Orbital Blow-out Fractures in Children: Characterization and Surgical Outcome

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Background: Trapdoor-type orbital fractures usually associated with marked motility restriction are common in the pediatric age group. We reviewed the characterization and surgical outcomes of orbital blow-out fracture in children.

Method: This is a retrospective review study. From Jan. 1997 to Dec. 2006, 75 patients under 18 years of age with orbital blow-out fractures were seen in the department of ophthalmology, Chang Gung Memorial Hospital. The medical records and computed tomography scans of these patients were reviewed.

Results: Forty-one patients were identified whose records were adequate to compare data. The mean age of the patients was 12.7 years and the mean duration of follow-up was 6.5 months. The most common causes of injury were assault (43.9%) and motor vehicle accidents (29.3%). Ninety-five percent of the patients had diplopia and ninety-three percent had extraocular muscle limitation. The incidence of trapdoor fracture in pediatric orbital fracture was 68.3%. Orbital blow-out fractures in these children most frequently involved the isolated orbital floor. The average time to surgical intervention was 23 days after injury; 53.8% patients received immediate (0-2 days) or early (3-14 days) repair. Improvement from preoperative supraduction limitation was statistically significant in the immediate (0-2 days), early (3-14 days) and delayed (15-30 days) surgical groups.

Conclusion: Orbital blow-out fractures in our pediatric patients were usually the result of assault or motor vehicle accident. Surgical repair within one month of injury led to better improvement and more complete resolution of ocular motility limitation and diplopia than late repairs.

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Key words: blow-out fracture, trapdoor, children, pediatric

Orbital fractures can occur in patients who have suffered blunt injury from traffic accidents, falls, violence or other orbital trauma.(1-7) The type of orbital floor fracture found in children differs from that found in adults.(8) Trapdoor-type orbital fractures usually associated with marked motility restriction and nausea or vomiting are common in the pediatric age group.(1,5) Possibly because of the greater elastici-

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ty of the orbital bones in the pediatric population, there is greater potential for development of trap-door-type fractures, which in turn can result in prolapsed orbital tissue getting caught and trapped in the fracture site.[1] The trapped tissue and muscle can then cause severe diplopia and an oculocardiac reflex.[9] Management of orbital blowout fractures remains controversial.[1,7,8,10,11] Because orbital fracture is relatively uncommon in children, and some studies have indicated that early diagnosis and surgical repair can lead to more rapid and more significant improvement,[2-4,6,8,12] we investigated the specific characterization and surgical outcomes of orbital blow-out fracture in children.

METHODS

Between Jan. 1997 and Dec. 2006, 75 patients under 18 years of age with orbital fractures were seen in the department of ophthalmology, Chang Gung Memorial Hospital. Patients who had other, coexisting facial fractures or orbital rim involvement were excluded from this study. In addition, patients with severe associated ocular trauma (such as traumatic optic neuropathy or eyeball rupture) were also excluded. A retrospective review of the medical records and the computed tomography (CT) scans of these patients was carried out by two of the authors (NC Wang and FR Yang). All patients had internal orbital fractures confirmed by axial and coronal CT scans. In this study, we investigated the cause of injury, clinical symptoms, associated ocular injury, radiographic data, timing of operation after injury, operative findings and postoperative results. Ocular motility restriction was subjectively graded from 0 to -4, with 0 representing no limitation and -4 representing no movement in the field of gaze.[1-3] Enophthalmos was measured by a Hertel exophthalmometer or was visually estimated in uncooperative patients. The indications for surgery included extraocular muscle restriction with diplopia, significant enophthalmos (> 2 mm) and large orbital wall defect found on CT (> 50% wall).[1] If surgical repair of the orbital floor fracture was indicated, surgery was performed under general anesthesia by three of our authors (L Ma, YJ Tsai and SY Wu), who also evaluated the patients before and after the surgery. Surgical repair was performed through a subcilicary incision or transconjunctival incision. Dissection was carried down to the inferior orbital rim and then the periosteum was incised to expose the fractured bone and the herniated orbital tissue. The trapped orbital tissue was carefully released and pulled back to the orbit while preserving the infraorbital nerve as much as possible. The fracture site was covered with Supramid® (S. Jackson, Inc., U.S.A.) or Medpor® (Porex, U.S.A.) and the forced duction test was performed to ensure that there was no more trapped tissue. The implant was fixed with Histoacryl® (B. Braun, U.S.A.) and the wound was closed after irrigation with gentamycin solution. Patients were then observed by our authors until they attained maximum return of function or failed to keep a follow-up appointment. Generally, the patients had regular follow-ups at 1 week, 1 month, 3 months and 6 months after surgery. To compare the surgical outcome, the patients were divided in to 4 groups based on the time from the trauma to the operation (0-2 days, 3-14 days, 15-30 days, and ≥ 31 days). Only patients who completed at least one month of follow-up were included for analysis. Statistical analysis was performed by Student's t-test and F test using SPSS. Within-group comparisons of postoperative and baseline values were analyzed by paired t-test. Between-group comparisons were analyzed by independent t-test (we first performed the F test to determine whether the variances were equal). A p value of less than 0.05 was considered statistically significant.

RESULTS

Seventy-five patients with orbital blow-out fracture were reviewed and 47 patients were identified whose records were adequate to compare data. Among 47 patients, five had facial bone fractures with or without traumatic optic neuropathy and one had eyeball rupture. They were also excluded. Forty-one patients (31 boys and 10 girls) with orbital wall fracture were finally included in our study. The mean age of the patients was 12.7 years (range, 5-18 years old; SD, ± 4.2). The mean duration of postoperative follow-up was 6.5 months (range, 0.3-59 months; SD, ± 9.9). Injury occurred on the right side in 21 of the patients (51.2%) and the left side in 20 (48.8%).

The most common causes of injury were assault (18 of 41) and motor vehicle accidents (12 of 41), followed by falls (7 of 41) and sports injuries (4 of 41) (Table 1). The signs and symptoms after injury

Table 1. Cause of Injury

Cause of injury	No. of patients (%)
Assault	18 (43.9)
Motor vehicle accident	12 (29.3)
Fall	7 (17.1)
Sports injury	4 (9.7)
Total	41 (100)

are shown in Table 2. Ninety-five percent of the patients had diplopia and 93% had ocular motility restriction. Thirty-eight percent of the patients had nausea or vomiting, 17% had enophthalmos and 7% had bradycardia. Furthermore, 6 patients (14.6%) suffered from associated ocular injuries, including canalicular disruption (3 of 41), simple lid laceration (2 of 41) and vitreous hemorrhage (1 of 41). The incidence of trapdoor fracture in pediatric orbital fracture was 68.3% (28 of 41). Orbital blow-out fractures most frequently involved the isolated orbital floor (68.3%), followed by a combination of the orbital floor and the medial wall (31.7%).

All 41 of our patients received surgical repair according to the general indications.[1,7] The timing to surgical intervention after the injury is noted in Table 3. The average time was 22.9 days (range, 0-240 days; SD, ± 38.4) and 53.8% of the patients (22 of 41) received immediate (0-2 days) or early (3-14 days) repair. Of the 41 patients who underwent surgical repair, four did so within 2 days after injury; 18, between 3 and 14 days after injury; 11, between 15 and 30 days after injury; and 8, 31 days or more days after injury. The fracture site was covered intraoperatively by Supramid® in 3 patients and Medpor® in 38.

Three patients were excluded from analysis of the benefits of surgery because of a short follow-up period (< one month). Table 4 summarizes the changes in diplopia and the mean change in supraduction limitation following the operation. Thirty-six patients presented with ocular motility restriction, and 37 with diplopia before surgical repair. After surgery, ocular motility restriction was resolved in 18 of the 36 patients (Fig. 1) The other 18 patients

Table 2. Signs and Symptoms

Sign and symptoms	No. of patients (%)
Diplopia	39 (95.1)
Ocular motility restriction	38 (92.7)
Nausea/vomiting	16 (39.0)
Enophthalmos	7 (17.1)
Bradycardia	3 (7.3)

Table 3. Time of Surgery after Injury

Time of surgery	No. of patients (%)
Immediate (0-2 days)	4 (9.8)
Early (3-14 days)	18 (43.9)
Delayed (15-30 days)	11 (26.8)
Late (≥ 31 days)	8 (19.5)
Total	41 (100)

Table 4. Postoperative Changes

Time of surgery	Patients	Ocular motility restriction		diplopia		Supraduction limitation		
		Pre-op.	Post-op.	Pre-op.	Post-op.	Pre-op.	Post-op.	Mean change
0-2 days	4	3	1	4	2	–2.75	–0.5	2.25 ± 1.48*
3-14 days	16	16	5	16	7	–3	–0.31	2.69 ± 0.85†
15-30 days	11	11	6	11	6	–2.55	–0.55	2.00 ± 1.34‡
≥ 31 days	7	6	6	6	6	–1.29	–0.86	0.43 ± 0.98§
Total	38Ⅱ	36	18	37	21	–2.53	–0.5	2.03

Abbreviations: Pre-op.: pre-operation; post-op.: post-operation; *: $p = 0.03$; †: $p = 0.0001$; ‡: $p = 0.0003$; §: $p = 0.28$; Ⅱ: Three patients who failed to follow-up for 1 month were excluded from this table.

showed ocular motility restriction at their last follow-up. At the same time, diplopia was resolved in 16 of the 37 patients. The remaining 21 patients showed diplopia at their last follow-up, although subjective diplopia improved, especially in the groups that underwent surgery within 1 month of injury. At postoperative follow-up, the mean change in supraduction limitation using the quantitative scale was 2.25 ± 1.48 for patients who underwent surgery within 2 days of injury ($p = 0.03$), 2.69 ± 0.85 for those with surgery within 3 to 14 days ($p = 0.0001$), 2.00 ± 1.34 for those with surgery within 15 to 30 days ($p = 0.0003$), and 0.43 ± 0.98 for those with surgery 31 or more days after injury ($p = 0.28$). Although the mean change in the early group (3-14 days) was more prominent than in the immediate group (< 2 days), no statistical difference was found ($p = 0.47$).

Six of the 38 patients (15.8%) had postoperative complications at their last postoperative visit (range, 4-26 months; mean, 11 months; SD, $\pm$ 8.7), as shown in Table 5. Two patients had persistent esotropia and two had persistent hypertropia. Two had persistent enophthalmos. One had ptosis, and the remaining patient complained of infraorbital nerve dysfunction. No vision loss was observed during follow-up.

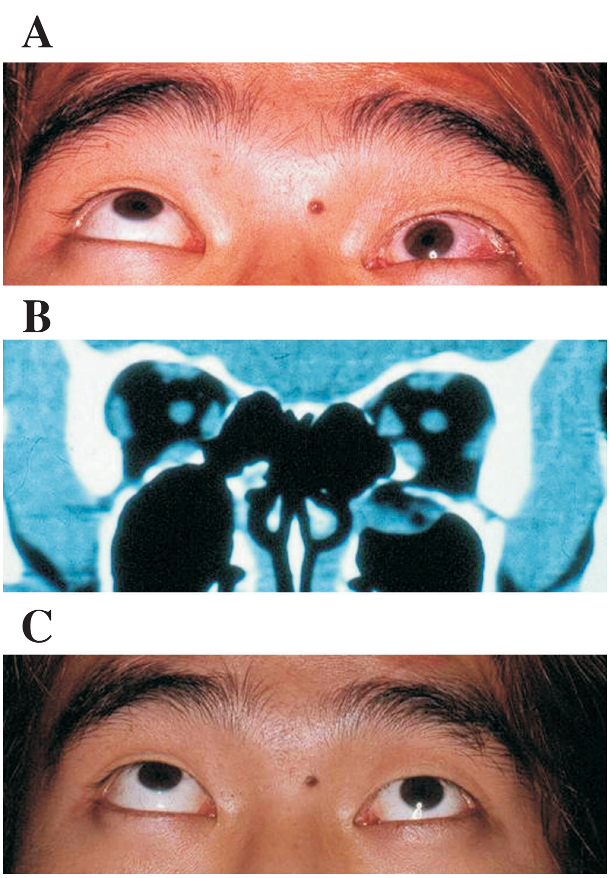

Fig. 1 A 16-year-old patient after a motor vehicle accident. (A) Marked upgaze restriction. (B) Computed tomography scan reveals a small crack on the orbital floor with tissue herniation into the maxillary sinus. (C) Upgaze restriction has improved after surgical repair.

DISCUSSION

The term ‘orbital blow-out fracture’ refers to the mechanism by which a blow to the eyeball is transposed to the orbital walls, causing them to fracture.[4] This often involves injury to the orbital floor.[1,3-5,7] The first recorded description was by Lang in 1889.[13] Orbital floor fracture is commonly seen as the result of blunt trauma to the face or orbit. However, facial fractures generally are uncommon in the pediatric population,[14-16] and orbital fractures represent 3% to 45% of all facial fractures in children.[7,15-21] In 1957, Smith and Regan described the signs and symptoms of orbital floor fractures with intact orbital rims.[22] Orbital fractures may occur in children who have sustained blunt injury in traffic accidents, falls or violence, or from other orbital trauma.[1-7] In our study, the most common causes of injury were assault (43.9%) and motor vehicle accidents (29.3%), followed by falls and sports injuries, However, in other published reports assault (20.1-68.2%) and sports injuries (15-50%) were the most common causes,[1-7] followed by falls and motor vehicle accidents. Our hospital is located near a freeway and is one of the main trauma centers in northern Taiwan. Therefore, our hospital has a large number

Table 5. Postoperative Complications in 38 Evaluated Patients

Complication	No. of patients (%)
Persistent esotropia	2 (5.3)
Persistent hypertropia	2 (5.3)
Persistent enophthalmos	2 (5.3)
Ptosis (not invocrimal system)	1 (2.6)
Infraorbital nerve dysfunction	1 (2.6)

of patients who have had severe motor vehicle accidents, which explains the high percentage of patients with these injuries in our study.

Our pediatric patients with a history of ocular injury and little clinical evidence of trauma had marked extraocular muscle limitation, especially in vertical gaze. Jordan et al. termed these cases ‘white-eyed blow-outs.[6] Diplopia and ocular motility restriction were the most common symptoms and signs in our study, in agreement with several published articles (74-100%).[2,5,6,8,12] Thirty-nine percent of the patients experienced nausea or vomiting, two other important symptoms. Urgent brain CT should be performed to assess possible brain injury in those with severe nausea and vomiting.[2] In addition, nausea and vomiting occurring with severe restriction of ocular motility suggest the possibility of a trapdoor fracture in pediatric patients.[9,23,24] These symptoms can be promptly relieved after surgery.[1,2] Generally, early significant enophthalmos (> 2 mm) may occur with a large non-trapdoor fracture.[1,2] Only 17.1% of our patients had enophthalmos, in agreement with other published articles (3-32%).[1,2,5] Three patients with trapdoor fractures had bradycardia caused by oculocardiac reflex.

Our study included 38 patients with trapdoor fractures. We exposed the incarcerated soft tissue and/or rectus muscle and then released them intraoperatively. Kwon reported that extraocular muscle limitation, diplopia and trapdoor fracture were more frequent in a pediatric group (81%, 100%, 81%) than in an adult group (43%, 50%, 44%).[8] Trapdoor fracture may contribute to diplopia and extraocular muscle limitation in children.[8] The incidence in pediatric orbital fracture is reported to be 24-93%.[1,2,3,5,7,25]

A trapdoor fracture is a linear orbital floor fracture which is hinged medially, and allows herniation of the orbital contents through the fracture and then traps the contents.[12] The trapped tissue and muscle may cause severe diplopia and oculocardiac reflex.[9] Because of the greater flexibility of the orbital bone in children, the herniated orbital content is easily trapped in the small fracture site.[5,26] The trapdoor impinges the herniated tissue and reduces blood flow to the muscle and perimuscular tissue.[6,26] This flexibility decreases with age, however, and as a result, the bone is crushed by impact in adults.[2,8]

The most common associated ocular injuries in our patients were canalicular duct disruption (7.3%), simple eyelid laceration (4.9%) and vitreous hemorrhage (2.4%). Visual acuity, and eyelid contour need to be checked carefully and patients must be assessed for any relative afferent papillary defect, because these associated injuries are easily misdiagnosed. Routine slit lamp and indirect ophthalmoscope examinations are also important.

The most appropriate timing for surgical repair after an orbital blow-out fracture is controversial.[1,7,8,10,11] The current accepted indications are internal orbital fracture with muscle incarceration resulting in ocular motility restriction with diplopia, early enophthalmos (> 2 mm), and large orbital defects (> 50% of the floor or medial wall).[1,7,11] Surgical intervention should be performed within 2 weeks.[27,28] For trapdoor fracture, early surgery within 2 to 4 days is more appropriate than a wait-and-watch period of 2 to 3 weeks.[6] The trapped perimuscular fat and connective tissue may set up a potential compartment-type situation leading to tissue ischemia and the possibility of resultant muscular and perimuscular fibrosis.[6] In 1974, Putterman recommended that patients with pure blow-out fractures be kept under observation for 4 to 6 months at least to determine the rate of improvement.[10] In 1991, de Man also suggested that a ‘wait-and watch’ policy was appropriate for blow-out fractures in adults.[25] Dutton felt, however, that in some situations surgical repair should not be delayed, and therefore summarized the indications for early surgery (within one to two weeks).[11] Furthermore, Kwon reported that the recovery period in children was shorter when surgical intervention was performed within 5 days after injury.[8] However, surgery might be required within 2 weeks in adults. Bansagi also found that early surgical intervention (< 2 weeks) resulted in a more complete return of ocular motility in a pediatric population,[1] while Egbert suggested surgery should be performed within 7 days for more rapid recovery.[2] Egbert also found surgery within one month of injury resulted in improvements of preoperative duction deficit and diplopia in all his patients.[2] Therefore, we divided the patients into 4 subgroups based on the time from the trauma to the operation, which was different from the other articles.[1-3,5,8] In our study, surgery within one month of injury resulted in improvement of preoperative ocular motility restriction and diplopia in all patients. Furthermore, 60% of patients showed complete resolution of preoperative ocular motility restriction, and 51.6% showed complete resolution of preoperative diplopia at the last postoperative follow-up. On the other hand, no patients showed complete resolution of ocular motility restriction or/and diplopia when surgery was performed more than one month after injury.

To compare the benefits of different timing of intervention, we analyzed the quantitative amount of supraduction limitation preoperatively and postoperatively in the 38 patients who underwent surgery and completed at least one month of follow-up since vertical motility impairment was the most common ocular motility disturbance and was associated with fracture of the orbital floor.[1-3,7] We found that improvement in preoperative supraduction limitation was greater in the immediate, early, and delayed groups. However, the mean supraduction limitation remaining postoperatively was between -0.31 and -0.55 at their last follow-up. In contrast, the late surgical group showed insignificant improvement (p = 0.28).

We found no immediate complications in our study. With respect to late complications, about 11% of our patients showed persistent hetertropia or hypertropia at their last postoperative visit. The possible role of direct damage to extraocular muscles or their innervating nerves must be considered.[4] Only 2 of the 7 patients with enophthalmos after injury had enophthalmos at the last postoperative follow-up and both had 2 mm of residual enophthalmos. The incidence of persistent enophthalmos in pediatric orbital fracture was reported to be 0-8.8%.[2,4,7] One of our patients had postoperative ptosis and surgical trauma during repair was the most likely cause. Six months later, no obvious improvement was found and surgical repair of ptosis was performed.

There are some limitations to our study. First, our hospital (Chang Gung Memorial Hospital) is a trauma center in northern Taiwan. There is inevitable referral bias because we receive more severe cases than other local hospitals. Meanwhile, patients referred to our hospital might have delays of days, or even for weeks. Second, we presented the characterization and surgical outcome only in those pediatric patients with internal orbital fractures. Those who had orbital blow-out fractures involving the orbital rims or facial bones were excluded. As a general rule, those patients have more complicated clinical conditions and results. Another limitation of our study was the variable follow-up period (0.3-59 months) and the fact that 18 patients (38%) received follow-up for less than 3 months. However, most retrospective studies have variable postoperative observation periods.

Conclusions

The injuries in our pediatric patients with orbital blow-out fractures were typically a result of assault or motor vehicle accident. Ocular motility restriction and diplopia were the most common manifestations. Because of the high incidence of trapdoor-type fracture in children, it is important to make an early diagnosis and provide surgical repair. Surgical repair within one month of injury leads to complete resolution or better postoperative improvement in ocular motility limitation and diplopia than late repairs.

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孩童眼眶骨折之特性與手術結果

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背 景： 兒童眼眶骨折表現和成人不同，我們針對兒童的眼底骨折提出其臨床特性及手術結果。

方 法： 回顧探討自 1997 年到 2006 年間，於長庚紀念醫院 75 名未滿 18 歲而患有眼眶骨折的兒童以進行統計分析。

結 果： 此研究包含 41 名患有單純性眼眶骨折且病歷記錄完整的病患，平均 12.7 歲，後續追蹤時間平均約 6.5 月。常見受傷原因是遭受攻擊 (43.9%) 和交通事故 (29.3%)。93% 的患者有眼球肌肉轉動限制。活板門型 (trapdoor) 骨折的發生率約爲 68.3%。在這些患者之中，41 名患者接受外科手術，平均是傷後 22 天接受手術。只要傷後 1 個月內進行手術，術後向上轉動 (supraduction) 相較於術前有明顯的改善。

結 論： 眼眶骨折的兒童病患通常是遭受攻擊或交通事故，而傷後一個月內進行外科手術可以改善或治癒眼球轉動限制及複視的現象。
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關鍵詞：眼眶骨折，活板門，孩童，兒童

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