

Commentary (Series editor: David Taylor)

Are airbags a risk for patients after radial keratotomy?

Recently, some investigators have expressed concern about the impaired integrity and decreased tensile strength of the cornea following radial keratotomy (RK) and wound healing, because of pathological findings in human and animal corneas.¹⁻³ Corneal tensile strength in eyes following RK has been evaluated in animal models. It has been reported that rabbit corneas require 54% less energy for rupture following RK than human control corneas over a 90 day period, and 98% of operated eyes rupture along one or more corneal incisions with or without extension into the sclera.⁴ In a histopathological study, incomplete healing 2 years after RK has been reported.⁵ In contrast, there was no significant difference in tensile strength between RK corneal strips and control strips from human cadaver eyes, indicating that the increase in susceptibility to rupture due to RK may be hard to predict and may depend on factors such as the size of the epithelial plug and the strength of the wound collagen.² However, after the epithelial plugs are replaced with collagen, there is no assurance that the tensile strength of the cornea will be more than 50% of the preoperative value, since the only barrier to globe rupture from direct external forces and internal forces of acutely raised intraocular pressure at the time of impact is the 0.02 to 0.05 mm of unincised corneal tissue, epithelial plugs, and irregular scar tissue.⁶

There are documented cases of RK wounds withstanding severe blunt ocular trauma; however, there are also reports of corneas that ruptured at RK incisions after trauma.^{6,7} Another report cites examples of corneal rupture through RK incisions after blunt trauma as late as after 10 years.⁸ Although the incidence and need for RK have been decreasing for several years because of the introduction and increase of laser in situ keratomileusis (LASIK) and photorefractive keratectomy (PRK) using the excimer laser, there remain a huge number of patients who have undergone RK, and the procedure remains a valuable method for correction of moderate myopia, notably because of its minimal cost.⁹

Airbags, which have been mandatory in the United States since 1991, are designed to mitigate head and upper torso injuries to the driver and passenger in frontal crashes of motor vehicles. The efficacy of airbags in the prevention of motor vehicle related injury and death is well documented.¹⁰ Despite the overall protective effect of airbags, they can cause fatal and non-fatal injuries if the driver's head, neck, chest, or arms are too close to the deploying airbag.^{11,12} Among the most severe airbag associated injuries are those of the ocular region. Although airbag induced ocular injuries are rare, they still present a serious concern because of the possibility of permanent damage or visual impairment. Gaseous and particulate components (sodium hydroxide, carbon monoxide) are emitted inside the vehicle at airbag deployment.¹³ However, skin abrasions and eyelid ecchymoses, the most common facial injuries, are usually short lived, and these chemical injuries due to airbags have less clinical importance than mechanical trauma. Airbag induced mechanical ocular injuries include corneal abrasion, corneal laceration, corneal endothelial cell loss, angle recession, hyphaema, cyclodialysis cleft, retinal haemorrhage, and retinal detachment.¹⁴⁻²⁰

A case of airbag related corneal rupture in a patient who had undergone RK 2 years previously has been reported.²¹ This patient was struck in the eye when the driver's side airbag inflated during a low speed collision. The critical determinant of severity of ocular injury associated with airbag deployment appears to be the aggressiveness of the airbag. The industry average for the deployment velocity of an airbag is 64.5 m/s and calculated deployment velocities range between 50 and 113 m/s.²² They inflate in about 10 ms in response to sudden longitudinal deceleration and deflate within seconds.

We have previously developed a simulation model of the human eyeball based on information obtained from cadaver eyes, using a specific software program for a computer,²³ and applied to it simulated airbag ocular injury to determine the physical and mechanical conditions of the impacting airbag causing corneal rupture in a post-RK eye. At an airbag impact velocity of 40.0 m/s, three of four, five of six, and eight of eight incisions were likely to rupture in the case of four, six, and eight incision procedures, respectively, leading to very likely globe rupture in all situations. It was also observed that lacerations extended beyond the incisions and involved the intact cornea at a velocity of 40.0 m/s (Fig 1). According to this result, at an ordinary airbag impact velocity of more than 50.0 m/s, corneal rupture is very likely to occur in the post-RK eye.

The other important factor determining ocular injury by an airbag is the distance between the driver's face and the steering wheel at the time of airbag inflation. Studies reporting measured distance between the driver and the steering wheel indicate that 5% of women sit within 10 inches (25 cm) of the steering wheel when driving a vehicle.^{4,12} In that case, given the decelerating nature of the collision and the relatively small size of the driver, the driver's face is most likely to be close to the steering wheel when the airbag inflates.¹⁶ It should be noted that according to these reports, RK is a probable risk factor for corneal rupture by airbag impact. Patients at increased risk of trauma, such as policemen, athletes, etc, should be counselled towards having a less structurally weakening refractive procedure such as PRK or LASIK. As part of the informed consent process, the patient should be told of the risk of globe rupture. Also, patients who have undergone RK may benefit from wearing protective eyewear not only when engaged in ball sports or hazardous activities, but also while driving cars equipped with airbags.⁷ It has been reported recently that a patient developed partial dislocation of the corneal LASIK flap, resulting in epithelial ingrowth beneath the LASIK flap.²⁴ The wound healing response of LASIK allows corneal flap separation from its stromal bed for an indeterminate time after surgery. Owing to the absence of a deep incision scar, serious corneal complication is rare in LASIK; however, the possible risk of corneal trauma should also be noted with this method.

In conclusion, it is important for eyecare providers and car manufacturers to cooperate in research aimed at modifying airbag design and deployment to minimise the risk of ocular injury. With information including past clinical reports and our simulated study, further refinements in

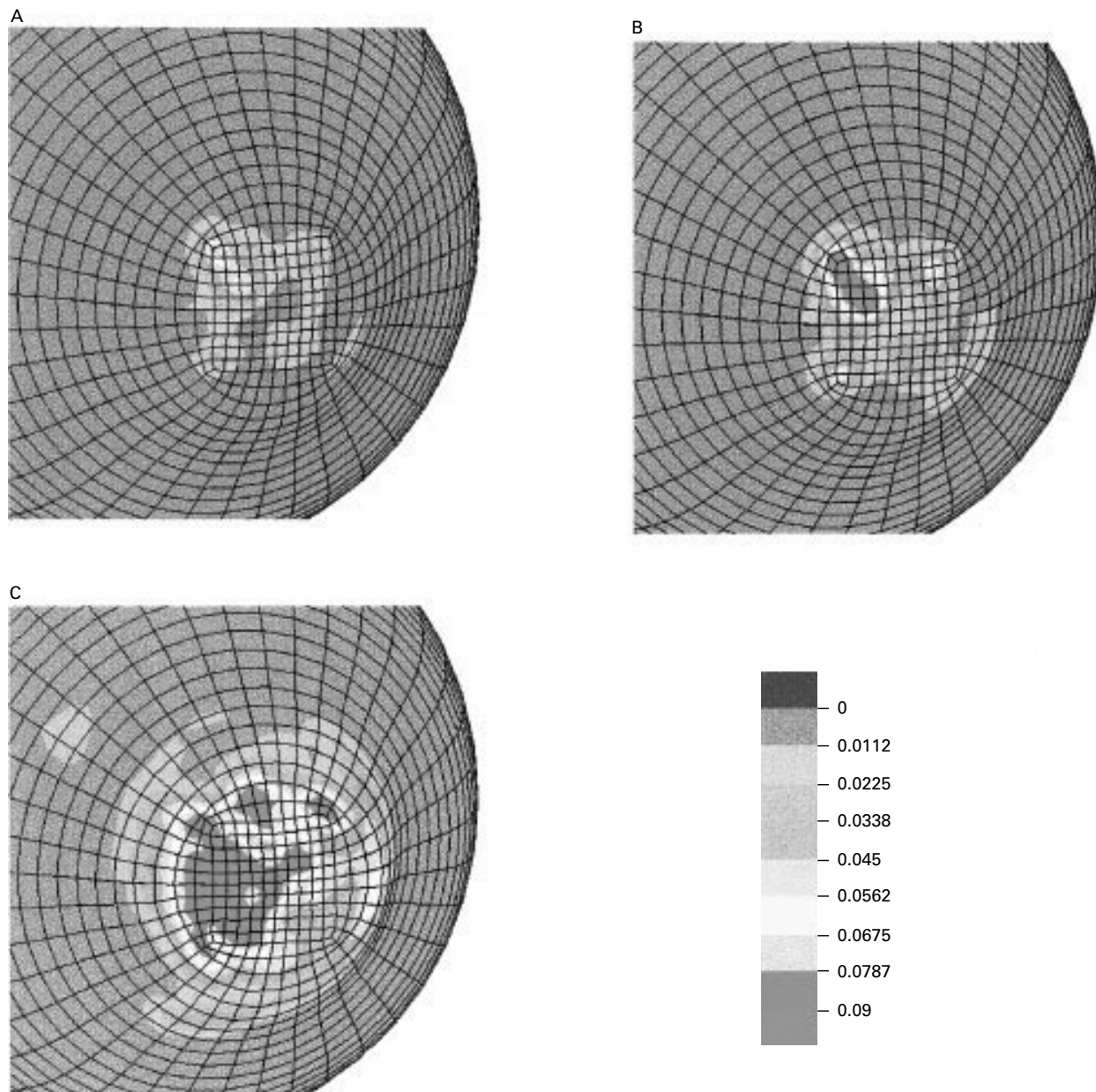


Figure 1 Simulated airbag impact on cornea at three different impacting velocities, 20.0 m/s (A), 30.0 m/s (B), and 40.0 (C) m/s. Results of strain in the case of four incision radial keratotomy are displayed. Bar indicates strain. Corneal rupture is very likely at an impact velocity of 40.0 m/s.

airbag activation, deployment, and design should be possible to prevent ocular morbidity from both driver's side and passenger's side airbags.

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