Visual outcome and prognostic factors after vitrectomy for posterior segment foreign bodies

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PURPOSE. *To identify the prognostic factors that predict final visual outcome in eyes with posterior segment intraocular foreign body (IOFB) injuries managed by primary pars plana vitrectomy.*
METHODS. *Ninety-six consecutive patients with posterior segment IOFB injuries were retrospectively reviewed. Factors analyzed included initial visual acuity (VA), time between injury and presentation, site of entrance wound, uveal prolapse, vitreous prolapse, traumatized iris, endophthalmitis, location and size of IOFB, use of scleral buckling and/or an encircling band, gas tamponade, lensectomy, number of surgical procedures, and development of retinal detachment. Data were analyzed using univariate and multivariate logistic regression analysis.*
RESULTS. *After a mean follow-up of 8.6 months, 63 eyes (65.6%) achieved VA of 20/200 or better, and 9 eyes (9.4%) had total retinal detachment complicated by inoperable proliferative vitreoretinopathy. On univariate analysis, predictors of poor vision (hand movements or less) were poor initial VA, corneoscleral entrance wound, uveal prolapse, vitreous prolapse, traumatized iris, and development of retinal detachment. In contrast, predictors of good visual outcome (20/200 or better) were absence of uveal prolapse, no endophthalmitis, and no retinal detachment. Multivariate analysis identified corneoscleral entrance wound, uveal prolapse, and development of retinal detachment as the only factors significantly associated with poor visual outcome. Absence of uveal prolapse was the only factor significantly associated with good visual outcome.*
CONCLUSIONS. *Final visual outcome is greatly determined by the severity of the primary injury. On multivariate analysis, significant predictive factors of final VA were corneoscleral entrance wound, presence or absence of uveal prolapse, and development of retinal detachment. (Eur J Ophthalmol 2000; 10: 304-11)*

KEY WORDS. *Intraocular foreign body, Ocular trauma, Vitrectomy, Endophthalmitis, Retinal detachment, Prognostic factors*

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Intraocular foreign bodies (IOFB) are a major cause of ocular trauma, accounting for 17-41% of penetrating ocular injuries (1-4). Vision can be lost not only as a result of the initial mechanical damage, but also because of secondary complications such as infective endophthalmitis, intraocular fibrocellular proliferation with cyclitic membrane formation and traction retinal detachment, and toxicity from retained reactive foreign material.

The patho-anatomical changes causing vitreoretinal complications after posterior segment penetrating injuries have been investigated in animal models (5-7) and human eyes (2, 8). Initially there is an inflammatory response, followed by fibrocellular pro-

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liferation, and then cyclitic membrane formation with secondary traction retinal detachment due to contraction of cellular membranes in the anteroperipheral part of the vitreous cavity (5-7). Ultrastructural study of the fibrocellular membranes found myofibroblasts, accounting for the contractile nature of the proliferative tissue (7).

Experimental observations indicate that blood is an important stimulus to the inflammatory response and is associated with significant cellular proliferation (5).

The development of vitreous microsurgical techniques has revolutionized the management of these severe injuries, offering a chance to abort the basic pathological processes leading to such devastating complications. Vitrectomy removes the vitreous and blood clot scaffold that provides a framework for the fibrous ingrowth. Vitrectomy clears the ocular media, allowing visualization and repair of retinal breaks and detachment. In many cases, vitrectomy permits precise visual localization and finely - controlled removal of IOFB. The removal of damaged vitreous, hemorrhage, lens cortex, and the foreign bodies themselves eliminates much of the stimulus for fibroglial proliferation (9).

The objectives of this study were to investigate the visual outcome after posterior segment IOFB injuries in 96 consecutive patients managed by primary pars plana vitrectomy, and to identify the significant prognostic factors for final vision.

MATERIALS AND METHODS

We retrospectively reviewed the medical records of 96 consecutive patients who had undergone surgery at our institution for posterior segment IOFB from 1992 to 1998. The cases were confirmed by a review of the surgical records.

The following data were extracted from the records: age and sex of the patient, activity at the time of injury, time elapsed between initial injury and presentation to our institution, preoperative visual acuity (VA), results of slit-lamp examination, of funduscopy with indirect ophthalmoscope, of ultrasound when ophthalmoscopy was not possible because of media haze, of foreign body localization with computed tomography (CT), details of all surgical procedures, complications of retained IOFB and postoperative VA. Data regarding the IOFB included its type, number, size, and location within the eye.

All but one of the injured patients were male. The mean age was 31.3 ± 9.9 years (range 7-65 years). Because our institution is a tertiary referral center, patients presented at varying times after injury and the time elapsed between initial injury and presentation was available for 87 patients. Of these, 7 (8%) presented within 24 hours of injury, 60 (69%) presented between 1 and 7 days, and 20 patients (23%) presented after more than 7 days.

Of the 96 cases with IOFB, 92 (95.8%) were due to metallic IOFB and the remaining 4 (4.2%) to concrete particles. Seventy-seven (80.2%) were caused by hammering metal on metal, 5 (5.2%) were caused by shotgun pellets, and 14 (14.6%) were caused by various other mechanisms most connected with the use of machine tools. The site of penetration was corneal in 63 eyes (65.6%), scleral in 20 (20.8%), corneoscleral in 9 (9.4%), and undetermined in 4 (4.2%). The entrance wound had been repaired in other hospitals in 18 eyes (18.8%).

Other findings on initial ophthalmologic examination included cataract in 70 eyes (72.9%), traumatized iris in 18 (18.8%), vitreous loss in 12 (12.5%), prolapse of uveal tissue in 8 (8.3%), retinal detachment in 6 (6.3%) and rubeosis iridis in 1 eye (1.0%). Most eyes had mild-to-severe vitreous hemorrhage. Endophthalmitis was suspected in 13 eyes (13.5%).

Ninety-four eyes contained one foreign body, one contained two, and one contained three. The location of the foreign body was intraretinal outside the macular area in 54 eyes (56.3%), lying on the surface of the retina outside the macular area in 14 eyes (14.6%), lying on the pars plana in 9 eyes (9.4%), intraretinal in the macular area in 8 eyes (8.3%), lying in the vitreous in 7 eyes (7.3%), and undetermined in 4 eyes (4.1%).

The IOFB had been measured in 76 eyes. The maximum size ranged from 1-2 mm in 28 eyes (36.8%), 2.1 - 4 mm in 19 eyes (25%), and more than 4 mm in 29 eyes (38.2%).

Of the 96 patients, 94 underwent pars plana vitrectomy in conjunction with repair of entrance wounds for those who had not yet had primary repair. Two eyes were eviscerated after primary repair because of very severe intraocular inflammation with a cloudy cornea due to *Clostridium perfringens* infection. Pars plana lensectomy was performed in 62 eyes. The foreign body was removed with an IOFB forceps in 89 eyes after enlarging the sclerotomy incision to allow the foreign body through. In five cases removal was accomplished with an electromagnet through the original wound. In these cases a small intravitreal magnetic foreign body could be seen, free of tissue incarceration or fibrin encapsulation. Retinal breaks were treated with trans-scleral cryotherapy or photocoagulation delivered either by endolaser or by binocular indirect ophthalmoscopy. Intraocular gas tamponade with a 25% sulphur hexafluoride-air mixture was used in 59 cases with preoperatively and intraoperatively attached retina. Prophylactic solid silicone encircling bands 2.5 mm wide were placed (pre-equatorial) to support the posterior margin of the vitreous base in 25 eyes with preoperatively and intraoperatively attached retina. Scleral buckling was done in conjunction with encircling bands in another 16 eyes to support retinal breaks without retinal detachment, detected at the time of vitrectomy. Most of these breaks were peripheral and posterior to the sclerotomy sites. In cases of suspected endophthalmitis, intravitreal antibiotics were given.

At the conclusion of the procedure, a meticulous 360° indirect ophthalmoscopy with scleral indentation was performed to check for any iatrogenic breaks posterior to the sclerotomies or elsewhere, and any such breaks were treated.

Of six eyes with preoperative retinal detachment, complete retinal reattachment was achieved in three using scleral buckling, relaxing retinotomy, perfluorocarbon liquid, and silicone oil tamponade.

The silicone oil was removed 2-4 months after surgery. In three eyes the detachment was complicated by severe proliferative vitreoretinopathy and was deemed inoperable, so only the foreign body was removed and the case was abandoned. The follow-up period of this study ranged from 2 to 36 months (mean ± S.D. 8.6 ± 9.9 months).

Statistical methods

The following factors were analyzed to establish which individual factors or combinations of factors influenced or predicted the final VA: 1) initial VA; 2) time elapsed between injury and presentation at our institution; 3) entrance wound location; 4) uveal prolapse; 5) vitreous prolapse; 6) traumatized iris; 7) endophthalmitis; 8) location IOFB; 9) size of IOFB; 10) use of scleral buckling and/or an encircling band; 11) use of gas tamponade; 12) lensectomy; 13) number of surgical procedures, and 14) development of retinal detachment.

Each of these factors was analyzed by the chi-squared or Fisher's exact tests to establish which were individually associated with either a good (20/200 or better) or poor (hand motion or less) visual outcome. Fisher's exact test was used when any expected cell frequency in a 2 x 2 table was less than 5. Multivariate logistic regression analysis was done using factors found to be significantly associated with final visual outcome in univariate analysis (with $p < 0.05$). Pro-

TABLE I - ORGANISMS AND VISUAL OUTCOME IN CASES WITH ENDOPHTHALMITIS

Organism	No. of eyes	Final visual acuity
- *Staphylococcus epidermidis*	4	CF, 20/100, 20/60, CF
- *Clostridium perfringens*	3	20/100, eviscerated, eviscerated
- *Staphylococcus aureus*	1	HM
- *Corynebacterium sp*	1	20/200
- *Staphylococcus epidermidis,* Moraxella sp	1	NLP (postoperatively developed combined CRAO and CRVO)
- Culture-negative	3	CF, CF, 20/40

CF = Counting Fingers; HM = Hand Motions; NLP = No Light Perception; CRAO = Central Retinal Artery Occlusion; CRVO = Central Retinal Vein Occlusion grams EPI version 6, and LR from the BMDP Statistical Package were used, respectively, for the univariate and multivariate analyses.

RESULTS

Of the 13 eyes with suspected endophthalmitis, 10 (10.4%) were culture-positive. Visual outcome and culture results are shown in Table 1. Retinal detachment occurred after vitrectomy in another 19 eyes. Complete retinal re-attachment was achieved in 12 of these and localized traction retinal detachment not involving the macula was seen in one eye. Nine eyes (9.4%) had total retinal detachment complicated by inoperable proliferative vitreoretinopathy at the final follow-up examination. Of 14 eyes with final VA of hand motions or less, nine had retinal detachment complicated by proliferative vitreoretinopathy, four had endophthalmitis, and one had phthisis bulbi.

Of the 96 eyes, 63 (65.6%) achieved VA of 20/200 or better; 49 eyes (51%) had final VA 20/100 or better, 22 (23%) reached 20/40 or better. Nineteen eyes (19.8%) had final VA of counting fingers, and 12 (12.5%) had hand motions or worse. Two eyes (2%) had to be eviscerated because of *Clostridium perfringens* panophthalmitis and orbital cellulitis. The range of initial and final VA is set out in Figure 1.

Univariate analysis identified the following variables as significantly associated with poor visual outcome (hand motions or less): 1) poor initial VA; 2) corneoscleral entrance wound; 3) uveal prolapse; 4) vitreous prolapse; 5) traumatized iris, and 6) development of retinal detachment. In contrast, absence of uveal prolapse, no endophthalmitis, and no retinal detachment were significantly associated with good visual outcome (20/200 or better) (Tab. II).

Multivariate logistic regression analysis identified corneoscleral entrance wound (odds ratio 18.8, 95% confidence interval [CI] = 1.35 - 263), uveal prolapse (odds ratio 9.81, 95% CI 1.58 - 61.1), and development of retinal detachment (odds ratio 5.38, 95% CI 1.22 - 23.8) as the only factors significantly associated with poor visual outcome (hand motions or less). In contrast, absence of uveal prolapse was the only factor significantly associated with good visual outcome (20/200 or better) (odds ratio 0.141, 95% CI 0.0261 - 0.765).

Preoperative Visual Acuity

Postoperative Visual Acuity	NLP	LP-HM	CF	20/200 — 20/100	20/80 — 20/40	>20/40	Total
> 20/40	1	12	0	2	0	3	18 (18.8%)
20/80-20/40	0	4	6	1	7	3	21 (21.9%)
20/200-20/100	0	6	1	3	5	9	24 (25%)
CF	0	7	2	0	1	9	19 (19.8%)
LP—HM	0	7	2	0	0	1	10 (10.3%)
NLP	0	4	0	0	0	0	4 (4.2%)
TOTAL	1 (1.0%)	40 (41.7%)	11 (11.5%)	6 (6.3%)	13 (13.5%)	25 (26%)	96 (100.0%)

Fig. 1 - *Preoperative visual acuity plotted against postoperative visual acuity for 96 eyes. The numbers above the diagonal squares indicate an improvement in visual acuity.*
CF = Counting Fingers; HM = Hand Motions; LP = Light Perception; NLP = No Light Perception.

We calculated the magnitudes of the regression coefficients in the hazard function for predicting the probability of a final poor visual outcome (hand motions or less). This analysis indicated that corneoscleral entrance wound was the most important independent risk factor, followed by uveal prolapse, and development of retinal detachment (regression coefficients were 2.936, 2.284, and 1.683 respectively).

DISCUSSION

In the current study of a homogeneous group of patients with posterior segment IOFB injuries managed by primary pars plana vitrectomy, 65.6% achieved VA of 20/200 or better. Previous studies have described visual outcome after IOFB injuries (3, 10-15) but a detailed comparison of postoperative VA in our series and other studies is complicated by a number of factors. In other series, cases of anterior segment IOFB, scleral foreign bodies, posterior segment IOFB and double perforation were included in the overall visual results. Several studies demonstrated that anterior segment IOFB had a better prognosis than posterior segment ones (3, 4, 11). Furthermore, these studies included cases managed by external magnet extraction and primary vitrectomy. Our study focused on posterior segment IOFB injuries managed by primary vitrectomy to facilitate comparisons and conclusions regarding the treatment of future cases. The only common group of patients with posterior segment IOFB managed by primary vitrectomy comes from Ahmadieh et al (16) in which the postoperative VA was 20/200 or better in 61.8% of cases.

In our series two eyes (2%) had to be eviscerated after primary repair because of very severe intraocular inflammation with a cloudy cornea due to *Clostridium perfringens* infection. Williams et al reported a 6% rate of enucleation (10), Armstrong 9% (14), Punnonen and Laatikainen 11% (3), and Behrens-Baumann and Praetorius 6.7% (17). The lower rate in our series might

TABLE II - PREDICTORS OF FINAL VISUAL OUTCOME

Risk factor	Postoperative visual acuity		
	NLP - HM	**CF**	**≥ 20/200**
• Initial visual acuity			
NLP-HM (n=41)	11 (26.8)	7 (17.1)	23 (56.1)
CF (n=11)	2 (18.2)	2 (18.2)	7 (63.6)
≥ 20/200 (n=44)	1 (2.3)	10 (22.7)	33 (75)
p value	0.0055*	0.7994	0.1842
• Entry wound			
Corneal (n=63)	8 (12.7)	13 (20.6)	42 (66.7)
Corneoscleral (n=9)	4 (44.4)	1 (11.2)	4 (44.4)
Scleral (n=20)	1 (5)	4 (20)	15 (75)
p value	0.0158*	0.7957	0.2718
• Uveal prolapse			
No (n=88)	9 (10.2)	18 (20.5)	61 (69.4)
Yes (n = 8)	5 (62.5)	1 (12.5)	2 (25)
p value	0.0014*	0.5033	0.0184*
• Traumatized iris			
No (n=78)	8 (10.3)	16 (20.5)	54 (69.2)
Yes (n=18)	6 (33.3)	3 (16.7)	9 (50)
p value	0.0222*	0.9673	0.2030
• Vitreous prolapse			
No (n=84)	9 (10.7)	18 (21.4)	57 (67.9)
Yes (n=12)	5 (41.7)	1 (8.3)	6 (50)
p value	0.014*	0.2621	0.1845
• Endophthalmitis			
No (n=83)	10 (12)	15 (18.1)	58 (69.9)
Yes (n=13)	4 (30.8)	4 (30.8)	5 (38.4)
p value	0.935	0.2351	0.0309*
• Retinal detachment			
No (n=71)	5 (7)	9 (12.7)	57 (80.3)
Yes (n=25)	9 (36)	10 (40)	6 (24)
p value	0.0013*	0.0053*	<0.001*

Percentages in parentheses
*Statistically significant at 5% level
NLP = No Light Perception; HM = Hand Motions; CF = Counting Fingers

be related to the prompt treatment of endophthalmitis with vitrectomy and intraocular antibiotics and the use of vitrectomy techniques which are useful in severely traumatized eyes and for the treatment of secondary complications, particularly retinal detachment. Esmaeli et al (2) found that vitrectomy reduced the incidence of enucleation in their series of penetrating ocular trauma.

The incidence of endophthalmitis in our series was 13.5%. Endophthalmitis was not predictive of poor visual outcome, though it was a negative predictor of good visual outcome. This may have been because most eyes with endophthalmitis were treated promptly with pars plana vitrectomy and intravitreal antibiotics. In our previous study, multivariate analysis identified endophthalmitis as a predictive factor for the development of retinal detachment after vitrectomy for posterior segment IOFB injuries (18). Previous large series have reported between 4.7% and 13.3% of infectious endophthalmitis after penetrating injury with an IOFB (3, 10, 12, 17, 19-21). *Clostridium perfringens* was cultured in 30% (3/10) of eyes with endophthalmitis and was the reason for evisceration of the two eyes in our study, confirming the grim prognosis with this organism. The third case was successfully treated with pars plana vitrectomy, removal of the foreign body and intravitreal antibiotics. VA improved from light perception to 20/100.

For reasons which remain unclear, *Bacillus* did not occur as a cause of post-traumatic endophthalmitis in this series. *Bacillus*, one of the most destructive bacteria to affect the eyes (22), was cultured either alone or with other organisms in 31-45.5% of cases with positive cultures in other reports of endophthalmitis after penetrating injury with an IOFB (10, 19-21). The lack of *Bacillus* in this series might be possibly related to the influence of local environmental factors of high temperature and dryness on Bacillus spores (23).

Eyes with retained IOFB are clearly at risk of infectious endophthalmitis because 28% of all such eyes have positive intraocular cultures (24). Prompt vitrectomy removes the IOFB which may be harboring infectious material, and irrigates the eye with sterile solution, thereby potentially reducing the amount of infectious material within the eye. One patient in our series underwent primary pars plana vitrectomy and removal of an intravitreal foreign body 10 hours after the trauma. The patient did not present with or develop clinical signs of endophthalmitis during the postoperative course, yet the vitreous biopsy grew *Clostridium perfringens*. Two months after the procedure, VA was 20/60 with no evidence of infection. Prophylactic use of intravenous vancomycin coupled with a third-generation cephalosporin such as ceftazidime gives good coverage for most organisms causing infectious endophthalmitis associated with an IOFB (25, 26).

Consistent with previous clinical series of IOFB (11-13, 15, 16), we found that retinal detachment complicated by proliferative vitreoretinopathy was significantly associated with poor visual outcome. The rate of final irreparable total retinal detachment was 9.4%, which compares favorably with the 7% reported by Williams et al (10), and is lower than the 25% reported by Ahmadieh et al (16), 15.6% reported by Gopal et al (11), 14% by Karel and Diblík (12), 21% by Punnonen and Laatikainen (3), and the 40% reported by Heimann et al (15). Similarly, Cardillo et al (27) showed that post-traumatic proliferative vitreoretinopathy was the main reason for loss of vision after trauma.

Clearly, despite surgical advances in managing IOFB, retinal detachment with proliferative vitreoretinopathy remains a frequent and devastating secondary complication. Therefore, patients with penetrating trauma involving the posterior segment known to be at high risk for development of proliferative vitreoretinopathy are potential candidates for pharmacological and possibly also genetic treatments to prevent or minimize fibrocellular proliferation (27).

Prolapse of vitreous and uveal tissue and iris trauma unfavourably affected the visual outcome. Other studies have also found that prolapse of intraocular tissues was a significant predictor of poor visual outcome. Punnonen and Laatikainen (3) observed that 64% of eyes with uveal and/or vitreous prolapse remained blind as compared with 19% of eyes without prolapse. Chiquet et al (13) reported poor visual outcome in 71.4% of eyes with initial prolapse of intraocular tissue as compared with 20.3% of eyes without prolapse. In our series, corneoscleral entry wounds were significant predictors of poor visual outcome. Similarly, Chiquet et al (13) found that an initial corneoscleral entry wound was a significant predictor of poor visual outcome.

Previous studies found that a large IOFB significantly predicted poor visual prognosis (11-14). We did not find any correlation between the size of the IOFB and the functional outcome of treatment. However, in our previous report, multivariate analysis showed that a large foreign body was a predictive factor for the development of retinal detachment after vitrectomy for posterior segment IOFB (18).

Like other studies (3, 10-14), our results indicated that poor presenting VA, reflecting the extent of initial intraocular injury, was a predictor of poor visual outcome. For eyes with low initial VA due to traumatic cataract, or vitreous hemorrhage, or both, pars plana vitrectomy raised VA from the lowest to the highest category in a significant number of eyes.

During the development of vitreous microsurgical techniques, the conventional use of an external magnet to extract metallic IOFB has become a questionable approach. Magnet extraction seems to be a gross maneuver in comparison to controlled vitreous microsurgery, and it can also produce complications such as iatrogenic retinal tears, retinal detachments, and hemorrhage. Additionally, clinical studies and reproducible animal models of penetrating ocular trauma have shown that the dismal prognosis is largely related to complications secondary to vitreous fibrocellular proliferation (2, 5-8). Magnet extraction without vitrectomy would be inadequate to prevent the basic pathological processes leading to such devastating complications. The external magnet may have a place in the management of magnetic IOFB that are well visualized, small and intravitreal in location. Primary pars plana vitrectomy is needed for the management of: 1) foreign bodies that are hard to see because of cataract or vitreous hemorrhage; 2) an intraretinal foreign body which is encapsulated; 3) concurrent intraocular damage such as retinal tear/detachment; 4) suspected infection (13, 28-30). Coleman et al (31) prefer magnetic extraction whenever possible, even in cases where posterior vitrectomy is indicated. They believe this limits the intraocular manipulation and minimizes the size of the removal wound for longitudinally aligned foreign bodies.

In summary, despite advances in vitreous microsurgical techniques, blindness is still a frequent result of posterior segment IOFB injuries. Final visual outcome depends very much on the severity of ocular damage at the time of the initial injury. In addition, development of retinal detachment complicated by proliferative vitreoretinopathy is strongly associated with a poor visual outcome. Continued efforts at prevention will help reduce the burden of these devastating ocular injuries.

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