

Open Globe Injuries: Epidemiological Study of Two Eye Clinics in Germany, 1981-1999

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Aim. To analyze the epidemiology of open eye globe injuries and their treatment outcomes in patients treated at two university eye clinics in Germany in the past two decades.

Methods. Retrospective analysis was performed of medical records of 1,026 patients with open globe injuries primarily treated at the Universities of Freiburg and Würzburg between January 1981 and December 1999. Final visual function was determined as a parameter of age, extent of injury, sex, cause of injury, and activity at the time of injury. Relative risk was calculated.

Results. After correction for the demographic distribution, the risk for open globe injury was 1.7 times the average for young adults and 0.6 for seniors. In the recent years, the risk for severe eye injury has been more equally distributed and is increasing for old people. The proportion of injuries at work decreased over the studied period from 42% to 32% for all open globe injuries, and the proportion of injuries in traffic accidents decreased from 30% to 4%. The number of eye injuries related to hobby activities increased. The proportion of enucleations and blindness decreased. Social life and income was moderately or severely impaired in 27% of patients after severe unilateral eye trauma. The median follow up of patients was 7 months.

Conclusion. The prevalence and types of open globe injuries changed over the years, especially in relation to the law requiring seat belt use in traffic. The progress in surgical techniques led to a significant reduction in the number of blind eyes after injury. The proportion of enucleations and blindness decreased partly due to better surgical techniques, but mostly due to the decrease in injuries with usually poor outcome, such as gunshots, ruptures, and windscreen injuries.

Key words: epidemiology; eye foreign bodies; eye injuries; socio-economic factors; vitrectomy

Ocular trauma may have a significant impact on the patient's quality of life. An ocular trauma requiring medical care occurs in 810 people per 100,000 population a year (1). Among these injuries, 10% result in incapacity for work lasting for more than 3 days. Five percent of ocular trauma are severe contusion injuries, 1-2% are open globe injuries, and 1% are severe chemical injuries (1).

The vocabulary to describe ocular injuries has been well standardized. The "Birmingham eye trauma terminology" (BETT, Fig. 1) for this type of injuries (2) is now recommended by many national and international ophthalmologic societies, including Deutsche Ophthalmologische Gesellschaft, American Academy of Ophthalmology, and International Society of Ocular Trauma. Severe eye injuries are divided into closed globe and open globe injuries. A closed globe injury may be a contusion or a lamellar laceration. An open globe injury may either be a rupture or a laceration. Lacerations may be penetrating injuries (entry wound only), intraocular foreign bodies, or perforating injuries (with an entry and an exit wound).

Severe contusions, open globe injuries, and chemical burns regularly require hospitalization and inpatient treatment.

The aim of this study was twofold: to establish whether the etiology of ocular trauma and its epidemiology changed over time and whether an open globe injury affected quality of life these patients. To

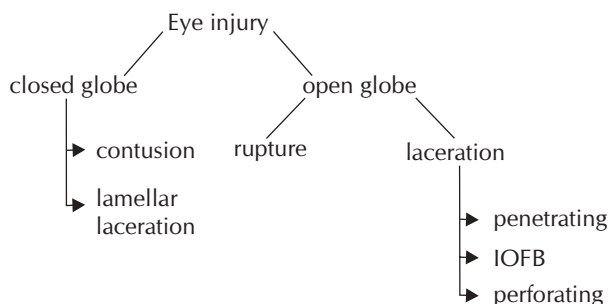


Figure 1. Birmingham Eye Trauma Terminology (BETT classification) of severe ocular trauma (ref. 2). IOFB – intraocular foreign body.

answer the former question, a retrospective analysis was performed of medical records on open globe injuries treated in two institutions over 18-year period. The answer to the latter question was obtained through a special questionnaire sent out to a sample of male patients of working age with open globe injury. The possible improvement in the outcome of open globe injuries, changing concepts of intraocular foreign body removal, timing of vitrectomy, and maximum surgery in blind eyes have also been addressed.

A local eye trauma registry may be used to determine the epidemiologic characteristics of ocular trauma. Such national eye trauma registries have been established in the United States, Israel, Finland, and Hungary (3), but not in the central Europe, where only hospital-based studies exist. However, data from hospital-based studies including population from major cities and industrial areas, such as Belfast (4), Vienna (5), and Cologne (6) cannot easily be compared with data from studies performed in rural areas, e.g., Kiel (7), Marburg or Freiburg (8,9), and Würzburg (10,11), because the etiology of eye trauma in urban and rural areas differs.

Patients and Methods

Patients

The source of data were medical records of 1,026 patients primarily treated for an open globe injury at the Ophthalmologic Departments of the University of Freiburg and University of Würzburg between 1981 and 1999. The Freiburg University Eye Clinic provides health care services for open globe injuries to 2.2 million inhabitants (Regierungsbezirk Südbaden, Report of the Statistisches Landesamt Baden Württemberg for 1993). It is the only institution within 100 km for this type of injuries. The Würzburg University Eye Clinic serves 1.5 million inhabitants (Regierungsbezirk Unterfranken and neighboring districts) and is the only institution within 100 km where open globe injuries can be treated. These facts allowed a representative profile of open globe injuries in this study. The patients who were treated only because of late sequels of an open globe injury or who were primarily treated elsewhere were excluded from analysis.

Methods

The data were retrospectively analyzed for the following variables: age, sex, last profession before the accident, mechanism and type of the injury, surgeries required, duration of hospitalization, and visual outcome at the end of follow up. Relative risk at a given age was calculated on the basis of the census in Baden-Württemberg 1987 (12) using the following formula: (number of injuries [age-group, sex]/population [age-group, sex]) × (total population/all injuries).

Also, sex ratio was redetermined after the number of injuries had been adjusted according to the age structure of the population. These data were compared with the data on open globe injuries not affecting the posterior eye segment.

A questionnaire was sent out to 55 patients of a working age, ie, between 15 and 65 years, with an open globe injury. The patients were injured in 1996/1997 and treated at the Würzburg University Eye Clinic. The response rate was 35/55. The questionnaire asked about work disablement after injury, type of work after recovery from eye injury, and personal satisfaction with the quality of life after injury.

Results

The calculated incidence of open ocular trauma was 3 injuries per 100,000 population a year for the 1981-1994 period, and 2.8 for the 1996-1999 period. For trend analysis, the investigated period was divided into five shorter periods: 1981-84, 1985-89,

1990-94, 1996-97, and 1998-99. Out of 859 injuries primarily treated in the 1981-1994 period, 794 records could be analyzed for their functional outcome after a follow up of 6 months. Median follow up was 7 months.

Sex Distribution

Most injuries occurred in men, ie, 84% of a total 1,026 injuries. Male to female ratio of injuries ranged from 4.1 for 1981-1984 and 1990-94 to 9.5 for 1996-1997, with the mean ratio being 5.3 (862 vs 164 injuries, respectively).

Age Distribution

Age distribution of open globe injuries was compared with the age distribution of the population of South West Germany according to the 1987 census (Fig. 2). The relative risk for each age group calculated from these data was highest for the 15-20 age group, and significantly lower for older groups (Fig. 3). The risk for open globe injuries was relatively high for the 21-44 age group, and increased for those aged 65 and

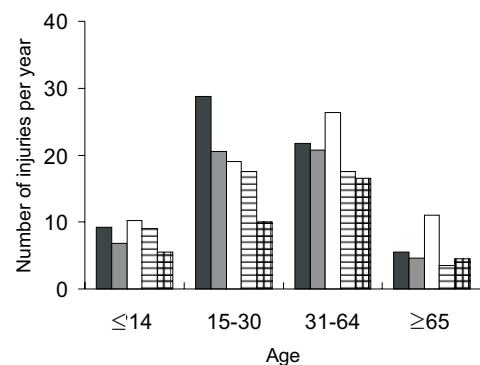


Figure 2. Age distribution of open globe injuries in two German University Eye Clinics, 1981-1999. Closed bars – 1981-1984; gray bars – 1985-1989; open bars – 1990-1994; horizontal lines – 1996-1997; grid bars – 1998-1999.

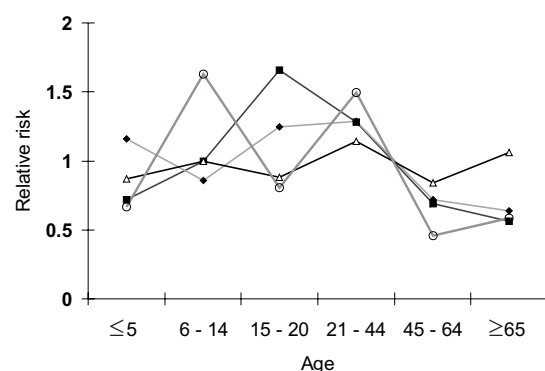


Figure 3. Relative risk of open globe injuries in 1981-1999: age distribution of open globe injuries was compared with the age distribution of the German population according to the census of 1987 in Baden-Württemberg (12), by using the following formula: (No. of injuries [age-group, sex]/population [age-group, sex]) × (total population/all injuries). Square – 1981-1985; rhomb – 1986-1989; triangle – 1990-1993; circle – 1996-1999.

older. The increase in the number of injuries in senior citizens was related to a higher proportion of globe ruptures, and previous cataract surgery was identified as a risk factor for this type of injury.

Activity at Time of Injury

The prevalence of injuries at work decreased only slightly. The number of injuries that occurred during leisure time activities increased, but of injuries received in traffic accidents decreased by 83% (Fig. 4).

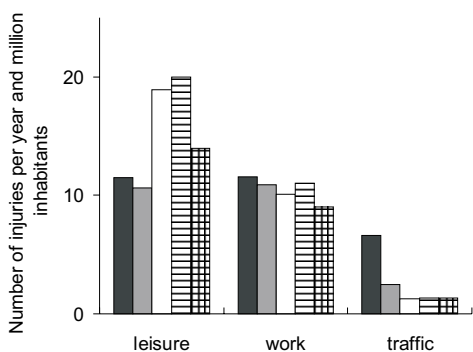


Figure 4. Number of injuries per year and per million inhabitants occurring at different activities in Baden-Württemberg. Closed bars – 1981-1984; gray bars – 1985-1989; open bars – 1990-1994; horizontal lines – 1996-1997; grid bars – 1998-1999.

Injuries at Work

Injuries at work accounted for 389 (37.9%) out of 1,026 injuries. During the period of 18 years, the proportion of injuries at work decreased from 42% to 32%. The decrease was especially evident among the younger workers (15-30 years of age). The remaining injuries occurred mostly in little handicraft workshops, building companies, and farms.

Injuries in Traffic Accidents

In the 1960s, the incidence of open globe injuries occurring in traffic accidents increased to 1.2/100,000 and slightly decreased to 0.8/100,000 in the early 1980s (Figs. 4 and 5). Figure 5 shows the number of open globe injuries in traffic accidents treated at the Universities of Freiburg and Würzburg over a period of 33 years. The data were compiled for Freiburg in 1966-1969 (Böcking, unpublished data), 1974-1980 (Hölzer, unpublished data) and 1981-1994 period; and from the University of Würzburg for 1988-1998 period. Both Universities cover the area of

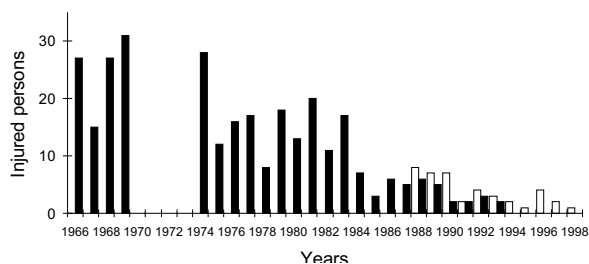


Figure 5. Annual number of open globe injuries in traffic accidents treated at the universities of Freiburg (closed bars) and Würzburg (open bars).

similar size and population structure. In 1974, all new cars had to be equipped with safety belts, which caused a slight decrease in the number of injuries from 25 per year to 16-20 per year.

Since 1984, when the seat belt legislation became effective, the number of eye injuries decreased by 83%, ie, to 2 per year today. The proportion of open globe injuries among eye injuries in traffic accidents decreased from 30% to 4%. The decline was most pronounced among young adults. Among the residual injuries, greater number of posterior segment injuries and their combination with mid-facial injuries were recorded, as well as an increase from 29% to 43% in the proportion of injuries resulting in blindness.

Injuries during daytime nearly completely disappeared, as they had been formerly related to inner city accidents at low speeds. The number of windscreen injuries received at night decreased only a little, but a third of these drivers did not wear safety belt and were drunk. Due to the better driving conditions, the decrease in injuries was more pronounced during the summer season than during the winter season. Injuries occurring during leisure time activities steadily increased, especially among those aged over 30. This increase was related to the increasing do-it-yourself activities and omission to apply safety measures.

Open Globe Injuries among Elderly

In the early 1990s, the number of injuries among people older than 65 years increased. A high proportion of patients in this group had had an eye surgery before. About 150,000 cataract operations per year were performed in Germany in the early 1980s, about 400,000 in the mid-1990, and about 600,000 today. The mean survival time after cataract operations was 5-7 years. From these numbers and from the demographic distribution in Germany, the calculated proportion of elderly people with cataract surgery was 10% in the early 1980s and 22% in the early 1990s. However, a proportion of patients surgically treated for cataract was three times higher in the 1981-1989 period and twice higher in the 1990-1993 period. Most of the open globe injuries (73%) among senior citizens were ruptures. In 90% of the previously operated cases, the eye ruptured along the former cataract wound, and in 10% on the equator, indicating greater susceptibility to globe rupture of people who had previous cataract surgery.

The proportion of people with cataract surgery in the group of elderly people with open globe injuries decreased to 22% in 1994 and to 16% in the 1996-1999 period, which was close to the expected proportion of those who had previous surgery among the elderly population (Table 1). This may indicate that the small and self-sealing tunnel incision used in Germany after 1992 reduced the risk of globe rupture after cataract surgery.

Functional Outcome of Ocular Trauma Treatment

The visual outcome of open globe injuries in female patients was less favorable than in male patients

Table 1. Prevalence of previous cataract surgeries in senior residents (aged ≥65 years) with globe ruptures*

Time period	No. of cataract surgeries /No. of ruptures
1981-1985	9/25
1986-1989	8/20
1990-1993	25/46
1994	2/9
1996-1999	3/19
Total (1981-1999)	47/119

*There were 10-25% cataract surgeries in the population aged ≥65 who had globe ruptures.

(Fig. 6), probably due to the different etiology of open globe injuries in men and women. The proportion of young women involved in traffic accidents and the proportion of old women suffering globe ruptures after a fall, both causes related to a poor functional result, was higher than that of men of the same age.

The injuries caused by foreign bodies from hammer and chisel or from rotating machines had a better

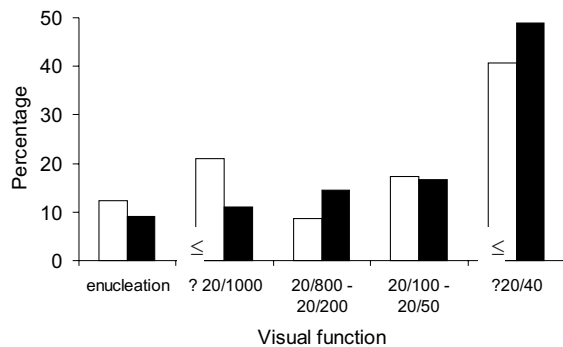


Figure 6. Visual outcome of open globe injuries (n = 529) in women (open bars, n = 81) and men (closed bars, n = 448). Injuries occurred between 1981 and 1989; median follow up was 7 months.

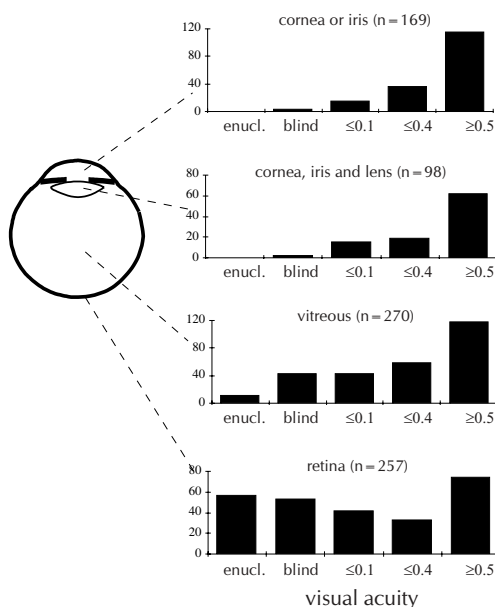


Figure 7. Extent of injury and visual outcome. Enucl. – enucleation

functional outcome than windscreen injuries, bullet injuries, or globe ruptures. Typical activities with a poor outcome were assaults, traffic accidents, and injuries at home and in agriculture. All these injuries, related to a poor visual outcome, had a higher proportion of posterior segment damages (Fig. 7).

Endophthalmitis

The overall risk of a posttraumatic endophthalmitis was 3.6%. We found an increased risk of 12% for eye injuries received during agricultural work. Open globe injuries caused by darts and arrows led to endophthalmitis in 13% of cases and injuries by tree branches in 20% of cases. The prevalence of endophthalmitis was found in injuries caused by pieces of fence wires or grapevine (38%). Posttraumatic endophthalmitis had an unfavorable functional outcome. The visual prognosis after endophthalmitis was poor. Out of 529 injuries evaluated for visual outcome during 1981-1989, there were 19 cases of posttraumatic endophthalmitis (3.6%). In 10 out of 19 cases, visual acuity after 7 months of follow up was counting fingers or less, and only in 4 out of these 19 cases it was 20/40 or better.

Timing of Vitrectomy in Severe Open Globe Injuries

In 7 eyes with severe globe rupture extending over 120-180 degrees (in 3 cases posteriorly to the equator and in 2 cases with no light perception), the wound was closed and a pars plana vitrectomy performed within 24 h after the trauma (Fig. 8). Pars plana vitrectomy in this stage of injury is not easy as fresh bleeding has to be controlled and a posterior vitreous detachment is induced in an eye with retinal detachment. Also, all blood, intrahyaloidal as well as subretinal, has to be removed. With the help of perfluorocarbon liquids and silicone oil, retinal reattachment and anatomic success could be reached in all cases, with functional result between no light perception and 0.4.

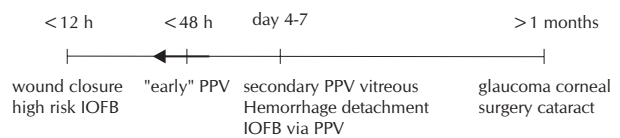


Figure 8. Timing of primary and secondary surgery for severe ocular injury. IOFB – intraocular foreign body; PPV – pars plana vitrectomy.

Questionnaire on Quality of Life after Eye Trauma

The average hospital stay of respondents to life quality questionnaire was 2.3 weeks. Mean absence from work due to injury was 11.4 weeks. Incapacity for work depended on the severity of injury. The patient with only corneal or scleral laceration was incapacitated for 3.4 weeks (median, 3 weeks), with involvement of the lens for 8.9 weeks (median, 4 weeks), and with retinal injuries for 18.8 weeks (median, 5 weeks). All 35 patients but one reported that

they could do the same work after the injury. In fact, 31 out of 35 patients reported that they still had the same job profile, 2 patients could work in their profession but had to change their job profile, and 2 patients lost their job because of their eye injury and had to re-train for another profession. Also, 31 out of 35 patients had no reduction of their income, and only 4 patients (with retinal involvement and prolonged disablement) reported a decrease of their salary.

Majority of the patients could also continue with their leisure time activities (30 out of 35 respondents). Five patients reported to have been forced by the eye injury to discontinue with their hobbies (motorcycling, squash, soccer, driving by night, and one did not specify his hobby). Sixteen out of 35 patients assessed their life quality as unchanged by the eye injury, whereas 10 patients noticed a minor decrease of life quality. Only 7 patients reported a major decrease and 2 patients a severe decrease in life quality.

Costs of Trauma Treatment

For the community, open globe injuries incur considerable costs: 2.3 weeks of hospitalization typically cost €6,000 in Germany. Further outpatient treatment may sum up to another €260. An average craftsman receives a salary of €1,800 a month (Statistisches Bundesamt, 1998). In case of the average disablement of 11.4 weeks, the employer pays 80% of the salary for the first 6 weeks, and the social insurance covers for the remaining 5.4 weeks of incapacity. This continued payment of wages sum up to another €4,000. Calculated from the incidence of open globe injuries of 3.0 per 100,000 population per year (8,9,13,14), costs for medical treatment and continued payment of wages sum up to over €25 million each year for open globe injuries alone in Germany.

Discussion

The proportion of injuries at work did not change, injuries in traffic accidents significantly decreased, injuries that occurred during leisure time activities increased, especially among do-it-yourself people, and globe ruptures among seniors increased.

From 1981 until 1999, the number of enucleations and in blindness following open globe injuries decreased. During this period, a major progress in the microsurgical techniques of posterior segment eye surgery occurred. It can, therefore, be assumed that the improvement of surgical techniques in the posterior segment surgery resulted in an overall improvement of functional results. Decreasing proportion of enucleations and blindness was more pronounced for women than for men. A major decline in severe ocular injuries received in traffic accidents was found for women. This would indicate that the improvement in the visual function after open globe injuries in women was related to the substantial decrease in injuries in traffic accidents and the changing patterns of injuries than to improved surgery alone.

Changes of the trauma type had a major influence on the overall functional outcome. Typical activities with a poor functional outcome were assaults, traffic accidents, and injuries at home and in agricul-

ture. Typical mechanisms with a bad outcome were gunshots, ruptures, and windscreen injuries. They were all related to a higher proportion of posterior segment injuries. The more posterior was the injury, the worse was its outcome. As old people tended to have more posterior segment injuries than young people, old people had worse results. Also, more and more patients with severe eye injuries, especially those combined with other injuries of the face, survive today, which is one of the reasons why the number of eye injuries resulting in blindness has increased (15,16). With a safety belt, eye injury in traffic accident has been nearly completely prevented.

Retinal Involvement and Visual Outcome

Retinal laceration as a single factor was highly predictive for an unfavorable visual outcome regardless of the localization of retinal involvement central or peripheral to the major arcades (8). However, in comparison with paramacular lesions, the involvement of the macula or the optic nerve tended to correlate with a more unfavorable visual outcome, which is accordance with findings by de Juan et al (17).

Retinal detachment with or without hemorrhage in severely injured eyes is predictive of poor vision (18). Development of primary retinal detachment or failure of vitrectomy or buckling procedure to prevent secondary retinal detachment (18-20) were the most important factors determining visual outcome in our study. Other factors correlating with an unfavorable visual outcome (17), such as scleral laceration, lens damage, or vitreal involvement, occurred more frequently in retinal than in non-retinal injuries. However, early vitrectomy in severely damaged eyes may reduce the frequency of complicated retinal detachments and failure of functional or anatomic reconstruction.

Socioeconomic Aspects of Open Globe Injuries

Sex distribution, age distribution, and the proportion of injuries at work have not changed significantly over the past 20 years (8,21). However, the data presented in this study show a steady decrease of the proportion of injuries at work. A working person with an open globe injury typically has 35 working years ahead of them, and severe losses of income might be expected (22). However, our questionnaire revealed that losses of salary were less than expected.

The calculated costs for medical treatment and continued payment of wages summed up to over €25 million each year for the estimated 2,500 open globe injuries alone in Germany. Compared with 1.25 million sport injuries that are recorded in Germany every year, which incur costs of €1.32 billion (23), the costs for the treatment of eye injuries are minimal.

Intraocular Foreign Body Removal

An intraocular foreign body was, and sometimes still is, usually removed with an extraocular magnet. Some use it as a diagnostic tool and perform a "magnet test" to reassure that the intraocular foreign body is iron and not copper. When the magnet is used without ophthalmoscopic control and is not properly aligned, it may cause major harm and additional

trauma to the eye-wall. Therefore, an increasing number of surgeons advocate the pars plana vitrectomy to remove an intraocular foreign body. Mester and Kuhn (24) concluded from the Hungarian Eye Trauma Registry data that the clinical outcome after intraocular foreign body removal by pars plana vitrectomy was superior to magnet extraction.

Timing of Vitrectomy in Severe Open Globe Injuries

It is widely accepted that, after wound closure and removal of toxic material from the eye, pars plana vitrectomy in traumatized eyes is best done between day 7 and 10, because in many cases a posterior vitreous detachment occurred by this time or is now easier to perform (25). Over the last years, a debate has been going on whether severe ruptures of eyes with incarcerated retina should have early pars plana vitrectomy within the first 2-3 days following trauma to avoid severe proliferative vitreoretinopathy and complicated retinal detachment. Concluding from the results of a consecutive series of 7 eyes with severe globe rupture often extending posteriorly to the equator, early pars plana vitrectomy should be considered in cases with severe ruptures or lacerations if an experienced surgeon is available. In addition, the secondary pars plana vitrectomy should be performed earlier than day 10, ie, between day 4 to 7.

Treatment of Blind Eyes

Treatment of blind eyes leads us to another question: should we treat blind eyes at all or do we have to consider iatrogenic risk of sympathetic ophthalmia? Bob Morris (26) checked the data from the United States Eye Injury Register and found out that 5% of all registered eyes with "no light perception" regained at least some ambulatory vision. An attempt of reconstruction was performed only in a small number of these patients, but some attained ambulatory vision again (at least 5/200). The incidence of sympathetic ophthalmia was estimated at 0.2% after an open globe injury. It is not proven that the number of surgeries increased this number. Moisseiev et al (27) concluded that no injured eye should be enucleated because of the risk of sympathetic ophthalmia if the patient could be maintained under observation. Current treatment regimen of eyes with no light perception is to perform investigative surgery as long as there might be any chance of functional success. From studies with severe retinal detachments, it is known that the patients will appreciate additional surgery even if only ambulatory vision can be achieved (26).

In conclusion, better surgical techniques led only to a minor amelioration of visual outcome in open globe injuries but to a significant reduction of blind eyes. Maximal surgery is appreciated by the patient. Reconstruction should be considered, even if there is no light perception. Preventive measures and changes in the mechanism of ocular trauma are more effective to ameliorate the clinical outcome.

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