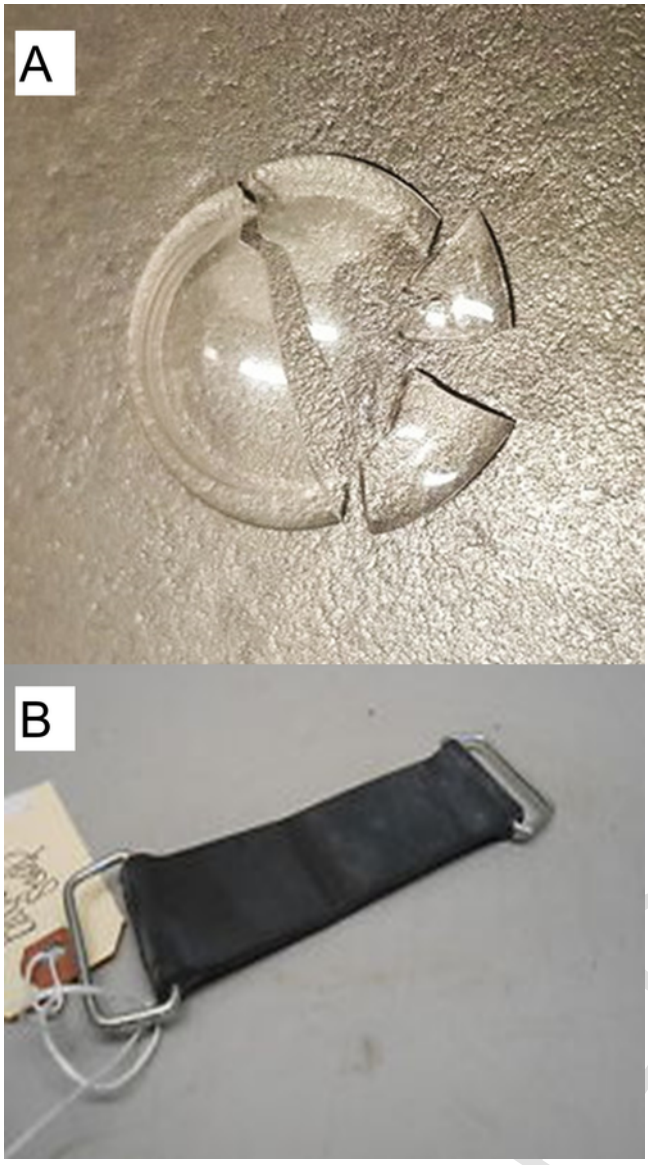

Fig. 3. (A) Contact lens fragments recovered by the patient; (B) Object that impacted the eye, consisting of a black rubber with two metal square rings.

The scleral supporting area of the lens was estimated using Image J 1.51 (National Institutes of Health, Bethesda, Maryland, USA) image processing software. Considering that the cornea has 11.9 mm diameter (measured with IOL Master, Meditec, Jena, Germany) and the lens 15.2 mm and a band of 0.5 mm in with between the supporting area and the limbus, there is a 1.15 mm width supporting band representing an 50.75 mm^2 area. The same software was used to estimate the lens-cornea separation resulting in 370 μm separation, being quite uniform with a mild asymmetry between the thinner superior and thicker inferior quadrants. This could be attributed to inferior lens deccentration commonly seen in ScCL fittings due to gravity action and scleral anatomy in the different quadrants of the landing zone.

Currently, the patient is wearing 15.2 mm ScCL in both eyes on a regular basis (5 times per week, between 8 and 12 h per day), reporting excellent comfort and vision (0.00logMar). No other adverse events were reported since the described accident.

Discussion

ScCL are beginning to enter mainstream contact lens practices, and gradually more specialists are prescribing them as treatment option for irregular corneas and for dry eye related cases. Recently, these lenses are also increasingly been prescribed for normal corneas as alternative to spectacles or other types of CL in cases of high refractive errors [7]. In this case report the authors hypothesized that the absence of clinically relevant damage to the ocular surface was due at least in part to the presence and protective nature of the ScCL. No impact signs were observed in the eyelids what suggests that the impacting object reached directly the ocular surface. The delay of 2 days in the schedule of an appointment was related with patient's availability and absence of complaints, as he didn't reported vision loss, or persistent redness once the lens pieces were removed. However, the authors want to reinforce the advice that these cases should be observed as soon as possible after the injury. In this case, penetrating injury was not considered possible giving the absence of severe symptoms, but such possibility cannot be ruled out in other similar events.

This is the first case in the peer reviewed literature reporting the potentially protective effect of a gas permeable ScCL in the event of impacting objects on the lens' surface. Although in this specific case the accident did not cause any severe corneal injury, it is important to know that ScCL can have a full breakage on eye which can potentially lead to corneal injuries in specific cases. The repercussions of these kind of accidents could be worse in more fragile corneas like post-surgical cases. However, the hypothetic protective advantage of ScCL has already been reported recently by Maria Walker et al. [10] in a case where a projectile hit the lens in situ without corneal damage but a hole in the lens. Reports of in situ breakage with different kinds of CL are rare but were previously mentioned in the literature before the appearance of rigid gas permeable (RGP) materials, and almost none of the published cases in humans reported significant injuries to corneal surface.

A study done with pigs eyes [11] encountered fewer and less severe corneal injuries from high-velocity projectiles in CL-wearing eyes than in controls and that those eyes wearing soft CL had more corneal damage than those wearing rigid lenses. The results of another early study with rabbits [12] wearing soft (HEMA) and rigid CL (PMMA) showedthat when in an environment with hot grid particles the CL (namely PMMA) will act as a protection shield However, when they were exposed to mechanical damage caused by large solid particles, the energy required for the projectiles to splinter the PMMA lenses was significantly lower than that required to perforate the cornea, so the authors believed that the corneal damage could be higher with these lenses than without them.

However, there are some other reports that contradict those arguments. In 1964, Brown [13] reported traumatic fractures of plastic CL resulting from fist injuries: one patient developed a corneal abrasion with remaining parts of the lens on eye and another patient had a minimal corneal abrasion 24 h after the injury. More recently, Caroline et al. [14] reported another case in which a 35-year-old female has been afflicted by a 3 mm piece of a large metal staple that broke her left corneal RGP lens in four pieces. Similarly to this case, the subject needed to remove the pieces immediately. By the time of examination, the subject still had two small epithelial defects and diffuse edema. The authors also hypothesized that the RGP lens had an important protective role to the corneal integrity (from a severe penetrating injury). They also hypothesized that "*The presence of a RGP lens can both slow down the velocity of an airborne projectile, and distribute the projectile's force over a significantly larger area before the contact lens breaks into multiple pieces*."

In 1981, Nilsson et al. [12] concluded that the rigidity of the material is a key factor, as low water content soft CL required a higher energy of the particle for the perforation of the lens than high water content CL, and that PMMA CLs broke at the same energy than that required for perforation of the cornea. Nowadays, patients frequently refer to mechanically break their RGPs during cleaning. Similarly, and considering the lower rigidity of modern RGP materials, it is expected that flying hard particles require low momentum to break the lenses: however, the remaining pieces of RGP lenses could be a risk for corneal injuries.

The XO material is currently used to manufacture ScCL as this material combines a high oxygen permeability required to minimize hypoxic effects. [9] As seen in Fig. 4 the evolution of Boston materials towards higher Dk values has resulted in lower hardness and modulus values. Therefore, the authors speculate that XO material is less brittle than older materials (like PMMA) and will present a more elastic behavior when subjected to mechanical stress and this might be a beneficial aspect to resist breakage during handling. In the present case, this might had also been beneficial in absorbing the energy of the impact before braking in pieces. The authors further hypothesize that the thick (over 300 μm in this case) post-lens tear film also acted as a cushioning factor spreading the incoming pressure over a larger surface and minimizing the risks for the ocular surface.

In conclusion, this case report describes the potential protective action of a ScCL device. Although the literature showed other cases where ScCL seemed to help protecting the eyes from potentially harmful projectiles, it is not the authors' intention to encourage the use of ScCL for eye protection as they do not replace safety glasses during potentially risky activities. However, this case report shows that the ScCL worn most probably had a protective effect to the corneal surface from the direct impact of a high-speed object. The main hypothesis is that the mechanical properties of the lens material, the wide lens-conjunctiva supporting area and the volume of tear reservoir acted as protective factors helping to absorb and distribute the kinetic energy of the impacting object.

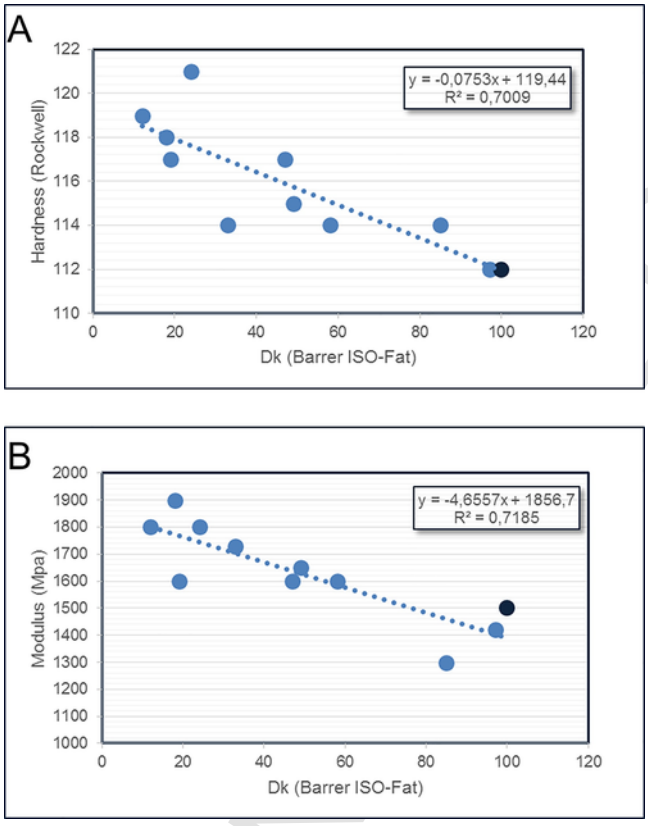

Fig. 4. Changes in hardness (A) and modulus (B) of RGP Boston materials as DK values increased. The XO material is highlighted in a darker color. Values extracted from Boston Product Guide.

Disclosure

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Written consent has been obtained from the patient to publish the information reported in this paper.

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