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Isolated orbital floor fractures in the paediatric patient: case series and review of management

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Abstract. Orbital injuries warranting surgical intervention are infrequent in the paediatric population, but 'blowout, trap door' fractures are unique in children and may constitute a relative surgical emergency. A retrospective review of isolated orbital floor fractures at the Royal Children's Hospital of Melbourne over a 10-year period was undertaken to evaluate the outcome of those patients who required surgical exploration. Twenty-two patients with documented isolated orbital floor injuries were studied. Preoperative signs and symptoms including diplopia, ocular motility, paresthesia, enophthalmos, hypoglobus, and the presence of nausea and vomiting were recorded. Thirteen patients underwent non-surgical management and nine patients underwent surgical exploration of the orbital floor via a trans-subconjunctival approach to reduce any entrapped soft tissue. Postoperative follow-up of these patients varied between 1 month and 18 months and none had any visual disturbance or diplopia in central gaze; however, two patients experienced diplopia in upward gaze at follow-up, although this did not impair the quality of life. Due to the risk of permanent soft tissue damage from the entrapment of the periorbita with or without extraocular muscle tissue, it is recommended that exploration be undertaken as soon as possible to minimize the risk of persistent diplopia due to impaired ocular motility.

Key words: fractures; orbit; paediatric.

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Orbital injuries warranting surgical intervention are infrequent in the paediatric population.[1] Due to a higher cranial to facial ratio in this age group, trauma to the head more often manifests as a skull fracture with or without head injury, with the relatively smaller facial complex being less frequently involved. The most common bony facial injuries seen in children are nasal fractures, but the most frequent fracture requiring hospitalization is the mandible.[1] A previously reported study of paediatric craniofacial trauma found that only 15% of all paediatric viscera-cranial injuries included orbit fractures, and of these, 40% involved the orbital floor.[2]

Due to the thin dimension of the orbital floor, it is the most frequently fractured wall of the orbit. The term 'blowout' fracture was introduced over half a century ago to describe fractures of the orbital floor with an intact rim.[3] The typical features associated with these fractures include pain in upward gaze, vertical diplopia, and infraorbital paresthesia. Enophthalmos or hypoglobus may be noted on examination, and if orbital tissues are trapped in the fracture, nausea and vomiting may be present.

A more specific clinical presentation, unique in the paediatric age group, is the 'trapdoor fracture' that can be observed on computed tomography (CT) imaging.[4] Immediately following a 'blowout' fracture, it is postulated that the thin elastic bone of the orbital floor flexes inferiorly with displacement of soft tissue orbital contents, and then reduces to its pre-injury position thus entrapping the herniated tissues in the fracture line. Such fractures are not restricted to the orbital floor.[5]

The aim of this investigation was to retrospectively review isolated orbital floor fractures in the paediatric population at the Royal Children's Hospital of Melbourne over a 10-year period and to evaluate the outcome of those patients who underwent surgical exploration, to compare the results with previous studies, and to emphasize the principles of management.

Patients and methods

The database of the Oral and Maxillofacial Surgery Unit at the Royal Children's Hospital of Melbourne was interrogated to identify patients with orbital fractures during the years 2002–2012 for a Unit audit. Orbital wall injuries with an associated adjacent fracture, such as the orbital rim, were excluded. A documented radiological diagnosis of an orbital wall fracture was a prerequisite for inclusion in the review. Thirty-one patients with isolated orbital fractures were identified, but two patients were excluded due to inadequate records. Seven of the patients had orbital roof fractures, one of which was in combination with an orbital floor fracture and one with a medial wall fracture. Two of these patients underwent surgical intervention due to fracture displacement into the periorbita. A total of 22 patients were recorded with isolated orbital floor injuries. Nine patients exhibiting clinical signs of suspected muscle entrapment underwent surgical intervention by one of three consultant surgeons using a standardized surgical approach.

At the time of presentation, the patient's age, gender, and mechanism of injury were recorded. Preoperative signs and symptoms including diplopia, ocular motility, paresthesia, enophthalmos, hypoglobus, and the presence of nausea and vomiting were noted. The operative management, postoperative results, and duration of follow-up were also documented. All operative cases underwent preoperative and postoperative ophthalmological assessment.

Surgical technique

Following endotracheal intubation and infiltration of long-acting local anaesthesia and adrenaline, a trans-conjunctival incision enabled dissection to the orbital rim. The periosteum was then incised and a sub-periosteal dissection performed to identify the fracture and continued posteriorly to identify the intact posterior bony ledge. The incarcerated, prolapsed periorbital soft tissues were then reduced and the displaced 'trapdoor' bony segment further reduced where necessary. In seven cases, a thin resorbable implant (Gelfilm; Pharmacia & Upjohn, Kalamazoo, MI, USA) was inserted between the bony floor and soft tissues of the periorbita to maintain a barrier during healing. A routine coronal approach and dissection beneath the orbital rim was undertaken for orbital roof fracture reduction.

Following fracture reduction, a forced duction test was performed routinely to ensure freedom of the soft tissues, as indicated by a normal range of upward rotation of the globe. The periosteum and conjunctiva were then closed with 4–0 and 6–0 resorbable sutures, respectively. Prophylactic amoxicillin 250 mg was administered together with 8-hourly dexamethasone 4 mg for 2 days. Eye observations were conducted 4-hourly for the first 24 h.

Results

The age range of the 22 patients with orbital floor fractures was 3–17 years (mean age 10.5 years). For those patients undergoing surgery, the mean age was 9 years, whereas the mean age of patients managed non-surgically was 13 years. The mechanisms of injury were varied (Table 1). Thirteen patients had right-sided orbital fractures and nine patients had left-sided injuries. Four patients, who were all managed non-surgically, had head injuries; two of these patients had radiological evidence of frontal sinus fractures and two had minor intracranial haemorrhage.

Table 1. Aetiology of orbital floor fracture.

Mechanism	Number
Sport	5
Bicycle/scooter	5
'Play fighting'	4
Collision (on foot)	3
Fall	3
MVA	2
Total	22

MVA, motor vehicle accident.

Nine of the 22 cases (41%) underwent surgical exploration (Table 2). One patient, at the request of ophthalmology, underwent a second procedure at 6 weeks due to marked diplopia suggesting a residual soft tissue incarceration, but no persistent entrapment was found and there was no further resolution in the immediate postoperative period. On presentation, six of the nine patients who underwent exploration experienced nausea and vomiting, whereas only four of the 13 patients treated non-surgically had these symptoms. Recurrent vomiting in one case, after the first dose of morphine, was attributed to opiate analgesia.

With respect to operative timing, seven of the nine cases were taken to theatre within 24 h. Two cases were explored on the same day as their injury and five patients on the first day post-injury. One patient underwent surgery at 4 days post-injury and the last patient underwent surgery on the tenth postoperative day due to evolving enophthalmos and no resolution of diplopia after initial non-surgical management.

Follow-up of the patients varied between 1 month and 18 months in our operative cases and none had any visual disturbance or diplopia in central gaze. Four patients (57%) had a full range of ocular movements and complete resolution of diplopia between 1 week and 3 months postoperatively. Ocular motility in the other three patients who underwent orbital floor exploration at under 24 h (43%) did not return to the normal pre-injury levels. One patient (age 9 years) had asymptomatic diplopia at extreme upward gaze at the 8 months review and the other (age 7 years) also had asymptomatic diplopia with a minor upward gaze restriction at 18 months. Neither patient required any further intervention and both were discharged from follow-up. The third patient (age 6 years) underwent a second exploration with no motility improvement but had no diplopia in primary gaze. The non-surgically managed cases received a shorter duration of follow-up, ranging from 2 weeks to 2 months.

With regard to the seven patients with orbital roof fractures, the age range was 5.3–14.5 years, with a mean of 9.75 years.

Table 2. Demographics, presentation, and follow-up of patients undergoing surgical exploration.

Patient	Age, years	Side	Diplopia	Extraocular movement	Nausea/ vomiting	CT of fracture	Time to surgery	Diplopia	Clinical enophthalmos
1	3	L	Moderate	Normal	Nil	Blowout displaced	<24 h	Resolved 7 days	Nil
2	6	L	Mild	Fixed globe	Yes	Blowout displaced	<24 h	Resolved 8 weeks	Nil
3	7	R	Severe	Reduced upward gaze	Yes	Blowout displaced	4 days	Resolved 6 weeks	Nil
4	7	R	Severe	Reduced upward gaze	Yes	Linear 'trapdoor'	<24 h	Residual upward at 18 months	Minimal
5	8	R	Vertical only	Reduced upward gaze	Yes	Linear 'trapdoor'	<24 h	Resolved 7 days	Nil
6	9	L	Vertical only	Reduced upward gaze	Yes	Blowout displaced	<24 h	Residual extreme upward	Nil
7	10	R	Vertical only	Reduced upward gaze	Yes	Blowout displaced	<24 h	Resolved 4 weeks	Minimal
8	12	L	Severe	Reduced upward gaze	Nil	Blowout displaced	10 days	Residual extreme upward	Minimal
9	13	R	Vertical only	Reduced upward gaze	Nil	Linear 'trapdoor'	<24 h	Resolved 12 weeks	Nil

CT, computed tomography; L, left; R, right.

There were two 'blow-in' fractures that were openly reduced; the remainder were minimally displaced or undisplaced and were treated non-surgically.

Discussion

Whilst the orbital floor remains the most frequent bony wall involved in both paediatric and adult injuries, there are observed differences in the anatomical location of fracture sites between the two groups. Younger patients aged up to 9 years are more likely to have anterior floor fractures, whereas older children have fractures extending into the posterior, medial, and lateral regions.[6] Orbital roof fractures in children, rarely occurring in adults, are as common as medial wall fractures in the paediatric population (13–19% of orbital wall fractures).[5,7] It is likely that orbital roof fractures are underreported in the literature, as they are often classified as fractures of the skull rather than the orbit.[8] It has been suggested that orbital roof fractures are typically seen in children younger than age 7 years, due to a proportionally larger cranium and lack of frontal sinus development that later affords some protection to the orbits.

Such differences in the incidence and location of fractures relate to the development and anatomy of the orbits. Orbital growth is significantly directed by ocular global development and is most rapid in the first 2 years, being essentially complete around 8 years of age.[9] The differences noted in the orbital fracture pattern in the paediatric group may be attributed to a greater cranium to face ratio, incompletely developed sinuses, the greater overlying mid-facial adipose, and greater elasticity of bone.[8]

The aetiology of orbital floor fractures in children also differs from the adult population where the most common causes (in decreasing frequency) are assault, falls, and traffic accidents.[10] In our study, sporting injuries and bicycle injuries were the most frequent causes. It should be noted that our category of assault refers to accidental injuries during 'play'.

General guidelines have evolved to assist in orbital floor trauma management in the adult population.[11] However, there is yet to be a consensus on the indications for orbital exploration and protocols for the timing of interventional surgery in children. Studies regarding the management of orbital floor trauma in the paediatric population remain limited, with only a few pertaining to orbital floor fractures involving operative managment.[6,12–14] In a review of the literature,[15] significant differences were noted between paediatric and adult patients, which included the mode of clinical presentation, differing fracture patterns, and the need for earlier intervention in the symptomatic group, as well as the expectation of a slower and poorer outcome in paediatric orbital floor fractures.[6,16] It was generally recorded that surgical intervention rates increase with the age of the patient.

In the paediatric population, nausea and vomiting are common presenting symptoms in 'trapdoor' fractures due to traction on entrapped orbital tissues.[17] This is due to the oculo-vagal reflex, with an increase in intra-orbital pressure that may also result in hypotension and bradycardia. Other studies cite the incidence of nausea and vomiting in 21–28% of cases.[5,14,17] Six of the nine operative patients in this study experienced vomiting and four patients had multiple episodes. Of the 13 non-surgical cases, three were documented as experiencing vomiting, although two of these had concurrent head injuries which could have accounted for this symptom. Excluding the two patients with head injuries, the incidence of vomiting in this study was marginally higher at 35%.

In an adult series of isolated orbital floor fractures, one third were associated with subconjunctival haemorrhage,[18] whereas in our patient sample, only one of the nine operative cases was documented as having subconjunctival haemorrhage. Hence, the remaining eight patients had no subconjunctival haemorrhage or periorbital ecchymosis, thus matching the criteria for 'white-eye' injuries, but had limitation of vertical ocular movement (Fig. 1). This may then be regarded as almost pathognomonic for orbital floor fractures with entrapment.

In a study using CT scanning for the diagnosis of incarceration of soft tissues in orbital floor fractures in the paediatric population, it was found that only nine cases of entrapment were diagnosed radiologically, whereas there were 21 intraoperatively documented entrapments (Fig. 2).[19] This suggests that entrapment should be weighted towards a clinical diagnosis in the paediatric population. In a review of adult fractures, magnetic resonance imaging (MRI) was superior in the diagnosis of soft tissue herniation in comparison to CT scanning and it was suggested that MRI has a role in clarifying soft tissue entrapment in unclear cases.[20] This may be a promising supplementary investigation in the diagnosis of trapdoor injuries in children, as it has been reported that orbital fractures may be more difficult to interpret in this age group.[8]

Fig. 1. An example of left ocular entrapment in a 'white-eye' orbital floor fracture.

Intervention in the paediatric orbit is advocated earlier than in the adult population.[5,12–14] It has been suggested that the timing of paediatric orbital surgery can be classified as immediate (0–48 h), early (3–14 days), and late (15 days or more), with a greater urgency for trapdoor fracture,[18] yet other authors have suggested that early surgery in the paediatric population may include up to several days post-injury.[21] While early treatment of a 'white-eye' orbital floor fracture may not be indicated from the clinical presentation alone, the radiological diagnosis of the trapdoor fracture with entrapped soft tissue/muscle contents may represent a surgical emergency requiring prompt management to avoid a poorer outcome if delayed beyond 48 h.[13,22]

The unique nature of 'trapdoor' fractures[4] and the resulting entrapment of adjacent extraocular muscles is also thought to result in a degree of muscle compartment pressure and subsequently ischaemia, as has been described in orthopaedic injuries.[16] Without prompt intervention, muscle ischaemia and/or scarring of the adjacent tissues may lead to impaired ocular mobility with consequent diplopia.[23] The observation that 'trapdoor' fractures are associated with a poorer outcome than displaced fractures[12] supports a compartment pressure theory, but may also reflect direct soft tissue injury from the reflexive reduction of elastic bone. It has been noted that diplopia in patients under 9 years of age takes twice as long to resolve as that in older paediatric patients (10–15 years).[6] Whatever the mechanism of soft tissue injury, early intervention is associated with a superior outcome in trapdoor fractures,[5,14,21] and surgery is therefore recommended within 2 days in this population.[13] It is possible that due to the rapid bone turnover in young patients, early callus formation may make surgical reduction more challenging and contribute to poorer outcomes.[24]

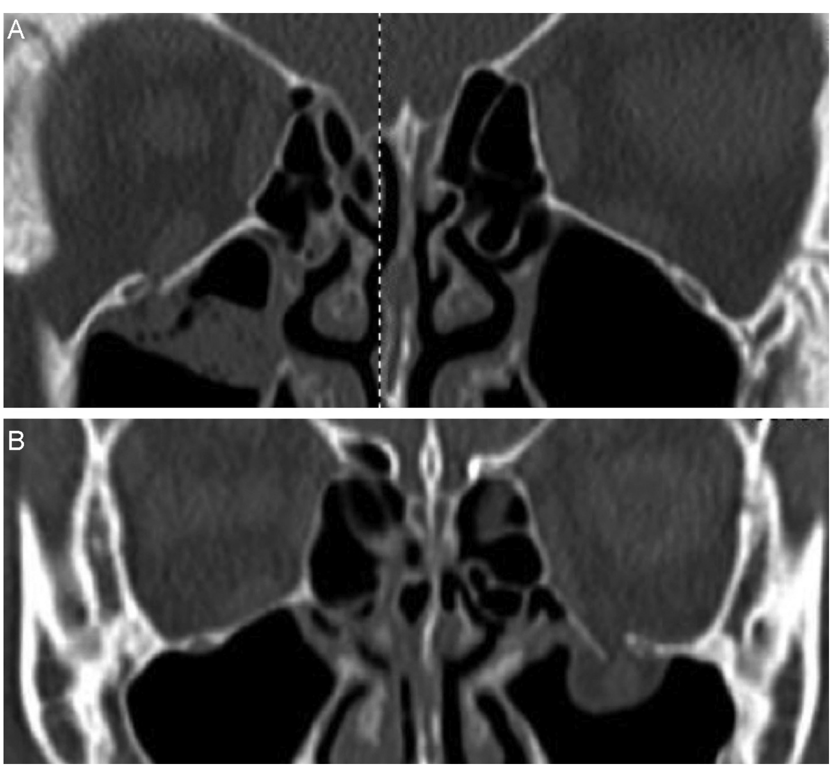

Fig. 2. (A) Right orbital floor 'trapdoor' fracture with entrapment of the inferior rectus (Gerbino type Ia[12]). (B) Left orbital floor 'trapdoor' fracture with herniation and entrapment of periorbital tissues (Gerbino type Ib[12]).

A trans-conjunctival approach is the preferred access to the orbital floor, because the absence of any skin creases in young patients means alternative skin incisions for access are less desirable. No lid complications such as entropion, ectropion, or epiphora were documented on follow-up. Reduction of the soft tissues requires support in order to prevent recurrent herniation,[22] and a simple resorbable material has proved sufficient for support in young patients.

In infancy, the orbital depth from the inferior orbital rim (∼30 mm) is about two-thirds that of the adult depth (45 mm) and is close to adult dimensions by 8 years.[25] Larger blowout fractures requiring posterior exploration were less frequent in this group, which may help to reduce the risk of iatrogenic retrobulbar haemorrhagic events and visual disturbances. Also, the differing paediatric anatomy may be relevant as there is a steeper orbital floor angle and it has been observed that the most inferior point on the orbital floor shifts posteriorly with age.[26]

It is acknowledged that this sample of isolated orbital floor fractures is limited, but our experience supports the recommendation that exploration of symptomatic orbital floor 'trapdoor' fractures be undertaken as soon as possible on presentation to minimize the risk of long-term diplopia due to extraocular muscle damage.

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None.

Competing interests

None.

Ethical approval

DAF # – DA067-2015-01 – Isolated orbital floor fractures in the paediatric patient; Research Ethics & Governance, on behalf of The Royal Children's Hospital Human Research Ethics Committee, expiry 06/01/2016.

Patient consent

Written patient consent was obtained.

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