Blowout Fractures: Surgical Outcome in Relation to Age, Time of Intervention, and Other Preoperative Risk Factors

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ABSTRACT

We sought to describe outcome of surgical repair in patients presenting with orbital blowout fractures. This noncomparative, retrospective, consecutive case series reviewed the case notes of 63 consecutive patients who underwent surgery for a blowout fracture between November 1992 and March 2005. Risk factors for motility outcome as well as presence of enophthalmos after surgery were analyzed. Children had earlier surgery than adults ($p < 0.001$) and tended to have better motility outcome than adults. Surgery performed within the first week showed a trend for better outcome, but this was not statistically significant ($p = 0.231$). Assault had the best motility outcome, compared with other modes of trauma. Patients with worse preoperative motility had better outcome ($p < 0.001$). Enophthalmos improved significantly after surgery ($p < 0.001$). Children as compared with adults and surgery performed within the first week tended to have better motility outcome, but this was not statistically significant.

KEYWORDS: Enophthalmos, motility outcome, orbital blowout fractures

Smith and Regan¹ designated the term *blowout fractures* of the orbit for orbital floor fractures without fracture of the orbital rim, but with entrapment of one or more soft tissue structures, which limit vertical motility and cause diplopia and enophthalmos. The current definition includes any internal orbital wall fracture without involvement of the rim but usually refers to the floor and medial wall. These fractures may be associated with corneal, eye globe, intracranial, optic nerve, and eyelid injuries.²⁻⁴

Acute symptoms of orbital blowout fractures include orbital pain, sunken eye, diplopia, and paresthesia in the infraorbital nerve distribution.^{5,6} Associated signs may include eyelid ecchymosis, subcutaneous emphy-

sema, mydriasis, lid laceration, angle recession, hyphema, and occasionally ptosis. Diplopia could be related to entrapment of the fibrous intermuscular septa or the muscle itself in the fracture site. Occasionally, it could be related to muscle damage⁷ or muscle paralysis due to trauma to a cranial nerve.⁸ Forced duction test and saccadic eye movements will be able to differentiate between the restrictive and paralytic diplopia.

Surgery or observation is the main treatment. In the past, the indications for surgery and the timing of surgery were controversial.⁹⁻¹¹ Putterman et al⁹ reported that all 57 patients in their group with pure blowout fractures of orbital floor had partially resolved their initial symptoms without intervention. Other reports

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indicated unresolved diplopia with delayed surgery.¹⁰ Today, there is clear consensus about the indications for early surgery.⁷ Here we report 63 patients who were managed with surgery for their blowout fractures, and we describe the patient characteristics in relation to the outcomes of ocular motility and enophthalmos after surgical repair.

METHODS

This is a retrospective review of case notes of 63 patients who had blowout fractures and were managed in a tertiary referral center in Southeast Asia between November 1992 and March 2005. Specifics of the patients' age, ethnicity, laterality of injury, the orbital wall involved from the computerized tomography (CT) report, the interval between the injury and time of intervention, the type of implant used to repair the blowout fractures as well as the follow-up period were noted.

The patients had field of binocular single vision and Lees screen tests to objectively chart the motility pre- and postoperatively. Lees screen test is similar to the Hess test, where the patient fixes with one eye at 9 points in an inner square and 17 points in an outer square sequentially, and charts diplopia at a screen placed at 90 degrees. The amount of motility restriction in elevation, depression, and horizontal gaze was assigned a number depending on the severity from 0 to 3, in which 0 signified no restriction, 1 signified mild motility restriction (beyond 25 degrees from primary position), 2 signified moderate motility restriction (between 16 and 25 degrees), and 3 signified severe motility restriction (between 0 and 15 degrees). A total motility score for each patient was obtained by adding the numbers for all directions of gaze preoperatively. A similar motility score was obtained for each patient postoperatively. All surgeries were performed through a transconjunctival approach with or without lateral cantholysis by experienced surgeons or under their supervision. The modes of trauma were noted. Blowout fracture types were categorized according to the involvement of the floor, medial wall, or both.

Definitions Used in the Study

Any patient ≤ 16 years was considered a child and patients over this age were considered as adults. Preoperative score is the motility score after trauma and immediately before surgery. Postoperative score is the motility score that was last documented in the postoperative period. Final score is the difference between the pre- and postoperative motility scores, and it ranged from -5 to 1 , in which positive final score indicates worsening of motility after surgery, 0 indicates no change, and negative final score indicates improvement in motility; the greater the decrease in score, the better the outcome.

The interval between the trauma and the surgery was considered immediate if it was in the first week and delayed if it was more than 1 week.

Enophthalmos was documented to be present if the affected side showed more than 2 mm retroplacement of the eye globe compared with the normal side and absent if the difference was 2 mm or less. The measurements were taken with a Hertel exophthalmometer.

Statistical Methods

STATA version 10 (Statacorp, College Station, TX) was used for analyzing the data. The pre- and postoperative motility scores and the final motility scores are expressed as the median, minimum, and maximum range. The association between the risk factors and the postoperative motility scores was analyzed using linear regression models. The changes in enophthalmos after surgery were assessed with McNemar chi-squared test. A p value of <0.05 was considered to be significant.

RESULTS

The distribution of different races in our study was similar to the racial distribution of our country. Median age was 27 ± 18.9 years (range 7 to 76); males were injured more than females (4.25:1). There were 13 children and 50 adults (20.6% children). Assault was the most prevalent mode of trauma. Table 1 shows the characteristics of the patients in the study.

Ecchymosis was the most encountered periorcular sign ($n = 57$; 89%), except for the few cases of "white-eye" blowout fractures. There were no cases of severe ocular injury or traumatic optic neuropathy.

Most of the surgeries were done by the oculoplastic team (58 patients; 93.6%). One patient (1.6%) was operated by facial plastic surgeons and three patients (4.8%) by a team of plastic surgeons and ophthalmologists. CT scan showed 49 (77.8%) isolated floor fractures, 5 (7.9%) medial fractures, and 9 (14.3%) combined floor and medial wall fractures.

Supramid[®] implant (S. Jackson, Inc., Alexandria, VA) was used in 29 (46.0%) patients, all of whom were operated before the year 2002; Medpor[®] (Porex Surgical, Inc., Fairburn, GA) in 23 (36.5%) patients; titanium mesh (Synthes Inc., Singapore) in one patient (1.6%); and the rest of the patients ($n = 10$; 15.9%) had bioresorbable implants (MacroPore[®], MacroPore Biosurgery, Inc., San Diego, CA, and Synthes Inc., Singapore).

The follow-up in most of the patients (53) was more than 6 months. Of the 10 remaining patients with less than 6 months follow-up, six had no diplopia and four patients had diplopia only in upgaze beyond 25 degrees at the last visit.

The median preoperative motility score was 3 (0 to 6), the median postoperative motility score was 1 (0 to 4),

Table 1 Patient Characteristics

	Surgical Patients (n = 63)
Age (y)	
≤16	12.5 ± 2.4
>16	34.3 ± 14.2
Total	29.8 ± 15.5
Gender	
Male	51 (81.0)
Female	12 (19.0)
Race	
Chinese	46 (73.0)
Malay	8 (12.7)
Indian	4 (6.4)
Other	5 (7.9)
Mode of trauma	
Assault	18 (28.6)
RTA	13 (20.6)
Industrial	10 (15.9)
Domestic accidents	14 (22.2)
Sports	8 (12.7)
Injury side	
Left	27 (54.0)
Right	23 (46.0)
Orbital wall involved	
Medial	5 (7.9)
Floor	49 (77.8)
Both	9 (14.3)
Time to intervention (wk)	
≤1	0.6 ± 0.4
>1	4.4 ± 3.1
Total	4 ± 3.2

Data are mean ± standard deviation or count (%). RTA, road traffic accidents.

thereby giving a final score of −2 (−5 to 1). Ten (15.6%) patients had diplopia in the primary position on presentation but none after surgery.

Children had significantly shorter intervention time (Mann-Whitney *U* test, $p < 0.001$) of 1.9 ± 1.3 weeks compared with adults (4.6 ± 3.3 weeks). No significant differences in mean intervention times were observed among gender, race, or modes of trauma.

Table 2 displays the percentages of patients who experienced each outcome category—poor, good, and no

Table 3 Univariate Linear Regression Analyses of the Risk Factors for Postoperative Motility Score, Adjusted for Preoperative Motility Score

	Mean Difference	SE	p Value
Age in years	0.005	0.008	0.552
Age group			
Adult vs. child	0.117	0.286	0.684
Gender			
Male vs. female	−0.198	0.303	0.517
Race			
Malay vs. Chinese	−0.311	0.377	0.414
Indian vs. Chinese	−0.262	0.479	0.587
Other vs. Chinese	−0.348	0.481	0.472
Mode of injury			
Industrial vs. RTA	−0.158	0.398	0.693
Domestic accident vs. RTA	0.372	0.351	0.294
Sports vs. RTA	−0.051	0.399	0.970
Assault vs. RTA	−0.532	0.335	0.118
Orbital wall			
Floor vs. medial	0.666	0.423	0.121
Combined vs. medial	0.419	0.527	0.431
Type of implant			
Supramid vs. Medpor	0.367	0.261	0.165
Titanium vs. Medpor	−0.969	0.924	0.299
Absorbable vs. Medpor	0.318	0.345	0.361
Time to intervention			
Delayed vs. immediate	0.482	0.398	0.231

SE, standard error.

change—stratified by age group and intervention time. There was only one patient with a poor postoperative motility outcome.

Linear regression analyses were performed to model the relationships between risk factors and postoperative motility score, after adjusting for the preoperative motility score. Table 3 shows the results of univariate analyses for several risk factors. The mean difference in postoperative score between delayed and immediate intervention was 0.482 ($p = 0.231$). Adults had a mean postoperative motility score of 0.117 higher than children ($p = 0.684$). Furthermore, patients with orbital floor fractures had mean postoperative scores of

Table 2 Percentage of Patients in Each Outcome Category by Age Group and Time to Intervention

Characteristic	% Patients with Poor Outcome (n = 1)	% Patients with No Change (n = 17)	% Patients with Good Outcome (n = 41)
Age group (y)			
≤16	0	15.4	84.6
>16	2.2	32.6	65.2
Time to intervention (wk)			
≤1	0	16.7	83.3
>1	1.9	30.8	67.3

Table 4 Multivariate Linear Regression Analysis of the Risk Factors for Postoperative Motility Score

	Mean Score Difference	SE	p Value
Race			
Malay vs. Chinese	-0.554	0.362	0.133
Indian vs. Chinese	-0.827	0.461	0.079
Other vs. Chinese	-0.668	0.467	0.160
Mode of injury			
Industrial vs. RTA	-0.025	0.409	0.951
Domestic accident vs. RTA	0.513	0.364	0.166
Sports vs. RTA	-0.133	0.406	0.745
Assault vs. RTA	-0.724	0.338	0.038
Type of implant			
Supramid vs. Medpor	0.071	0.255	0.781
Titanium vs. Medpor	-1.561	0.890	0.086
Absorbable vs. Medpor	0.377	0.324	0.251
Time to intervention			
Delayed vs. Immediate	0.657	0.390	0.099
Initial motility score	0.278	0.081	0.001

RTA, road traffic accidents; SE, standard error.

0.6 ($p=0.177$) higher than those with medial wall fractures, indicating a relatively worse outcome. However, no significant results were found in the univariate analysis.

Table 4 displays the results of a multivariate linear regression analysis on the data. The risk factors included in the model were race, mode of injury, type of implant, and intervention time, controlling for preoperative motility score. The mean adjusted difference in postoperative motility score between delayed and immediate intervention was 0.657 ($p=0.099$). There was a significant mean adjusted difference in postoperative scores between road traffic accidents and the other modes of injuries ($p=0.013$). In particular, assault had a better outcome compared road traffic accident (mean adjusted difference = -0.724, $p=0.038$). Chinese patients had poorer outcomes compared with Malays, Indians, and other races ($p=0.131$), although this was not statistically significant.

Enophthalmos was documented in 12 (20.0%) patients preoperatively. Surgery made significant improvement to enophthalmos ($p<0.001$, McNemar test). In terms of surgical complications, one patient (1.6%) had his motility score worsen from 1 preoperatively to 2 postoperatively; one patient (1.6%) had delayed lateral canthal dystopia; and there were no cases of visual loss.

DISCUSSION

Diplopia is subjective and is difficult to quantify. To study outcome, we felt that it would be better to use an

objective method such as Lees screen, which measures the ocular motility. Restriction of motility in one gaze can have a bearing on other gazes. By using a motility score, we found it easier to make comparisons and do statistical analyses. Therefore, we graded the motility restriction in different gazes and then added all of them for the total motility score. A high negative final score indicates a good outcome, whereas a positive score indicates poorer outcome. A 0 score indicates no change despite successful surgical results of enophthalmos correction. This could be viewed as a limitation of using such a scoring system.

For each increase in preoperative motility score, postoperative score decreases by 0.28, and hence greater improvement was observed in subjects with higher preoperative motility score. This lends support to the existing practice of intervening surgically in patients who persist to have severe diplopia after the edema and hemorrhage resolve.

In our series, children had intervention significantly earlier in keeping with the high incidence of trapdoor fractures and had better motility outcome compared with adults, supporting the findings of Hoşal and Beatty.¹² Leitch et al¹³ found no difference in outcome between the adults and children.

The management of orbital blowout fractures was debated a lot in the past. Putterman et al⁹ and Koornneef¹⁴ have popularized the concept of observation period for adults with isolated orbital floor fractures to see if the motility would improve spontaneously. But when the CT scan shows entrapment of muscle in adults, spontaneous resolution of duction deficits is unlikely with conservative measures.¹⁵

In our series, indications for surgery were similar to the recommendations made by Burnstine.⁶ We found that patients who underwent surgery in the first week after presentation showed a trend for better outcome and final score. Although these results were not statistically significant, they do agree with previous reports.^{6,10,12,16}

Isolated floor fractures on either side of the infraorbital groove formed the majority of the blowouts.¹⁶ The presence of the neurovascular bundle within the infraorbital groove and the ethmoidal air cells adjacent to the medial wall may provide some protection from fracture of the bones in those areas.^{16,17} We showed a trend for orbital floor fractures to have poorer motility outcome compared with medial wall fractures, which contradicts other reports^{12,14} that suggest worse outcome with medial wall fractures. However, our results were not powered enough to show statistical significance.

There was no significant difference in the motility outcomes in relation to the type of implants. Nevertheless, our present practice is to use Medpor[®] or bioresorbable implants.

Enophthalmos is a sign of orbital blowout fracture, and it might even cause limitation of extraocular muscle excursion due to a misplaced pulley system that normally makes the extraocular muscle efficient. Significant enophthalmos after orbital injury and floor fractures is usually not immediately apparent because of edema and hemorrhage in orbital tissues, except in children who have "white-eye" blowout fractures. CT scan is useful in predicting significant postinjury enophthalmos.¹⁸ Burnstine⁶ recommends surgical repair within 2 weeks if greater than half of the floor is depressed. In our series, the enophthalmos significantly improved after surgery, which is comparable to other series reporting on residual enophthalmos.¹²

There were no cases of severe ocular injury or optic neuropathy at presentation in our series. Other features, such as reduced visual acuity and pupillary abnormalities, should be looked for, as they may signify covert intraocular injury or neurological damage requiring further management. Oculocardiac reflex is described as a sign of trapdoor pediatric orbital floor fractures,¹⁹ and it is an indication for an urgent intervention.⁶ This was not specifically looked at in our study as methodical documentation of such signs was not found in the case records.

The short follow-up in 10 cases did not adversely affect our statistical results as all of these patients had either no diplopia or diplopia only in extreme upgaze.

Surgical intervention for blowout fractures is not without complications, which were of minor nature in this series. The most worrisome complication is the loss of vision, which has been reported to occur in 1/1500¹⁷ surgeries; we did not encounter any visual deterioration in any patient after the surgery.

This retrospective study should be viewed in light of several limitations. The data were recorded variably by different people, and missing data and variable follow-up periods pose difficulties as in all retrospective studies. Although our study involves a relatively large group of patients, attempts to subcategorize subjects result in smaller numbers of subjects in each group, making a valid relationship between variables impossible to determine.

The relationship between the effects of age, involved wall, and preoperative diplopia on the outcome of surgery is still a matter of debate. Doing a prospective study is not out of reach by measuring the amount of diplopia in a more objective way, using Hess Aria Ratio (HAR%) as suggested by Furuta et al,²⁰ by measuring the size of the fracture with CT scan; and by stipulating similar follow-up periods.

In conclusion, although there is a clinical trend toward favorable results in children as compared with adults and immediate as compared with delayed surgical intervention in cases of blowout fractures, these were not statistically significant. Surgery reduces the incidence of

residual diplopia and enophthalmos in cases of blowout fractures requiring surgery with minimal complications. Patients with severe initial motility restriction and injuries resulting from assaults show the most improvement in eye motility postoperatively.

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