Innovative Treatment for Severe Ocular Trauma

a report by

Wolfgang F Schrader

Head, Vitreoretinal Department, Maximilians Eye Clinic, Nürnberg

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Despite the progress in vitreoretinal surgery, the anatomical and functional results of severe ocular injuries involving the posterior segment are still discouraging. Perforating injuries and ruptures that extend posterior to the muscle insertions have the worst outcomes. When the secondary intervention is usually performed, between seven days and 14 post-trauma, it is not unusual for severe proliferative vitreoretinopathy (PVR) to have already occurred. This article will show that, based on a new approach of acting on rather than reacting to alterations secondary to severe posterior segment trauma, the functional results of these injuries may be further improved. The internal reconstruction already takes place at the same time as the primary wound closure, or alternatively within 100 hours of the trauma. This idea is currently being further investigated in a prospective multicentre multinational study conducted by the World Eye Injury Register (WEIR).

An ocular injury can completely change the life of an injured person. Eye injuries that require medical treatment occur in 810 people per 100,000 in the general population. Among those who suffer these injuries, around 10% are not capable of working for three or more days. However, 94.5% of all ocular injuries are not serious, and most of them consist of foreign bodies in the cornea or superficial conjunctival lesions. Among the 5.5% that constitute serious injuries, 80% are contusions with anterior chamber haemorrhage or chemical injuries, and 20% are open globe injuries.

Terminology of Ocular Trauma

In this article, terms are used according to the Birmingham Eye Trauma Terminology (BETT) system, which is now acknowledged by most national and international ophthalmological associations (among them the American Academy of Ophthalmology [AAO], the International Society of Ocular Trauma [ISOT] and the German Ophthalmological Society [DOG]). According to this classification, closed globe injuries are distinguished from open globe injuries. Closed globe injuries obviously include blunt trauma such as contusion bulbi, but also scleral or corneal lacerations, as long as they do not penetrate the eye wall. Among lacerating open globe injuries, penetrating injuries (with only an entry wound) are differentiated from perforating injuries (with both an entry and an exit wound). Injuries with intraocular foreign bodies should also be categorised with the open globe injuries; however, they belong to a separate category, as they usually have an entry wound only (such as a penetrating injury) but may behave like a perforating injury (when the foreign body injures the retina and choroid from the inside of the eye). The following article reviews different surgical approaches to improving the functional outcome of serious open globe injuries. Among these open globe injuries, perforating eye injuries and ruptures, especially those reaching the sclera behind the muscle insertions, have the worst anatomical and functional outcomes, as PVR with subsequent retinal detachment is often observed early in these cases.

Factors that Determine the Anatomical and Functional Outcome of Ocular Trauma

The anatomical and functional outcome of an open globe injury is determined by four factors: the mechanism of the injury, patient age, extent of the injury and surgical approach.

Impact of the Mechanism of the Injury

The mechanism of the injury has a major impact on the functional outcome. The mean risk of endophthalmitis following an open globe injury is 3.6% (2–7%). Half of all people with post-traumatic endophthalmitis will lose their vision, and only 25% of those injured regain a visual acuity of 20/40 or better. The risk of post-traumatic endophthalmitis is elevated in an agricultural environment; the average risk is 12%. In our own series of 1,026 injuries, eye injuries caused by wires carried a high risk (38%) of endophthalmitis. An open globe injury sustained by a tree branch carries a 20% risk, and injuries by arrows or darts a 13% risk.

Impact of Age

The older the patient, the worse the outcome. We registered a blindness rate (according to German law 20/400 or less) or loss of the eye (enucleation) rate following open globe injuries in the zero- to 14-year-old age group of less than 20%, which is half the rate found in those above 65 years of age. The latter age group contributed to 9% of all open globe injuries, but to 41% of ruptures. Of the injured eyes in the older age group, 39% had already undergone eye surgery (mostly cataract surgery). The anatomical and functional outcome of an open globe injury is determined by four factors: the mechanism of the injury, patient age, extent of the injury and surgical approach.

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- the rate of eyes with previous ocular surgery changed over time;
- among the 25 ruptures in the older age group registered between 1981 and 1985, nine (36%) had undergone previous cataract surgery;
- among the 20 ruptured eyes of the same age group that occurred between 1986 and 1989, eight (49%) had undergone previous cataract surgery;
- between 1990 and 1993, the absolute number of ruptures in this age group doubled to 46 cases, with 25 (54%) having had previous cataract surgery, and...
In the 1980s, most surgeons used wide corneal or corneoscleral incisions for cataract surgery. In the early 1990s, smaller corneoscleral tunnel incisions were introduced, which we regard as being the reason for the decline in the absolute number of ruptures. However, due to demographic changes, the rate of rupture is now increasing again.

**Extent of Injury**

If the injury is restricted to the anterior segment of the eye, the majority of eyes will regain reading ability. However, if the retina is involved, only a minority of eyes will reach a useful function level again. In our series, half of the eyes with retinal involvement became blind or had to be enucleated.

**Surgical Approach**

Thirty-five years ago, attempts were made not to limit primary surgery to wound closure, but to also proceed with an internal reconstruction by using the newly developed pars plana vitrectomy. It was already known that lens fragments and vitreous haemorrhage induced a chronic inflammatory reaction that enabled the development of strands, membranes, retinal detachment, hypotony or phthisis. Retinal detachment was found in 37% of all open globe injuries and a reattachment could be achieved in 66% of these cases.

**Primary Internal Reconstructions**

In November 2004, Kuhn and the author developed the protocol for a pragmatic approach that on the one hand supports the idea of acting before PVR with synechiae, retinal detachment and tractional folds can develop to prevent the expected complications related to vitreous traction, vitreous haemorrhage or retinal incarceration, but on the other hand to leave a time-frame of 100 hours.

**Prospective Evaluation of Early Vitrectomy**

As even in specialized institutions a trauma surgeon is not always available, Kuhn and the current author developed the concept of a pragmatic approach that on the one hand supports the idea of acting before PVR with synechiae, retinal detachment and tractional folds can develop to prevent the expected complications related to vitreous traction, vitreous haemorrhage or retinal incarceration, but on the other hand to leave a time-frame of 100 hours.

In November 2004, Kuhn and the author developed the protocol for a prospective multicentre trial, the Proactive Management of Eyes with Perforating/Rupture/intraocular foreign bodies (IOFBs) Injuries study. The aim of this study is to compare the anatomical and functional results of early vitrectomy (within 100 hours of the trauma) with vitrectomy in the second post-traumatic week. The results of early vitrectomy will be compared with matched cases from the WEIR database. The inclusion criteria are:

- perforations, i.e. eye injuries with a corneal or scleral entry wound and a scleral exit wound;
- intraocular foreign bodies with an impact deeper than the retina, i.e. with choroidal or scleral involvement; and
- ruptures reaching behind the muscle insertions.

Those with endophthalmitis are excluded, as the condition develops independently of the surgical approach and will interfere with the anatomical and functional outcome. The occurrence of PVR and full-thickness retinal folds will be compared between the two treatment groups. The primary surgical procedure will be the wound closure plus a...
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Surgery Ocular Trauma

**Is No Light Perception Exclusion a Criterion for Attempting a Secondary Reconstruction?**

In the 1980s, the treatment strategy was quite clear. If there was little hope for a functional reconstruction, enucleation was advised to prevent sympathetic ophthalmia. Any eye that had lost the ability to perceive light was considered to be non-reparable. It was only 10 years ago that Morris et al. reported on their attempts to reconstruct 11 eyes with severe ocular trauma that could not perceive light. The authors succeeded in restoring some function in seven of 11 cases. According to an analysis in the WEIR of 340 severely injured eyes that presented without light perception upon initial examination, an attempt to reconstruct these eyes was undertaken in only 28 cases. Of the 312 eyes that were not reconstructed, 298 remained without light perception, six were legally blind but could perceive light, three had some ambulatory vision, one recovered a visual acuity of between 20/200 and 20/50 and four recovered spontaneously to a visual acuity of 20/40 or better. However, among the 28 eyes in which a reconstruction was attempted, no eye had to be enucleated and no eye remained unable to perceive light. Twenty-one patients regained light perception and two ambulatory vision below 20/200. In four eyes, a visual acuity of between 20/160 and 20/50 could be restored, and one eye even received a visual acuity of better than 20/40. One may conclude from this observation that any attempt to reconstruct an eye is useful to preserve the eye functionally and keep the chance of a functional improvement, irrespective of an initial complete functional loss.

This observational study began in November 2004, and vitreoretinal centres are participating worldwide. After an interim analysis of the first 21 cases from three centres, 19 reached a complete retinal attachment. Two of the 19 suffered a secondary retinal detachment that could be reattached in both cases. In three eyes an epiretinal membrane had to be removed. After six months, six patients still had a silicone oil tamponade, 10 had their silicone oil tamponade removed and five did not need an oil tamponade (see Figure 1a). Two of 21 patients had a visual acuity of below 20/200, 10 regained an acuity of between 20/200 and 20/60 and nine had 20/50 vision or better. In summary, the majority of eyes reached a satisfying functional outcome.

**Figure 1a: Schematic Representation of a Prophylactic Chorioretinectomy**

After complete vitrectomy followed by diathermy destruction of the choroid and retina, 1mm of retina and choroid is cut out so that bare sclera is visible around the scar. Photocoagulation is applied to the remaining edge.

**Figure 1b: The Retina Is Healing without Any Traction**

Photocoagulation is applied to the remaining edge.