Innovative Treatment for Severe Ocular Trauma

a report by
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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 days seven 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.[1] 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.[1] Among the 5.5% that constitute serious injuries, 80% are contusions with anterior chamber haemorrhage or chemical injuries, and 20% are open globe injuries.[1]

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]).[2] According to this classification, closed globe injuries are distinguished from open globe injuries. Closed globe injuries obviously include blunt trauma such as contusio 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).[2] 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.[3]

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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%).[3] 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.[3] 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 endopthalmitis. An open globe injury sustained by a tree branch carries a 20% risk, and injuries by arrows or darts a 13% risk.[3]

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). In a survey of the causes and anatomical and functional results of 1,026 open globe injuries that we published in 2004, we also noted that:

- the rate of eyes with previous ocular surgery changed over time;[3]
- 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

- the rate of previously operated eyes among the ruptures declined to two of nine (22%) in 1994, and further to three of 19 (16%) between 1996 and 1999.

In the 1980s most surgeons used wide corneal or corneoscleral incisions for cataract surgery. In the early 1990s smaller cornescleral tunnel incisions were introduced, which we regard as being the reason for the decline in the absolute number of ruptures.[3] 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 functioning level again. In our series, half of the eyes with retinal involvement became blind or had to be enucleated.[3,4]

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.[5] 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.[5] Lemmen and Heimann reported on severe ocular injuries that could be anatomically and functionally sufficiently reconstructed by early intervention with pars plana vitrectomy and silicone oil.[6] However, the question remains as to when this internal reconstruction is best performed. Theoretically, an internal reconstruction becomes easier after a spontaneous vitreous detachment has developed. However, if a pars plana vitrectomy is performed between days seven and 14, in many cases PVR has already developed, impairing the vitrectomy or even making an internal reconstruction impossible. On the other hand, if a pars plana vitrectomy is performed within the first few post-traumatic days, there is a higher risk of bleeding and surgery might become more difficult because of haemorrhage. However, it may be easier because membranes and strands have not yet developed. It is possible that an early intervention may reduce the rate of PVR.

Wound Closure Combined with Primary Internal Reconstruction

We attempted to combine primary wound closure with internal reconstruction for severe ocular ruptures of perforating injuries in Wuerzburg if there was a retinal surgeon available. If no retinal surgeon was available, we performed the primary wound closure in the classic way, with reconstruction taking place at around post-traumatic day seven.

The typical procedure was as follows. In addition to the wound closure procedure, an encircling band was sutured on with only gentle indentation. Three classic ports were prepared for 20-gauge vitrectomy. An anterior vitrectomy was performed via this pars plana approach and the crystalline lens was removed if it had not already been expelled by the trauma. Frequently, a refixation of the ciliary body or the iris base was necessary using the MacCannel technique modified by Mackensen.[7] A complete pars plana vitrectomy was performed with induction of a posterior hyaloid detachment (which is often difficult at this time) and the retina was stabilised with perfluorocarbon liquids, endolaser cerclage and, finally, an exchange of perfluorocarbon liquids for silicone oil. This procedure takes about 2.5–3.5 hours. It is mandatory that the surgeon is experienced in all of the difficulties in posterior and anterior segment surgeries. In the past, the surgical tasks were split between the anterior and posterior segment surgeons. However, today more and more of the younger generation of posterior segment surgeons are also able to perform difficult anterior segment surgeries, and therefore are qualified to perform 'pole-to-pole' surgery, a term coined by the Italian Cesare Forlini.

Retrospective Evaluation of Primary Internal Reconstructions

We retrospectively analysed the outcome of 71 perforating injuries and ruptures treated at the University Eye Hospital of Wuerzburg. At six months after trauma, 25% of these eyes had a visual acuity of 20/200 or more, 25% became blind (no light perception) or phthisical or had to be enucleated and the remaining 50% regained only ambulatory vision.

If the secondary vitrectomy was performed more than four days after trauma, only three of 29 eyes (10%) reached a visual acuity of 20/200 or better, while six of 29 (21%) became blind (no light perception), phthisical or had to be enucleated. Following primary vitrectomy (within 12 hours of the trauma) or early vitrectomy (within 100 hours), nine of 27 eyes (33%) regained visual acuity of 20/200 or better, while three (11%) became blind or had to be enucleated. There is a trend for more patients to regain useful vision when internal reconstruction is performed within one week of trauma.

Prospective Evaluation of Early Vitrectomy

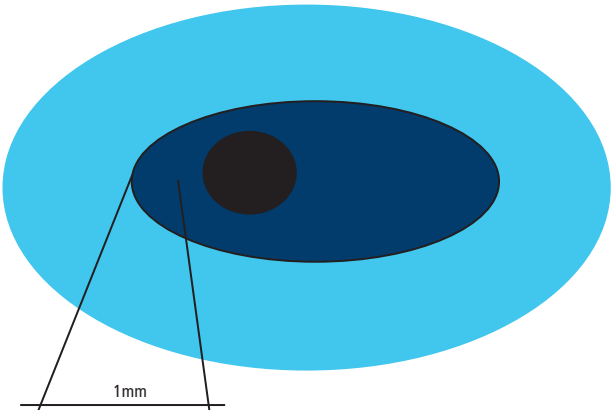
As even in specialised institutions a trauma surgeon is not always available, Kuhn and the current author developed the concept of a pragmatic approach that on the one hand supports the idea of acting before PVR with synechiae, retinal detachment and tractional folds can develop to prevent the expected complications related to vitreous traction, vitreous haemorrhage or retinal incarceration,[8] 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 chororidal or scleral involvement; and
- ruptures reaching behind the muscle insertions.

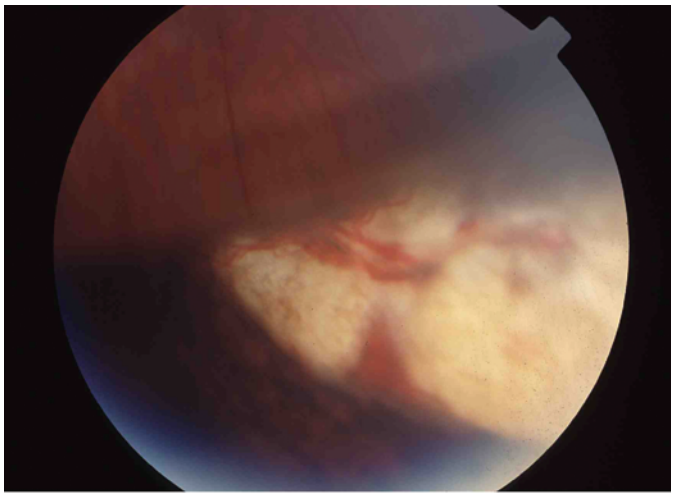
Those with endophthalmitis are excluded, as the condition develops independently of the surgical approach and will interfere with the anatomical and functional outcome. The occurrence of PVR and full-thickness retinal folds will be compared between the two treatment groups. The primary surgical procedure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

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



limited anterior segment reconstruction with the removal of major vitreous tractions between the entry and exit wounds by a limited vitrectomy. Within 100 hours (i.e. four days and four hours), a complete anterior and posterior vitrectomy will be performed, including a complete posterior vitreous detachment and the removal of all tractional components around the exit wound. To reach this goal, 1mm of retina and choroid around the exit wound will be diathermised and removed after a retinopexy with endolaser plus an 360° endolaser cerclage has been performed (see *Figures 1a and 1b*). Usually, a temporary silicone oil tamponde is used to secure the retinal attachment.

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 1b*). 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.

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.[9] 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.[10] 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.[11] 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 20/2000 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.[11] One may conclude from this observation that any attempt to reconstruct an eye is useful to preserve the eye anatomically and keep the chance of a functional improvement, irrespective of an initial complete functional loss.

This observation not only proves that a missing light perception is no contraindication to an attempt to reconstruct an eye anatomically. Despite repeated surgeries, the risk of sympathetic ophthamia has not risen above 0.1–0.3% during the last four decades.[12,13] In 1984, despite the then common strategy, Belkin advised not to enucleate an injured eye only because of the risk of sympathetic ophthalmia and as long as the patient can be kept under observation. On the other hand, evisceration seems to be no measure to prevent the development of sympathetic ophthalmia.[14,15] ■

1. Mönestam E, Björnsti U, Eye injuries in northern Sweden, *Acta Ophthalmol*, 1991;69:1–5.
2. Kuhn F, Morris RE, Witherspoon CD, et al., A standardized classification of ocular trauma terminology, *Graefes Arch Clin Exp Ophthalmol*, 1996;234:399–403.
3. Schrader WF, Epidemiologie bulbuseröffnender Augenverletzungen: Analyse von 1026 Fällen über 18 Jahre, *Klin Monatsbl Augenheilkd*, 2004;221(8):629–35.
4. Kuhn F, Morris R, Witherspoon CD, Mann L, Epidemiology of blinding trauma in the US Eye Injury Registry, *Ophthalmic Epidemiol*, 2006;13:209–16.
5. Faulborn J, Atkinson A, Olivier D, Results of primary vitrectomy in severe perforating ocular injuries, *Mod Probl Ophthalmol*, 1977;18:245–6.
6. Lemmen KD, Heimann K, Früh-Vitrektomie mit primärer Silikonolinjektion bei schwerstverletzten Augen, *Klin Monatsbl Augenheilkd*, 1988;193:594–601.
7. Mackensen G, Chirurgie der Iris und des Ziliarkörpers. In: Mackensen G, Neubauer H (eds), *Augenärztliche Operationen*, Heidelberg: Springer, 1989;1.
8. Kuhn F, Mester V, Morris R, A proactive treatment approach for eyes with perforating injury, *Klin Monatsbl Augenheilkd*, 2004;221:622–8.
9. Canavan YM, Archer DB, The traumatized eye, *Trans Ophthalmol Soc UK*, 1982;102:79–84.
10. Morris R, Kuhn F, Witherspoon C, Management of the opaque media eye with no light perception (NPL) after recent injury. In: Alfaro V, Liggett P (eds), *Vitreoretinal Surgery of the Injured Eye*, Philadelphia, 1998.
11. Morris R, Management of ocular trauma: Treatment options for eyes with no light perception, Proceedings of the 12th Congress of the Societas Ophthalmologica Europæe, Stockholm 1999.
12. Allen JC, Sympathetic ophthalmia: a disappearing disease, *JAMA*, 1969;209:1090.
13. Liddy BSTL, Stuart J, Sympathetic ophthalmia in Canada, *Can J Ophthalmol*, 1972;7:157–9.
14. Freidlin J, Pak J, Tessler HH, et al., Sympathetic ophthalmia after injury in the Iraq war, *Ophthal Plast Reconstr Surg*, 2006;22(2):133–4.
15. du Toit N, Motala MI, Richards J, et al., The risk of sympathetic ophthalmia following evisceration for penetrating eye injuries at Groote Schuur Hospital, *Br J Ophthalmol*, 2008;92(1):61–3.