

Vitreoretinal surgery after childhood ocular trauma

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CLINICAL STUDY

Abstract

Aim In adults modern vitreoretinal surgery allows many traumatised eyes to be salvaged. However, one third of serious eye injuries occur in the paediatric age group and trauma is a leading cause of monocular blindness in childhood. This study aims to report the indications, complications and outcomes for vitreoretinal surgical intervention after childhood ocular trauma.

Methods Retrospective case note review of 61 children (age 16 years or less) undergoing vitreoretinal surgical procedures following ocular trauma at a tertiary referral centre.

Results Twenty-eight children (45.9%) had open globe injuries (OGI) and 33 closed globe injuries (CGI, 54.1%). The mean age of children with OGI was 9.5 years and with CGI 12.3 years ($P=0.0068$). Forty-seven children had traumatic retinal detachments (77.1%), which in 17 cases were treated with conventional scleral buckling surgery and in 30 by vitrectomy. Retinal re-attachment was achieved after one procedure in 70.6% with scleral buckling and 46.7% with vitrectomy. Fourteen children (22.9%) had attached retinas but required vitrectomy for other reasons. After a mean follow-up of 19.6 months, the median visual acuity (VA) of the children improved from counting fingers at presentation to 6/36 at final review ($P=0.0031$). Traumatic retinal detachment requiring vitrectomy was associated with poor visual outcome ($P=0.0003$).

Conclusion Vitreoretinal intervention resulted in an improvement in vision in 32 children (57.1%) and stabilised 11 at their presenting acuity (19.6%). Two thirds of the children attained a final VA of 6/60 or better. Proliferative vitreoretinopathy was the cause of redetachment in 68.2% of cases and was significantly associated with a poor outcome ($P<0.0001$).

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Introduction

Children aged under 10 years account for 6.5% of all eye injuries,¹ but 21–35% of hospital admissions for eye trauma are from the paediatric age group.^{2–4} Children are overrepresented among individuals with serious eye injuries, accounting for approximately one-third of cases.^{5,6} Most surgeons agree that vitreoretinal surgical techniques allow many poor prognosis eyes to be salvaged,^{7,8} but trauma remains a leading cause of monocular blindness in children.⁹ We wish to report the indications for, complications of, and outcomes of vitreoretinal intervention in the management of childhood ocular trauma.

Methods

We reviewed the case notes of all children aged 16 years or younger undergoing vitreoretinal surgery (either pars plana vitrectomy or scleral buckling) at Moorfields Eye Hospital between March 1991 and September 1999. From these, we identified those children with a history of ocular trauma for detailed review. Data collected included demographics, presenting examination findings, prior ocular surgery, operative details and complications, and outcome.

We classified the type of injury according to the standardised classification of ocular trauma proposed by Kuhn *et al*¹⁰ (Figure 1). We analysed the data to determine the indications for vitreoretinal surgical intervention, its complications, and outcomes. We also performed univariate analysis to identify factors associated with a poor visual outcome.

Snellen visual acuities (VA) were recorded using the following scale: 6/5, 6/6, 6/9, 6/12, 6/18, 6/24, 6/36, 6/60, counting fingers (CF), hand movements, perception of light, and no perception of light (NPL). We defined the VA of enucleated eyes as NPL. Data were compared

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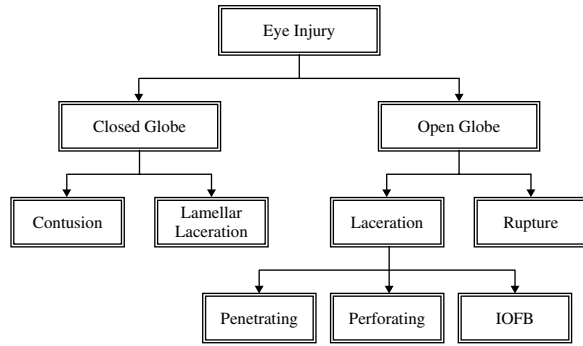


Figure 1 Classification of ocular trauma (after Kuhn *et al*¹¹).

using non-parametric statistical methods. If a calculated VA lies between two points on the scale, we quote the lower point followed by the plus symbol, for example 6/60+.

The chi-squared test (χ^2) was used to compare proportions between groups, or the Fisher exact test when any cell in the contingency table was less than five. The two-tailed unpaired *t*-test was employed for comparing continuous variables between groups, the Mann–Whitney U-test for comparing discrete variables between groups, and the Wilcoxon rank sum test for comparing paired discrete variables. A *P*-value of less than 0.05 was considered significant.

Results

We identified 61 children who underwent vitreoretinal surgery following ocular trauma. There were 49 boys and 12 girls (4.1 : 1 ratio) with a mean age of 11.1 years (range 18 months to 16 years). All the patients had the initial management of their eye injury by ophthalmologists outside the Moorfields Vitreoretinal Service and were subsequently referred for further assessment.

Twenty-eight children (45.9%) had open globe injuries (OGI); there were two cases of intra-ocular foreign body (IOFB), two perforating injuries, 23 penetrating injuries, and one globe rupture. Thirty-three children (54.1%) had contusive closed globe injuries (CGI). All injuries were unilateral. Table 1 summarises the demographics of the two groups.

One patient with OGI and seven patients with CGI had pre-existing ocular or systemic diagnoses (OGI: Ehlers–Danlos syndrome; CGI: retinopathy of prematurity — two cases, congenital glaucoma, high myopia, Marfan’s syndrome, Stickler’s syndrome and, Cornelia de Lange syndrome — one case each).

All eyes with OGI had had primary surgical repair before referral. In three the crystalline lens was lost at the time of injury, in a further two a lensectomy was performed and one of these had a primary intra-ocular lens implant.

Table 1 Demographics of children with eye injuries

	Open globe injuries n = 28	Closed globe injuries n = 33	<i>P</i> -values
Mean age (SD)	9.5 (4.1)	12.3 (2.8)	0.0068 ^a
Boys : girls	21 : 7	28 : 5	0.3349 ^b
% Boys	75.0	85.3	

SD, standard deviation.

^aUnpaired *t*-test.

^b χ^2 test.

Of the eyes with CGI, three had undergone retinal re-attachment surgery at the referring hospital (two scleral buckling procedures, one vitrectomy) and two had undergone cataract extraction, one with lens implant.

Preoperative findings

Clinical findings at presentation are summarised in Table 2. Retinal detachment (RD) was present in 17 eyes after OGI (60.7%) and in 30 following CGI (90.9%, Fisher exact test: *P* = 0.0067). There was no difference between the groups with respect to macular involvement in the detachment, the presence of proliferative vitreoretinopathy (PVR), or the presence of vitreous haemorrhage. Children with OGI were significantly more likely to have cataract or lens subluxation than those with CGI (57.1 *vs* 6.1%, Fisher exact test: *P* < 0.0001).

We identified three subgroups of children. Group A are those with traumatic RD treated with scleral buckling, group B are those with traumatic RD treated with vitrectomy, and group C are those with attached retinas who underwent vitrectomy for other trauma-related indications.

Traumatic retinal detachment

Children with traumatic RD after OGI were significantly more likely to undergo vitrectomy than those with traumatic RD after CGI. Sixteen of the 17 children with RD after OGI underwent pars plana vitrectomy (94.1%), compared to 14 of the 30 with RD resulting from CGI (46.7%, Fisher exact test: *P* < 0.0001).

Group A: scleral buckling for traumatic retinal detachment

In total, 17 children underwent scleral buckling surgery for traumatic RD (27.9%). Indications for scleral buckling were absence of cataract, minimal vitreous haemorrhage or haze, single retinal break (four eyes, 23.5%), retinal dialysis (12 eyes, 70.6%), and absence of PVR. In all cases, a circumferential silicone explant was placed, and none were encircled. Subretinal fluid was drained in nine

Table 2 Ocular complications at presentation

	All injuries (n = 61)	Open globe injuries (n = 28)	Closed globe injuries (n = 33)
Retinal detachment	47 (77.0%)	17 (60.7%)	30 (90.9%)
Macula-off detachment ^a	31 (66.0%)	10 (58.8%)	21 (70.0%)
Traumatic cataract	16 ^b (26.2%)	14 ^b (50.0%)	2 (6.1%)
Vitreous haemorrhage	13 (21.3%)	8 (28.6%)	5 (15.1%)
Aphakic/pseudophakic	7 (11.5%)	5 (17.8%)	2 (6.1%)
PVR Grade C or worse ^a	5 (10.6%)	2 (11.8%)	3 (10.0%)
Endophthalmitis	4 (6.6%)	4 (14.3%)	
Lens subluxation or dislocation	3 ^b (4.6%)	3 ^b (10.7%)	
Intraocular foreign body	2 (3.3%)	2 (7.1%)	
Macular hole	1 (1.6%)		1 (3.0%)

^aProportion given as the percentage of eyes with retinal detachment.

^bOne cataractous lens also subluxed.

eyes (52.9%) and one eye had a D-ACE procedure (drain-air-cryopexy-explant sequence). Surgery was successful after the first procedure in 12 eyes (70.6%), after the second in another four eyes (23.5%), and in the final case the retina was re-attached after a total of four procedures for PVR, including intra-ocular tamponade with silicone oil.

Group B: vitrectomy for traumatic retinal detachment

Thirty eyes underwent vitrectomy for traumatic RD (49.2%). Indications for vitrectomy were prior failed vitreoretinal surgery, cataract or lens subluxation, vitreous haemorrhage or haze, multiple retinal breaks, posterior retinal breaks, giant retinal tear, PVR, retinal or vitreous incarceration, and intragel abscess. The agent used for retinal tamponade was sulphur hexafluoride gas (SF₆) in five eyes, perfluoropropane gas (C₃F₈) in five eyes and silicone oil in 20 eyes. There was no significant difference in the ages of children receiving oil or gas tamponade (unpaired *t*-test: *P* = 0.3531). Primary success was achieved in 14 eyes (46.7%), but 16 retinas re-detached (53.3%), 13 as a result of PVR. No further detachment surgery was performed in six cases, and the other 10 eyes underwent a median of two more vitreoretinal procedures (range 1–5). Ultimately, complete retinal re-attachment was achieved in 17 eyes (56.7%, two with continued silicone oil tamponade) and re-attachment at the posterior pole in another nine eyes (30.0%, four with silicone oil tamponade). Retinal re-attachment surgery failed in four eyes (13.3%), and two of these eyes became phthisical.

Group C: vitrectomy for other trauma-related indications

Fourteen children had attached retinas but underwent vitrectomy for other indications related to the eye injury (22.9%). These included cataract or lens

subluxation, vitreous haemorrhage or haze, removal of intra-ocular foreign body, or macular hole. One eye developed retinal detachment with PVR postoperatively (5.9%) and despite further surgery became phthisical.

Proliferative vitreoretinopathy

PVR was observed at presentation in five eyes, and a further 12 eyes developed new PVR after the first surgical procedure. PVR therefore affected 17 of the 61 eyes studied (27.9%), or 35.4% of the 48 eyes that had or developed retinal detachment, and was the cause of 15 of the 22 re-detachments (68.2%). An additional four eyes (6.6%) developed epiretinal membranes on attached retina.

Visual outcomes

The patients were followed for a mean of 19.6 months (SD 19.0 months, median 12.5 months). Two patients were followed for less than a month because they had travelled from distant referral centres for surgery and were subsequently reviewed locally. These two patients and another three with incomplete VA data are not included in the analysis of visual outcome.

Table 3 summarises the visual outcomes of 56 of the 61 children requiring vitreoretinal surgery after eye trauma. The median VA of all the patients together improved from CF at presentation to 6/36 at final follow-up (Wilcoxon signed rank test: *P* = 0.0031).

Children with OGI had a median VA at presentation of CF, significantly worse than those with CGI (median VA 6/60, Mann–Whitney U-test: *P* = 0.0016). Following vitreoretinal surgery, the median VA both groups improved to 6/36 (Wilcoxon signed rank test: *P* = 0.0082 for OGI and *P* = 0.1068 for CGI). There was no statistically significant difference in the final VA of these two groups (Mann–Whitney U-test: *P* = 0.2044).

Table 3 Visual outcomes after vitreoretinal surgery for eye injuries

	All injuries (n = 56)	Open globe injuries (n = 25)	Closed globe injuries (n = 31)
<i>Median VA</i>			
Preoperative	CF	CF	6/60
Final	6/36	6/36	6/36
Improved	32 (57.1%)	15 (60.0%)	17 (54.8%)
Unchanged	11 (19.6%)	6 (24.0%)	5 (16.1%)
Worse	13 (23.2%)	4 (16.0%)	9 (29.0%)
<i>Final VA</i>			
≥6/60	37 (66.1%)	15 (60.0%)	22 (71.0%)
≥6/12	13 (23.2%)	6 (24.0%)	7 (22.6%)
	Group A Scleral buckle for traumatic RD (n = 17)	Group B Vitrectomy for traumatic RD (n = 28)	Group C Vitrectomy for other indications (n = 11)
<i>Median VA</i>			
Preoperative	6/36	CF	CF
Final	6/24	CF	6/18
Improved	11 (64.8%)	10 (35.7%)	11 (100.0%)
Unchanged	3 (17.6%)	8 (28.6%)	0
Worse	3 (17.6%)	10 (35.7%)	0
<i>Final VA</i>			
≥6/60	15 (88.2%)	12 (42.9%)	10 (90.9%)
≥6/12	6 (35.3%)	2 (7.1%)	5 (45.4%)

Prognostic factors

We performed univariate analysis to identify factors associated with a poor visual outcome, defined as a final VA of CF or worse. There was no significant association between outcome and the following factors: patient age, type of injury, the presence of lens injury, vitreous haemorrhage or endophthalmitis, and requirement for more than one vitreoretinal surgical procedure. The association between poor outcome and presence of RD at presentation approached, but did not reach, statistical significance (Fisher exact test: $P = 0.0769$).

Preoperative VA of CF or worse was associated with a poor outcome (χ^2 : $P = 0.0306$), as was the necessity for vitrectomy in the presence of traumatic RD (Fisher exact test: $P = 0.0003$). The presence or development of PVR was significantly associated with poor outcome (Fisher exact test: $P < 0.0001$). The presence of partial or total RD at final follow-up was associated with a poor visual outcome (Fisher exact test: $P = 0.0001$), as was the retention of silicone oil in the eye (Fisher exact test: $P = 0.0002$).

Discussion

We have described a series of 61 children selected by their need for vitreoretinal surgery after ocular trauma.

The 4:1 ratio of boys to girls in this study is similar to that reported in other series.^{3,9,11-13} The mean age of children with OGI was 9.5 years, comparable to other reports,¹¹⁻¹³ however, we found that children with CGI were significantly older (mean age 12.3 years, $P = 0.0068$). The majority of injuries in children under 10 years result from blows or falls, whereas the leading cause after this age is sport,⁹ possibly resulting in different patterns of injury, and this may explain the observed age difference.

Seven of our patients had ocular diagnoses associated with an enlarged or weakened globe that rendered the eye vulnerable to trauma (Ehlers–Danlos syndrome, retinopathy of prematurity, high myopia, Marfan’s syndrome, and Stickler’s syndrome). Another patient had repeated trauma as a result of ‘head-banging’ associated with Cornelia de Lange syndrome.

The children in this study were referred from other hospitals and so the details of the extent of the ocular injury were not available in many cases. We were therefore unable to grade the severity of the injury according to the Ocular Trauma Classification Group (OTCG) terminology¹⁴ and instead we used the simpler classification of Kuhn *et al*¹⁰

Children with OGI had significantly more lens injury than those with CGI (64.3 vs 6.1%, $P < 0.0001$). This may suggest that OGI is more likely to cause damage to the

lens or zonules, but in this selected series may also imply that lens injury after OGI is more likely to require vitreoretinal management than after CGI.

A significantly higher proportion of children in the CGI group had RD (90.9%) than the OGI group (60.7%, $P=0.0067$); however, this difference may simply reflect the additional indications for vitreoretinal intervention in the OGI group, such as IOFB and lens injury.

Of the children with traumatic RD, those with OGI were more likely to require vitrectomy than those with CGI (94.1 *vs* 46.7%, $P<0.0001$). Retinal dialysis is the commonest type of retinal break seen after CGI,^{15,16} responsible for more than half of RDs after this mechanism of injury, and tractional horseshoe tears account for about another 20%.¹⁷ Scleral buckling techniques are therefore likely to be successful in a high proportion of cases of RD after CGI. Retinal breaks after OGI may be large or posteriorly located, or result from fibrocellular proliferation and contraction within the vitreous.¹⁸ Vitrectomy techniques are therefore more likely to be required in these cases.

Group A consisted of 17 children who underwent a scleral buckling procedure. We used segmental circumferential solid silicone explants in all cases and no eye was encircled. Subretinal fluid was drained in a high proportion of cases (52.9%), similar to the rate reported by Häring *et al*¹⁹ Retinal re-attachment was achieved after one operation in 70.6% of cases, and this primary success rate is lower than the 88% reported in other series.^{19,20} However, only 24–56% of detachments in these reports were following trauma, and different surgical techniques were used, including placement of an encircling band. There was a statistically significant improvement in median VA from 6/36 to 6/24 ($P=0.0419$), with the majority of children achieving vision of 6/60 or better (88.2%) and over one-third 6/12 or better.

Group B included 30 children with traumatic RD requiring vitrectomy. Silicone oil was injected in 20 (66.7%), similar to the rate reported in another series of traumatic paediatric retinal detachments.²¹ The high rate of silicone oil use is due in part to the complexity of some traumatic RDs, but a second important factor is the expected compliance of children with postoperative posturing. We found no significant difference in the ages of children receiving oil or gas tamponade, but it is impossible to control for the complexity of the detachment in the analysis.

Full anatomic re-attachment of the retina was achieved with one procedure in 46.7% of eyes in group B. The visual results in this group were the most disappointing, with no change in the median VA from CF. About one third of eyes improved, one-third were stabilized, and one-third worsened, but 42.9% of children achieved a VA of 6/60 or better at final follow-up. The anatomic and

visual results in our series are better than those reported by Sarrazin *et al*²¹ (33% primary anatomic success, VA $\geq 6/60$ in 31%).

Children in group C had attached retinas but underwent vitrectomy for a variety of other trauma-related indications, mainly opacities in the ocular media. No eye had RD at presentation and it is therefore not surprising that this group had the best anatomic and visual outcome.

Visual acuity was measured by the means most appropriate to the child's age and converted to the 6 m Snellen equivalent. Such measurements may be inaccurate in small children, particularly if the child is distressed. It is therefore possible that the preoperative acuities in particular may be underestimates of the true acuity at that time, and therefore exaggerate the apparent improvement at final follow-up.

The visual results in our patients with OGI are comparable to other published series. Sixty per cent of the children in this study achieved a final VA of 6/60 or better, compared to between 56 and 74% reported in the literature.^{12,13} We were unable to find any literature reporting visual outcomes after CGI for comparison with our series.

There are many studies of the prognostic factors of OGI in adults. These are summarised in the report by the OTCG and include type of injury, VA, relative afferent pupillary defect, location of injury, wound size, vitreous haemorrhage, lenticular injury, RD, and endophthalmitis.¹⁴ Prognostic factors after OGI in children are less well defined. Features predictive of good visual outcome include age over 8 years, good initial VA, and small, anterior eyewall perforations. Poor prognostic factors include age less than 4 years, poor initial VA, large, posterior perforations, lenticular damage, and presence of RD.^{11–13}

In this study, we defined poor outcome as CF or worse. We were unable to demonstrate any significant association between outcome and patient age, type of injury, presence of lens injury, vitreous haemorrhage, or endophthalmitis. The association between poor outcome and traumatic RD approached statistical significance ($P=0.0769$). It is perhaps surprising that there was no significant association between visual outcome and, in particular, endophthalmitis or traumatic RD. The patients in this series were selected by their need for vitreoretinal surgery and therefore are likely to represent the more severe end of the paediatric trauma spectrum. In addition, the proportion of patients with ocular co-pathology (seven out of 61) is high. Both these factors may bias the results.

Factors significantly associated with poor outcome were preoperative VA CF or worse, presence of PVR, and traumatic RD requiring vitrectomy. Scleral lacerations

extending posterior to the rectus muscle insertions carry a poor prognosis, and it is these injuries that are most likely to result in retinal detachment with vitreous haemorrhage or PVR and require vitrectomy. We had incomplete information regarding the posterior extent of the wound in the OGI group, but it is likely that the association between traumatic RD requiring vitrectomy and poor outcome is a surrogate marker for the severity of the ocular injury.

The presence of RD at final follow-up was also associated with poor outcome, but interestingly there was no association between outcome and number of surgical procedures required. This perhaps suggests that several attempts to re-attach the retina may be justified, but clearly the risk of multiple anaesthetics and the psychological effects of repeated procedures on the child and his or her family must also be taken into account.

PVR was a significant factor influencing the visual and anatomic outcome for the children in this study. About one third of eyes had retinal detachment complicated by PVR, and PVR was the cause of surgical failure in two thirds of cases. PVR is the only potentially modifiable risk factor for poor outcome identified by this study. Adjuvant treatment with 5-fluorouracil and heparin infusion has been shown to reduce the incidence of PVR in adult retinal detachment.²² Children with traumatic retinal detachment may also benefit from adjuvant treatment to reduce the incidence of this devastating complication, although further studies are required to confirm this.

Conclusions

It is not surprising that visual outcomes were best in those children whose injury did not result in traumatic RD. Scleral buckling for traumatic RD in children produced good anatomic and visual results and therefore should be considered in cases with clear media, anterior breaks, and no PVR. Vitrectomy for traumatic RD had the most disappointing outcomes, but this group self-selects the most severe injuries. PVR was a significant contributing factor to poor outcomes.

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