UNIVERSITY OF MANITOBA

AN ANALYSIS OF PURE ORBITAL BLOWOUT FRACTURES: DEMOGRAPHICS AND SURGICAL OUTCOMES

Bachelor of Science in Dentistry (B.Sc. Dent) Thesis

By

Justin Diamond

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Supervisors

Dr. R. Elgazzar & Dr. A. Shah

Oral and Maxillofacial Surgery

Dental Diagnostic and Surgical Sciences

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DEDICATION

This work is dedicated to my family who supported me during my study and my career.

ABSTRACT

Purpose: To examine and present an investigation of the etiology, incidence, and surgical outcomes of pure orbital blowout fractures in Winnipeg, Canada over a ten-year period.

Materials and Methods: A retrospective chart analysis was done on all cases of orbital blowout fractures seen at the Health Science Center in Winnipeg, Manitoba, Canada during the ten (10) year period of April 1, 2004 to March 31, 2014.

Results: There were 254 cases involving orbital blowout fractures that were seen and treated at the Health Science Centre between April 1, 2004 and March 31, 2014. 91 of the 254 cases were diagnosed as pure orbital blowout fractures. Men outnumbered women in all age categories of assessment and outnumbered women 3:1 overall in the study. Violent assaults and motor vehicle collisions (MVCs) were the leading etiology of injury. The most common associated, immediate symptoms involved in all cases were diplopia, ecchymosis, pain, restricted eye movement, enophthalmos and crepitus. It was found that for treatment of pure orbital blowout fractures standard treatment approaches of subciliary and transconjunctival were most common with subciliary approach used the most in this study. Nearly 80% of all cases in this study were repaired with titanium mesh implant material and another 10% having used Medpor porous polyethelyne (PE).

Post-operative complications included diplopia, pain, blurred vision, V_2 numbness, enophthalmos and chemosis. All cases not showing acceptable improvements at two weeks post-operatively were reassessed and either treated by another specialty or had a secondary surgery to repair acute or chronic issues related to the initial surgery.

Conclusions: Consistent with other studies, titanium and porous PE implant materials for surgical repair of pure orbital floor blowout fractures proved to be satisfactory reparative materials. Subciliary and transconjunctival surgical approaches as reviewed in this study showed acceptable long-term results with the alloplastic implant materials and minimal post-operative complications.

KEY WORDS

Orbital Blow-out Fracture; Surgical Approaches; Orbital Reconstruction; Surgical Complications.

INTRODUCTION

Orbital blowout fractures are one of the most common occurring facial bone injuries.[1-4] Pure orbital blowout fractures occur in the inferior (and medial) wall of the orbit caused by blunt trauma to the orbit. Cases of pure orbital blowout fractures have increased in the past 10 years. These injuries are usually caused by blunt force trauma in the periorbital region including violent assault, motor vehicle collisions (MVCs), falls, sports injuries, and blast injuries.[1,2,5,6,10,11]

Failure to immediately recognize, diagnose and treat these injuries can result in substantial cosmetic and functional problems, including diplopia, enophthalmos, movement limitation, and parasthesia.[2]

Retrospective chart analysis done on all cases of orbital blowout fractures seen at the Health Science Center (HSC) in Winnipeg, Manitoba, Canada between April 1, 2004 and March 31, 2014 shows 254 noted cases involving fractures to the orbit. This included 91 cases of pure orbital blowout fractures.

The two current theories regarding the mechanism of action for the "blowout" fracture are the buckling and hydraulic theories.[2-4,7,8,10] The buckling theory, first described by Lefort, claims a force indirectly transmits pressure from the orbital rim along the bones to the floor of the orbit. This causes a rippling effect of the orbital walls causing the bones to distort and eventually fracture. From this, an anterior-posterior compression of the bones and subsequent inferior buckling (cracking) of the bones into the maxillary sinus.[3,4,7] The hydraulic theory argues that the direct transmission of pressure from the ocular globe and intra-orbital content to the peri-ocular structures eventually transmits to the orbital floor, blowing it out.[1,3,4,7] Most fractures occur on the posterior medial region, where the bone is the thinnest. The increased intra-ocular pressure simultaneously fractures the bones and pushes the orbital contents into the sinus. Although the buckling theory has recently been criticized, recent studies have concluded that both theories still remain valid.[3,4]

The most common side effects of orbital blowout fractures include diplopia, enophthalmos, decreased extraocular movement, hypoesthesia (V_2), and periorbital ecchymosis.[7,10]

MATERIALS AND METHODS

A retrospective chart analysis was done on all cases of orbital blowout fractures treated at the Health Sciences Centre in Winnipeg, Manitoba, Canada during the ten (10) year period from April 1, 2004 to March 31, 2014. Analysis showed 254 cases involving trauma to the orbit. However, only 181 charts included sufficient relevant data for further study. To be included in this study, cases had to involve orbital floor and/or medial orbital wall fractures. Pure orbital blowout fractures traditionally involve only the floor of the orbit, but the medial wall was included due to the high degree of involvement in these injuries; this is attributed to the medial wall being extremely thin and fragile. Exclusion was determined for cases that had orbital rim or other orbital wall fractures, or cases that did not have orbital floor and/or medial wall fractures, or patients who did not require orbital surgical intervention.

Analysis of pre-operative CT scans and medical records, including intra-operative notes, showed that only 91 of those cases met these inclusion criteria. Data was collected to include gender, age, etiology of injury, pre-operative symptoms, and surgical approach, implant material, post-operative sequela as well as post-operative complications.

RESULTS

Age and Sex:

Of the 91 patients assessed, the age range was from 17-78 with an average age of 35.7 years. There was a 3:1 incidence of male to female, where 68/91 (75%) were male patients and 23/91 (25%) were female. Grouping the patients in ten-year age intervals (Figure 1), there were 23 (25%) patients under 25 years old, 32 (35.2%) patients between 26-35 years of age, 14 (15.4%) patients between 36-45 years of age, 14 (15.4%) patients between 46-55 years of age and 8 (8.8%) patients over the age of 55. Incidence of injury was the highest in patients from 26-35 years of age, with males in that group being the highest group affected.

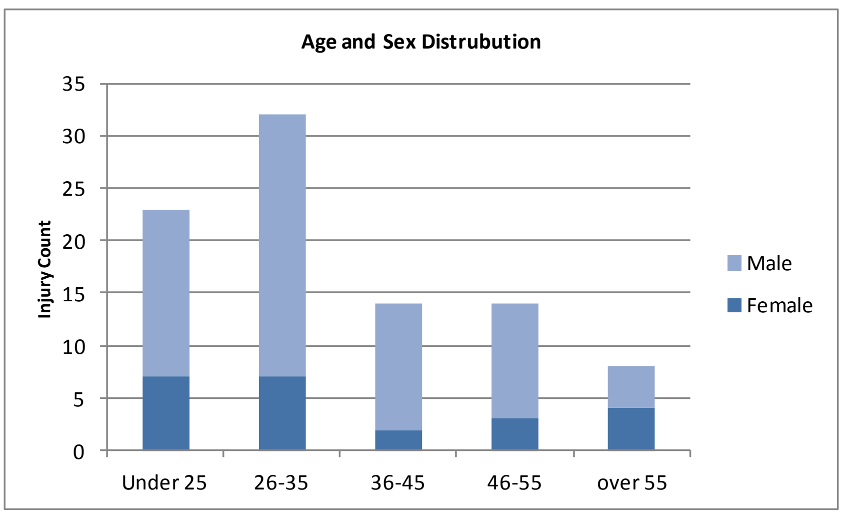

Figure 1: Incidence of Injury by Age and Sex

Etiology:

Out of the 91 cases, 62 (68%) were caused by violent assault (Table 1). This represented the highest incidence compared to any other cause for both male and female patients. Violent assault was also the most common cause of orbital blowout injuries in all but two age categories for both male and female patients. MVCs were the second leading cause of injury, accounting for 14 (15.4%) injuries. Other causes included falls, which caused a further seven (7.7%) injuries, other non-identified causes, which caused six (6.6%) injuries, one sports-related injury (1.1%), and one (1.1%) blast injury.

Table 1: Cause of Injury by Age and Sex

	Assault	Blast	Fall	MVC	Other	Sports	Grand Total
Female	**12**		**4**	**6**	**1**		**23**
Under 25	5			2			7
26-35	6			1			7
36-45	1		1				2
46-55				2	1		3
Over 55			3	1			4
Male	**50**	**1**	**3**	**8**	**5**	**1**	**68**
Under 25	14			2			16
26-35	20	1		3		1	25
36-45	9		1	2			12
46-55	6		2	1	2		11
Over 55	1				3		4
Grand Total	**62**	**1**	**7**	**14**	**6**	**1**	**91**

Location of Injury:

47/91 (51.6%) of cases included injuries on the left side. Another 39/91 (42.9%) of cases included injuries on the right side. Out of the 47 cases involving injuries on the left side, 34 were as a result of violent assaults. 24 cases of assault resulted in injury to the right side (Table 2). In other studies, injuries occurred at a higher prevalence on the left. These numbers relate to the higher prevalence of right-handed dominant populations. Although injuries on the left outnumbered those on the right in this study, the injuries on both the left and the right were more similar in this study than in others. In 5/91 (5.5%) cases, injuries occurred bilaterally.

Table 2: Cause and Location of Injury

Etiology	Left	Right	Bilateral	Grand Total
Assault	34	25	2	61
Blast	1			1
Fall	2	5		7
MVC	6	7	2	15
Other	3	2	1	6
Sport	1			1
Grand Total	**47**	**39**	**5**	**91**

Pre-Operative Ocular Symptoms:

Pre-operative symptoms included diplopia in 62/91 (68.1%) cases, ecchymosis in 85/91 (93.4%) cases, pain in 73/91 (80.2%) cases, and crepitus in 6/91 (6.6%) cases. Enophthalmos was found in 17/91 (18.7%) cases and restricted eye movement in 29/91 (31.9%) of cases.

Surgical Techniques:

Treatment of facial trauma at the Health Sciences Centre is based on a rotation schedule between the plastic surgery and oral maxillofacial surgery departments. Case determination is assigned based on an on-call rotation, patient's needs, and the nature of primary and associated injuries. Since the Health Sciences Centre is a level I trauma center, multiple specialists are often present upon first assessment and may even be present in the operating room. Plastic surgery teams were the primary surgical team in 39/91 cases. Oral maxillofacial surgery surgical teams were responsible for 51/91 cases. One patient chart was missing information on the primary care team.

Treatment of pure orbital blowout fractures included surgery through subciliary incision in 37/91 (41%) patients, transconjunctival incision in 23/91 (25%) patients, and 31/91

(34%) of patients were treated by "other" approaches including Gilles approach, upper buccal sulcus incision, and existing lacerations (Figure 2, Table 3). Treatment of 72/91 (79%) patients were repaired with titanium sheeting and screws, while only 9/91 (10%) were repaired with Medpor sheeting. Of the remaining cases, 3/91 (3%) were treated using both Titanium and Medpor combinations, and 7/91 (8%) were treated using other materials (Figure 2, Table 3).

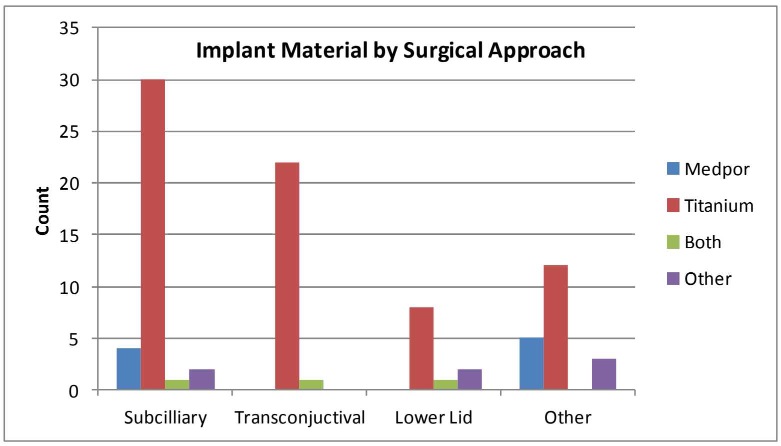

Figure 2: Implant Material by Surgical Approach

Table 3: Implant Material Usage by Surgical Approach

	Medpor	Titanium	Both	Other	Grand Total
Subcilliary	4	30	1	2	37
Transconjunctival		22	1		23
Lower Lid		8	1	2	11
Other	5	12		3	20
Grand Total	**9**	**72**	**3**	**7**	**91**

Post-Operative Symptoms and Complications:

Post-operative sequela included diplopia, decreased extra-ocular movement, pain, blurred vision, enophthalmos, edema, subconjuctival hemorrhage, headaches, and V_2

hypo/parasthesia. 24/91 (26.4%) patients suffered long-term symptoms (greater than two week post-operatively). Among these 24 patients, complications included 18/24 (75%) cases of diplopia, 5/24 (20.8%) cases of V_2 hypo/parasthesia, 3/24 (12.5%) cases of extra-ocular movement limitation, 7/24 (29.2%) reports of pain, and 5/24 (20.8%) cases of blurred vision.

Twenty-one of the 24 cases involving complications lasting greater than two weeks were initially treated with Titanium implants (Table 4). 6/21 of those cases required a second surgery to repair the problem. Of those 6/21 that required a second surgery, 1/21 was due to displacement of the implant and the 2/21 were due to a malpositioned implant, 1/21second surgeries were designed to correct entrapment of orbital contents, 1/21 was due to upper lid ptosis, 1/21 was for chronic epiphora, and 1/21 was needed for reconstruction of the orbital floor. 1/21 case required a second surgery that did not involve long-term complications. In that case, a second surgery was completed 5 days after the original surgery to correct an inadequate reduction of the orbital floor and medial wall mesh of the titanium mesh implant.

Table 4: Implant Material by Surgical Approach Requiring Second

	Second Surgery Required		
	Yes	No	Grand Total
Subcilliary			
Both		1	1
Medpor		4	4
Other		2	2
Titanium	1	29	30
Transconjunctival			
Both		1	1
Titanium	4	18	22
Lower Lid			
Both		1	1
Other		2	2
Titanium	1	7	8
Other			
Medpor		5	5
Other		3	3
Titanium	1	11	12
Grand Total	**7**	**84**	**91**

One of the 24 cases involving complications lasting greater than two weeks were treated with Medpor implants and the remaining two cases were treated with gold plates and non-titanium orbital plates. There were no cases included in the study that involved intra-operative complications due to surgical error or pre-existing conditions secondary to the patient's injuries.

DISCUSSION

There are two categories of orbital blowout fractures, pure and impure based on the involvement of the orbital rim; the later involves the orbital rim.[2,10] An orbital blowout fracture can occur in isolation or as a more complex craniofacial fracture pattern.[3,6] Soft tissue injury may or maybe not be involved. Blowout fractures are purely internal fractures which are confined to the orbital walls and therefore do not involve the orbital rim.[8] Pure orbital blowout fractures involve the medial wall of the orbit and the orbital floor, and herniate ("blow-out") the orbital contents into the adjacent sinuses.[2,3,6,10] These fractures involve the internal walls of the orbit with entrapment of soft-tissues, which limits ocular mobility and causes diplopia and enophthalmos.[2,12] A second classification can describe these fractures as trapdoor and nontrapdoor fractures. Trapdoor fractures, most often seen in children, describes a blowout fracture with minimal displacement of the bone fragments.[5] It involves a fracture in which one edge of the orbital floor is still connected in its original position and can permit entrapment of orbital contents. It is often termed a "white-eye" blowout fracture because of the lack of subconjuctival hemorrhage.[3] A nontrapdoor fracture refers to complete separation of the orbital floor from its original position and allowing movement of the periorbital contents into the maxillary sinus leading to increased orbital volume.[1,3]

Examination of pure orbital blowout fracture treatments at the Health Sciences Centre over the 10-year period, found 254 cases. Of those, 91 could be classified as pure orbital blowout fractures involving only the floor and/or medial wall of the orbit. These injuries were mostly caused by assault, motor vehicle collisions, falls, and sports injuries.[4,10,13]

The main etiological factor for pure orbital blowout fractures was violent assault, corresponding with a recent rise in violent assault cases.[4] MVCs in this study were the second leading cause contributing to both pure and impure blowout fractures but presented roughly 1.5 times more as impure fractures. This can be a factor of high-energy collisions where there are a number of different systems involved with extensive, nonspecific trauma. Other similar studies have made the connection between MVCs and impure fractures as well as links between low-energy injuries such as violent assaults and pure fractures.[2] While this study shows there are more impure fractures (20) than pure fractures (14) caused by MVCs (high-energy trauma) and more pure fractures (62) than impure fractures (55) caused by assaults (low-energy trauma) the incidence of cases are too similar to conclude that there is an association in this study. Although other studies have found evidence to support this association, these findings were not present in this study. Orbital blowout fractures caused by falls were most prevalent in women over the age of 55.

Due to the high number of violent assaults (68.1%) and MVCs (15.4%), it was found that there was no significant observance of left sided injuries compared to other similar studies. In these studies, the number of left-sided injuries was more pronounced due to the high prevalence of right-handed individuals. It can hypothesized that the nature and severity of the violent assaults as well as the significance of the high-impact, generalized trauma seen in MVCs, the number of left-sided pure orbital blowout fractures would have been reduced as the injuries would have been more extensive. A large majority of injuries to the left side of the face were excluded for including injuries to the orbital rim and other surrounding structures.

The extensive analysis of orbital blowout fractures shows that the number of male patients out numbers female patients for almost every category, in multiple studies.[2,3,9,11,13] In this study, men outnumbered women 3:1. Age ranges for this study were from 17 to 78 years. While the age range is extreme, most studies show that the highest incidence of injuries occurs between the ages of 20-35 years.[1-3,10] Observed in this study, the age group with the highest incidence of injury was 26-35 in both genders. Historically the incidence of blowout fractures in those younger than 10 years is very low. This is presumably because a larger cranium and less pneumatization of the paranasal sinuses, especially the maxillary sinus in younger children[2].

The most frequent sequela (pre-operative symptoms) of pure orbital blowout fractures includes diplopia, enophthalmos, as well as limitation in extra-ocular movement, ecchymosis, and pain.[2,4,7,8] Restricted ocular movement causes diplopia from trapping of the orbital contents/extraocular contents or damage to the nerves innervating the extra-ocular muscles. Enophthalmos is usually seen associated with an enlarged orbital cavity after a blowout fracture. This can sometime be hidden initially due to swelling of the surrounding tissues.[4] The nature of this injury is of trauma origin. With the high incidence of violent assaults and MVCs causing trauma in this study, there are multi-system involvements in many of the cases. This lead to many patients being admitted to the hospital with major facial trauma where the status of the orbit that could not be immediately assessed. In all cases, an initial, pre-operative CT scan was preformed to assess the status of the orbit and the orbital contents (Figure 3)[10].

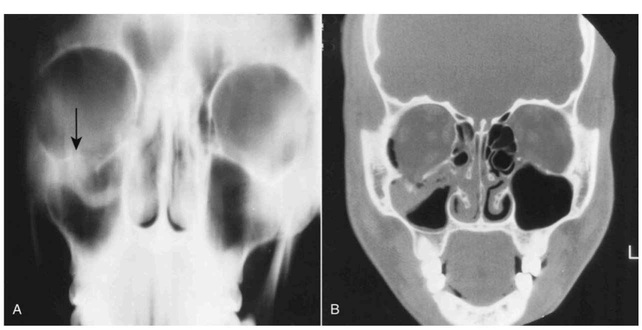

Figure 3: A, The tomographic view demonstrates a disruption of orbital floor (*arrow*). B, Computed tomography scan showing disruptions of the medial wall and floor of the right orbit.(Hupp 496)[9]

Management of patients falls into three categories: conservatively, closed reduction, and open reduction. Conservative treatment involved pain and symptom management without reduction or repair of injuries by active or surgical means. Closed reduction is the manipulation of bones without surgical means. Finally, open reduction is manipulation of the bones with or without an implant prosthetic by surgical means. Cases involving treatment without surgical intervention, conservative treatment, and those with closed reduction were excluded from the study. Cases of open reduction were included.

Kochhar and Byrne claim that the timing of surgery to repair complex midfacial fractures may vary; some surgeons prefer to wait for edema to subside before treatment but others argue that it is best to restore bony architecture early. Additionally, in severe trauma situations, stabilization of the patient with life-threatening injuries takes priority.[14] Treatment of the injuries can be done immediately, within two weeks or after two weeks during a time of prolonged observation.[3,4,7] Immediate surgical treatment is recommended in cases of fractures characterized by orbital soft tissue entrapment with non-resolving oculocardiac reflex, early enophthalmos or hypoglobus associated with marked facial asymmetry.[3,7,15] Several studies also recommended early intervention in children with evidence of muscle entrapment which leads to fat ischemia and result in permanent diplopia.[3,16] Surgical repair within two weeks time is justifiable for adults with symptomatic diplopia with positive force duction testing, evidence of muscle entrapment and little clinical improvement over that time. Surgical repair should be considered with increasing symptoms (V_2 hypothesia) or orbital floor defect greater than 50% with concurrent enophthalmos.[5,7,17]

Baino comments that medical treatment without surgery may be preferred in patients who present with weak enophthalmos (<2mm), a lack of marked hypoglobus, absence of muscle or soft tissue entrapment, good ocular mobility, a fracture involving less than 50% of the orbital floor, no diplopia, or a patient where surgical intervention is contraindicated.[4] Surgical repair might be delayed due to the absence of clinical signs such as enophthalmos due to periorbital edema and hemorrhage. A study done by Hawes and Dortzbach in 1983 showed the usefulness of CT imaging in predicting post-injury enophthalmos, and they recommend surgical repair within two weeks time if greater than half of the orbital floor is depressed.[7,18] In this study the time from injury to surgery ranged between 0 – 24 days, with the average time, excluding outliers, being 6.9 days.

Management of orbital injuries has become standardized over the past century. Surgical repair of the injuries were accomplished via three main surgical techniques: subciliary incision, transconjunctival incision, and lower lid incisions. The specific treatment is individualized and dependent on the surgeon and the presentation of the injuries.[4,10] The specific technique is determined with attention to cosmetic and functional outcomes. Subciliary incisions are performed through in the lower eyelid 2 mm below the edge of the eyelid and there is little to no risk of the lower eyelid shortening or ectropion.[19] The transconjunctional approach is cosmetically preferred and is preformed by pulling the lower eyelid forward with the incision made without involving the skin or muscle. This approach is surgically similar in providing exposure and access to the orbital floor, but has shown to be aesthetically superior to other approaches and has minimal complications but increased risk of entropion. This method minimizes scar formation but offers more limited access to the medial portion of the orbital floor.[20] The predominant surgical approach in this study was subciliary (40.7%), which was associated with 8.8% incidence of long-term complications of the overall cases in this study. Each long-term complication was found to have prolonged diplopia with one case reporting blurriness and another headaches present at one-year post-operative. Diplopia was found to occur in extreme gazes. All long-term cases were referred to ophthalmology specialists for further treatment. Every case reported that symptoms were improving over the course of two to four months time post-operative and that monitoring by the oral maxillofacial and plastic surgery teams would continue as needed by the patient. Only one case treated via subciliary approach required a second surgery to remove the orbital floor plate due to a medial rectus entrapment. In this case, the patient experienced diplopia in all gazes, loss of balance, and limited extraocular movement. CT results confirmed the diagnosis and the titanium mesh orbital floor plate was removed immediately. Residual diplopia remained for roughly four months following the second operation but was only present in extreme gaze. It was determined in consultation with the oral maxillofacial team and ophthalmologists that no further intervention would be required.

The transconjunctival approach was the second most used surgical approach, accounting for 23/91 (25.3%) of cases. 11/91 (12%) patients treated in this study by transconjunctival approach suffered from long-term complications. Most complications again involved residual diplopia, enophthalmos, decreased range of motion and V_2 hypothesia. All patients reported an improvement in symptoms within the first four months after surgery.

Lower Lid incisions made up 11 (12%) cases in this study. As this approach leaves the patient with a less aesthetic appearance, recent trends have been to preform orbital surgery via the subciliary and transconjunctival approaches.[10] Two long-term complications were noted with lower lid incisions, representing 2.2% of all cases.

In addition to these surgical approaches, the 20 remaining cases in this study were treated by “other” surgical means. These include incisions via existing facial lacerations, upper buccal sulcus, bi-coronal, and Gillies incisions. Three of these cases involved long-term complications with one requiring subsequent surgery.

All surgical approaches showed a relatively low level of complications.[10,11] Transconjunctival surgeries showed the highest level of long-term complications, apparent in 12% of cases. In all, 24 cases showed long-term signs and symptoms post-operatively, with seven requiring a second surgery to correct issues with the first. The high reported failure rate for this technique can be attributed to the higher incidence of use, the larger size of bone defects present in cases when titanium implants are preferred, and the inability of the implant material to resorb and form new tissue in its place.

Repair of injuries aims to restore the continuity of the orbital floor and to provide adequate support for the orbital contents. Surgical treatment and management of fractures varies based on the individual patient and the clinical findings of the injury.[2,4,5,11] Reconstruction materials can vary from autologous bone (from the ribs, mandible, calvarial or iliac bone), bioceramics (hydroxyapatite), metals (titanium mesh), polymers and composites.[4,5] To date, there is no recognized consensus on the best choice of biomaterials/implants for orbital floor reconstruction. The choice for optimal repair is influenced, in part, by the clinical characteristics of the injury, cost, the patient's clinical history, as well as the opinion and experience of the surgeon.[4,5,11] In 2011, Baino discussed the evolution of biomaterials and implant material for orbital floor reconstruction. Baino wrote that an ideal implant biomaterial should be i) biocompatible, ii) available in sufficient quantities, iii) strong enough to support the orbital contents and related compressive forces, iv) easy to shape to fit the orbital defect and regional anatomy, v) easily fixable in situ, vi) not prone to migration, vii) osteoinductive, and viii) bioresorbable with minimal foreign body reaction.[4] Various studies have tried to determine a suitable biological or synthetic material, with a truly ideal option yet to be found. The two most important characteristics determining the material used in management of the fracture are the size/shape of the fracture and whether or not any orbital contents have prolapsed into the maxillary sinus.[4,5]

In 1998, Marthog commented that it is difficult to properly compare the performance of different materials as the literature does not have a uniform set of parameters between each material; indications for surgery, surgical technique, and follow-up period.[21] Although all materials used have both positive and negative side effects when determining if they are a suitable option, the use of autografts is commonly recognized as the "gold standard" in reconstructive bone surgery.[4] In a recent study in 2010, Tabrizi *et al* assessed the success of orbital floor reconstruction using autogenous bone as well as synthetic materials including titanium, Medpor, Medpor Titan and resorbable plates.

Their study concluded that bone grafts lead to minimal post-operative infections and were deemed an excellent choice for reconstruction material. Titanium, Medpor as well as Medpor Titan also proved to provide excellent structural reconstruction for large defects.[22] Autografting involves harvesting the patient's own tissue from a donor site and transplanting it to the damaged area. Synthetic polymeric implants have also shown to be highly biocompatible. The most commonly used are titanium mesh implants, particularly in large defects or fractures involving the orbital rim.[4,5] Medpor are titanium sheets covered on both sides by a sheet of porous polyethylene. These should be considered when autografts are not feasible and the fractures do not involve the orbital rim or the entire wall of the orbit. Absorbable plates or sheets are generally preferred in patients with developing skeletons (children).[22] Wang *et al*. examined the success of titanium, PE and autologous bone, and found that all patients had good results. They concluded that porous PE and titanium would be most desirable, as they do not require a second surgery to harvest bone for re-implantation.

In cases studied at HSC, titanium implant material was overwhelmingly the material of choice. 79.1% (72/91) of all cases were repaired using titanium mesh plates and screws. Titanium has been used in craniofacial reconstruction and orbital floor repair for decades (Figure 4A). It is highly biocompatible and has high rigidity and strength, making it ideal for bone reconstruction. Titanium also has a high ability to be osseointegrated into surrounding tissues and is particularly useful for large orbital floor fractures requiring significant rigidity and strength.[4] Titanium, as tested in other studies, has shown to be extremely safe and there have been minimal post-operative infections reported in patients treated with titanium implants. A report done in 2003 by Ellis and Tan showed that compared to cranial bone grafts, titanium mesh showed better overall reconstruction, while noting the existence of individual variability.[4,23] Despite its many advantages, there have been some reports of serious post-operative complications with titanium mesh implants. This material is non-absorbable and cannot be replaced by new soft or bone tissue, meaning the implant will essentially remain *in situ* indefinitely. Lastly, there is the associated cost of the custom-made titanium devices compared to other available materials.[4,24]

Medpor sheeting is a porous ultra-high density polyethylene (PE) material. It is available commercially for nearly 20 years as sheets of various thickness (0.4-1.5mm) and sizes that are easily adapted by the surgeon for use in each case (Figure 4B). The presence of pores in the implant material promotes tissue ingrowth and implant vascularization while reducing foreign body reactions and capsule formation.[4] A post-traumatic study by Lupi *et al* in 2004 has shown that porous PE sheets represent a stable platform for orbital soft tissue growth that did not result in implant migration, extrusion or enophthalmos.[25] While autogenous bone grafting is still considered the "gold standard" for orbital reconstruction and a metric to which all other materials are compared its major disadvantage is the potential morbidity associated with the donor site. Medpor has showed comparable results to autogenous bone grafting in a 2008 study by Wajih *et al* but was concluded that due to both the potential morbidity from the secondary (donor) site and longer operating times, Medpor would be a better implant choice.[13] A comparative study by Wang *et al* published in 2008 between titanium mesh implants and porous PE show both materials were found to be ideal for orbital floor repair. Titanium mesh was used in fractures with large defects that were not easy to fix without obvious enophthalmos, and porous PE could be used in fractures that needed to have orbital volume restored.[26] Similar to the results of titanium implants, porous PE has still been reported to have significant complications associated with its use in similar studies.[4] Medpor was used in 9/91 (9.9%) of cases in this study. In three cases in this study, both Medpor and titanium mesh (Medpor Titan) were used for reconstruction of orbital defects (Figure 4C).

Figure 4: Orbital Floor Reconstruction Implant Materials: (A) Titanium Mesh Implant (AO Foundation)[27], (B) Porous Polyethylene Sheet (AO Foundation)[27], (C) Medpor Titan (Stryker)

CONCLUSIONS

Consistent with other studies, titanium and porous PE implant materials for surgical repair of pure orbital floor blowout fractures proved to be satisfactory reparative materials. Subciliary and transconjunctival surgical approaches as reviewed in this study showed acceptable long-term results with the alloplastic implant materials and minimal post-operative complications.

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