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Causes and Surgical Outcome of Orbital Wall Fractures in Mongolia

Uyen Bold[1,2], Sanjaa Erz[1,2], Udval Sanjaa[1], Ulziijargal Khadbaatar[2], Undraa Bat-Erdene[2]

[1]Orbita Eye Hospital, Ulaanbaatar, Mongolia; [2]Ophthalmology Department of Ach Medical University, Ulaanbaatar Mongolia

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Corresponding Author
Uyen Bold, MD
Orbita Eye Hospital, Ulaanbaatar
14250, Mongolia
Tel: +976-9913-0990
Fax: +11330500
E-mail: uyenbold@gmail.com

Objective: To determine causes, clinical manifestations of orbital wall blowout fractures, and evaluate surgical outcomes. **Methods:** A retrospective study with repeated measurements was conducted in 194 cases with orbital reconstructive surgery between 2002 and 2017 at Orbita Eye Hospital. The analyzed variables were patient age, sex, causes, and clinical manifestation of orbital wall fractures. Surgical outcomes, implant dependent, and surgical approach complications were prospectively analyzed in 60 patients up to 24 months after the initial surgery. **Results:** Orbital wall fractures were caused by assault in 82.7% of cases, household accidents 9.9%, car accidents 7.4%, and 0% by a sports injury. Diplopia was noted in 16.7%, extraocular movement limitation in 16.7%, enophthalmos in 23.3% for 24 months, or and more following surgery. In 4.2% of cases, prolapse of the orbital fat was noted using the transconjunctival approach, and 16.6% eyelid retraction with scarring in the subciliary approach. Implant displacement was noted 6.6% of cases in which a silicone sheet was used to reconstruct the fracture defect. **Conclusions:** Assault was the leading cause of orbital fractures, and this most often occurred in young males in Mongolia. Common signs and symptoms of orbital fractures were enophthalmos, diplopia, and extraocular movement limitation. The range of post-surgical enophthalmos, diplopia, and implant-related complications was consistent with those reported by other studies.

Keywords: Orbital Fracture, Reconstructive Surgery, Enophthalmos, Diplopia, Mongolia

Introduction

An orbital wall blowout fracture is a traumatic deformity of the orbital floor or medial wall that typically occurs due to the impact of a blunt object larger than the eye socket and creates an opening from the orbit into the maxillary and ethmoid sinuses. The injury is characterized by diplopia (double vision), enophthalmos (sunken ocular globe), and numbness of the cheek and upper gums due to infraorbital nerve injury. The fracture configuration is irrespective of social and economic development, geographic and demographics, age, and gender. The typical causes are facial trauma combined with orbital trauma due to altercations, industrial injuries, followed by road accidents and sports injuries. This injury occurs more than 100,000 times per year in the USA. Many blowout fractures are combined with facial trauma, with frequency ranging from 26-40% of the cases. In Russians during times of peace, a history of an orbital wall fracture is present in 2-8% in adults and 0.9%

in children[1]. In addition, 92% of orbital blowout fractures were combined with otolaryngologic injuries, 47% with facial trauma, 45% with brain injury, and 11% with other systemic injuries. A 5-year retrospective clinical and epidemiologic study conducted in 2003 in Iran among 237 patients found that road accidents caused 54% of blowout fractures, assault caused 9.7%, sports 6.3%, and warfare caused 9.7%, respectively. Also, in a study done in Sweden, the majority of orbital wall fractures were caused by road accidents. Further, research in Argentina found that 58% of orbital wall fractures were due to road accidents, 24% assault, and 15% sports injuries, respectively[2].

Orbital blowout fractures were rarely reported from 1960 to 1990 in Mongolia, with only 8 cases were registered during this period. Five of these injuries were due to domestic violence, and 3 cases were due to assault[3] During that time, conservative methods of treatment, such as removal of orbital foreign body, anti-inflammatory therapy, etc., were used to relieve symptoms. Since the transition to the market economy in the early 1990s, the frequency of the reported orbital fractures has increased to 179 cases per annum due to the changes in the society[4, 5]. As the number of injuries increased in Mongolia, operative repair of these injuries was begun, with the first reconstruction of the orbital wall with an autogenous implant (ear cartilage) was done by a team headed by Prof. E. Sanjaa. Existing surgical techniques were refined with modifications to the silastic sheets to make them more suitable for orbital reconstruction surgery. Also, the fixation methods were refined to improve implant stability and to decrease implant-related complications. The objectives of this study were to determine causes, clinical manifestations of orbital blowout fractures in Mongolia, and to evaluate surgical outcomes of these refined techniques.

Material and Methods

One hundred and ninety-four people with an orbital blowout fracture who underwent orbital reconstruction surgery at Orbita Eye Hospital in Ulaanbaatar, Mongolia, between 2002 and 2017 were included in our study. The medical records of 134 of these patients were retrospectively reviewed, while the remaining 60 were studied prospectively before surgery and at six months, 12 months, and 24 months after surgery. Our study inclusion criteria were: 1) isolated orbital blowout fracture (medial and inferior wall) defined as Level 1 and 2 by Jaquie'ry classification[6] 2) surgery within 6 months of injury, 3) diplopia present for less than 6 months, and 4) no sinus inflammation or tumor prior to the injury.

Surgical technique

All surgeries were done by one experienced surgeon (S.E.). Depending on the size and location of the orbital wall fracture, a transconjunctival or subciliary approach was chosen. Transconjunctival approach: The conjunctiva was incised, and the incision was extended using scissors and dissected to the septum. The orbital fat was retracted, and the periosteum was incised. The fracture site with its bone defect was identified, and the incarcerated soft tissues or rectus muscle was released. A 2 mm silastic sheet non-resorbable implant (Visiontech 666, China) or polycaprolactone bioresorbable implant (Osteopore International Pte Ltd., Singapore) was chosen to fill the wall defect. When a silastic sheet was used, a 1.5 mm hole was made on orbital wall margin through which the implant was fixed using non-absorbable suture. The forced duction test was performed to check for the complete release of any entrapped orbital soft tissue[6]. The conjunctiva was closed with 7-0 Vicryl suture (Ethicon Inc, USA). Subciliary approach: The skin was incised with #15 blade then the orbicularis muscle and periosteum were dissected to expose orbital wall defect. The bone defect was identified, and the incarcerated soft tissues or rectus muscle was released. A silastic sheet or PCL implant was chosen to fill the wall defect. When a silastic sheet was used, it was attached to the orbital wall using a non-absorbable suture passed through a 1.5 mm hole drilled through the orbital wall margin. The forced duction test was performed to check for the complete release of the entrapped orbital soft tissues. The periosteum was closed with 5-0 Vicryl, and the skin wound was closed with 7-0 Prolene suture (Ethicon Inc, USA).

Measurements

The demographic data of the patients were collected. Extraocular movement limitation and diplopia were measured by Aronov method, and enophthalmos was examined with a standard Hertel exophthalmometer (Specmedpribor, USSR)[4]. Each of these measurements was obtained preoperatively at six months, 12 months, and 24 months after surgery.

Statistical analysis

The demographic data were presented as mean ± standard deviation. The Cochran's Q test was used to make non-parametric multiple comparisons assessing paired differences in repeated measurements and comparisons between groups. The Wilcoxon sign rank test was used to make multiple post-hoc comparisons. Fisher's exact test was used to compare the frequency of surgical complications. P-values of <0.05 were considered statistically significant. All analyses were performed using IBM SPSS Statistics version 25.

Ethical statements

Ethical approval for this study was obtained on May 21, 2015, from the Institute of Medical Science of Mongolia. Written informed consent was obtained from the study participants.

Results

One hundred ninety-four patients were enrolled in the study at a mean follow up of 65.48 ± 42 months at Orbita Eye Hospital from 2002 to 2017. The average age was 30.4 ± 10.2 years. The baseline demographics of age, gender, and orbital wall fracture causes are shown in Table 1. The gender ratio (M:F) was 2:1. The causes of the orbital fractures are shown in Figure 1.

Diplopia was present in 61.4% of patients, and pain was present in 49.5%. Infraorbital nerve palsy was present in 25 (12.3 %) of patients with orbital inferior wall fractures. Enophthalmos was identified in 114 (56.4 %) cases with ocular movement limitation in 97 (48%) cases, respectively.

We prospectively evaluated surgical outcomes in 60 cases with ocular movement limitation, diplopia, and enophthalmos at six, 12, 24, and more months after surgery. The mean size of orbital wall defect among 60 cases was 1.55 ± 0.79 cm^2 (0.5 - 4.1 cm^2). Scarring, eyelid retraction, and displacement of the canthal tendon were complications experienced by the participants.

One case (4.2%) of prolapsed of orbital fat was noted in the transconjunctival approach, while 3 cases (16.6%) of eyelid retraction with scarring were noted in the subciliary approach (Table 4). The outcomes of these two groups were not statistically significant. Consequently, the transconjunctival approach had fewer complications with perfect cosmetic results.

Diplopia was noted in 2 cases (3.3%) at six months, 2 cases (3.3%) at 12 months, and 10 cases (16.7%) at 24 or more months after surgery, respectively. Ocular movement limitations were present in 1 case (1.7%) at six months, 1 case (1.7%) at 12 months, and 10 cases (16.7%) at 24 or more months after surgery. Diplopia and extraocular movement limitations were present in 10 cases, of which 2 cases had symptoms within 14 days, seven within 1-2 months, and in 1 case, more than two

Table 1. Patient demographics and causes of orbital fractures in 192 study participants.

Variables	%
Gender	
Male	66.7
Female	33.3
Age (years)	
0-10	1.98
11-20	11.9
21-40	70.3
41-60	14.92
61 above	0.9
Mean age (SD)	30.4 ± 10.2
Education	
Bachelor	45
Diploma	1
High school education	45
Elementary school education	8.9
Causes	
Assault	82.7
Household and industrial trauma	9.9
Road accident	7.4
Sport injury	
Mean size of orbital wall defect	1.55 ± 0.79 cm^2

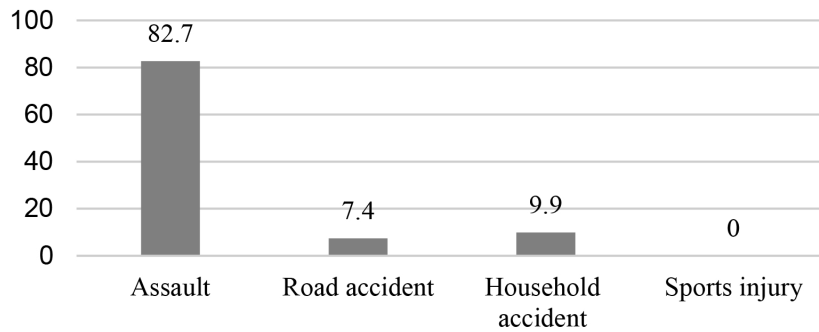

Figure 1. Causes of orbital wall fractures in 192 Mongolian patients.

months after surgery. Also, 5 cases with soft tissue incarceration were noted. From this, we conclude surgical timing, orbital soft tissue incarceration, scarring of orbital fat tissue, and the local inflammatory reaction during the full absorption period may result in diplopia in the cases mentioned above. There were statistically significant differences in the frequency of occurrence of diplopia pre-operatively compared to after the surgery ($p \leq .05$).

Enophthalmos was present in 2 (3.3) cases at six and 12 months post-op and 14 (23.3%) cases after 24 months after surgery. The enophthalmos improved in six cases (10%) but, remained unchanged with the operation in 2 (3.3%) cases, and 1 mm enophthalmos was newly formed in 6 (10%) cases after surgery. There was a statistically significant improvement at 6 and 12 months after surgery, but worsening of extraocular movement limitation and enophthalmos at 24 and more months following the operation (Table 2). We found that this worsening rate related to whether the implant was absorbable or not and to the extent of scarring of orbital fat tissue surrounding the implant after surgery using PCL. In contrast to surgery using PCL, enophthalmos after surgery with silastic sheet was due to scarring of the surrounding orbital fat tissue, as the silastic sheet was non-absorbable.

The implant-dependent complications were analyzed. There were no implant-dependent complications in the cases where PCL was used, but 2 (6.6%) of cases using silastic had implant-related complications due to implant extrusion, and reaction to the implant. There were no complications related to the use of PCL in our study, likely because it is osteoinductive and its osteoconductive surface characteristics facilitate the initial fixation of the implant before its resorption (Table 4).

Table 2. Repeated measurements ocular movement limitation, diplopia, and enophthalmos at the different time intervals.

%		Preoperatively	6 months	12 months	24 months	†p-value
		%	%	%		
Diplopia						<.0001
	No	55.0 %	96.7 %	96.7 %	83.3 %	
	Yes	45.0 %	3.3 %	3.3 %	16.7 %	
Extraocular movement limitation						<.0001
	No	81.7 %	98.3 %	98.3 %	83.3 %	
	Yes	18.3 %	1.7 %	1.7 %	16.7 %	
Enophthalmos						<.0001
	No	30.0 %	96.7 %	96.7 %	76.7 %	
	Yes	70.0 %	3.3 %	3.3 %	23.3 %	

P-value using the Cochran's Q test. Multiple comparisons are shown in Table 3.

Table 3. Multiple comparisons between the pre- and postoperative ocular movement limitation, diplopia, and enophthalmos at the different time intervals (n=60)

	Measurement intervals	π (%)	π (%)	Absolute Difference |π - π |	p-value
Diplopia					
	$Diplopia_0$ x $Diplopia_1$	45	3.33	41.67	.00001
	$Diplopia_0$ x $Diplopia_2$	45	3.33	41.67	.00001
	$Diplopia_0$ x $Diplopia_3$	45	13.33	31.67	.00001
	$Diplopia_1$ x $Diplopia_2$	3.33	3.33	0	1
	$Diplopia_1$ x $Diplopia_3$	3.33	13.33	10	.07031
	$Diplopia_2$ x $Diplopia_3$	3.33	13.33	10	.07031
EOML					
	$EOML_0$ x $EOML_1$	18.33	1.67	16.67	.00635
	$EOML_0$ x $EOML_2$	18.33	1.67	16.67	.00635
	$EOML_0$ x $EOML_3$	18.33	16.67	1.67	1
	$EOML_1$ x $EOML_2$	1.67	1.67	0	.00001
	$EOML_1$ x $EOML_3$	1.67	16.67	15	.00391
	$EOML_2$ x $EOML_3$	1.67	16.67	15	.00391
Enophthalmos					
	$Enophthalmos_0$ x $Enophthalmos_1$	70	3.33	66.67	.00001
	$Enophthalmos_0$ x $Enophthalmos_2$	70	3.33	66.67	.00001
	$Enophthalmos_0$ x $Enophthalmos_3$	70	23.33	46.67	.00001
	$Enophthalmos_1$ x $Enophthalmos_2$	3.33	3.33	0	1
	$Enophthalmos_1$ x $Enophthalmos_3$	3.33	23.33	20	.00183
	$Enophthalmos_2$ x $Enophthalmos_3$	3.33	23.33	20	.00049

EOML- extraocular movement limitation, $_0$Preoperative, $_1$six months after surgery, $_2$12 months after surgery, $_3$24 months after surgery, † p-value using the Wilcoxon sign rank test. The measurements used for these comparisons are summarized in Table 2.

Table 4. Surgical complications stratified by surgical approach.

%	Total %	Transconjunctival approach %	Subcilary approach	p-value
Scar				
No	95.0 %	100 %	82.4 %	.020
Yes	5.0 %	0 %	17.6 %	
Orbital fat prolapse				
No	98.3 %	97.7 %	100 %	.956
Yes	1.7 %	2.3 %	0 %	
Implant migration				
No	96.7 %	100 %	88.2 %	.077
Yes	3.3 %	0 %	11.8 %	

p-value using Fisher's exact test

Discussion

Orbital wall fracture is the most common orbital pathology irrespective of social and economic development, geographic and demographics, age, and gender. Further, there have been only 8 cases registered for 30 years between 1960-1990 in Mongolia[7-9]. Since 1990, there have been many changes and problems across all economic sectors in Mongolia during the transition from a socialist economy to a market economy. For example, the number of cases of trauma, especially, facial trauma and orbital wall fractures, have increased dramatically in the medical sector. One orbital wall fracture was registered every three years from 1960 to 1990, in contrast to the 179 cases per annum registered in 2017[10,11].

According to our study, the most common cause of retroorbital fracture was assault, at 82.7%, and this is two to four times higher than cases in other countries[1,5,7,10]. The main reason is directly related to less compassion and a decrease in ethics over the years. Furthermore, unemployment and excessive alcohol consumption have led to the above-mentioned reasons[12].

The second most common cause was household and industrial trauma, which was responsible for 9.9% of the cases. According to studies conducted in the USA, household trauma, particularly, falls have been considered the second common cause of retroorbital wall fractures at (25.6%), which means results of this study and our study are similar[1].

The third common cause was road accidents, which occurred in 7.4% of the cases. This is related to the increase in the total number of vehicles of Mongolia from 620,661 in 2013 to 815,009 in 2017[12]. The total number of road accidents in 2017 was 4712, out of which 44.5% were due to speeding, and 2.2% were due to the consumption of alcohol[6]. Sports injuries have not been registered in our study.

Sports injuries, industrial and road accidents were the leading causes of orbital wall fracture in the USA and other developing countries[7]. Males aged 21-35 are most commonly involved in such accidents. However, the percentage of women, youth, and old persons in such cases has not been decreased. In recent years, the number of traumatic fractures related to assault has decreased. However, facial trauma and orbital wall fracture are still common among females[6]. In the case of Russia, household trauma caused 65.4% of the fractures, assault 21.7%, and industrial trauma 15.5%, respectively. In a 5-year retrospective clinical and epidemiologic study conducted in 2003 in Iran with 237 patients, road accidents caused 54% of orbital fractures, assault caused 9.7%, sports injuries 6.3%, and warfare 9.7%, respectively[5,13-16]. Similarly, the majority of orbital wall fractures in Sweden were caused by road accidents[7]. Further, research in Argentina found that 58% of etiology the orbital wall fractures were due to road accidents, 24% assault, and 15% sports injuries respectively[8,17-21].

In our study, 194 patients were included, of which 133 were males (66.7%), and 60 were females (33.3%). The gender ratio was 2.:1 (M: F). This indicator is similar to the results of the study by Neuman et al[8].

The average patient age of the patients in our study was 30.4 ±10.2 years. This is similar to the average patient age of 32 by Manolidis, 15-35 by Tomich et al., and 33 by Rodríguez-Perales et al[8,9]. Like them, we conclude that orbital trauma tends to occur predominantly in young males.

Orbital wall fractures commonly occur in conjunction with facial trauma, and ocular disturbances and cosmetic changes occur in such trauma. Subjectively, the occurrence of diplopia was present in 61.4% and pain in 49.5% of the cases, respectively. Infraorbital nerve palsy was present in orbital inferior wall fractures in 25 (12.3%) cases in our study. Objectively, enophthalmos occurred 114 (56.4 %) and extraocular movement limitation 97 (48%), respectively. As noted in reference and textbooks, orbital fractures present with enophthalmos, extraocular movement limitation, hypoesthesia due to infraorbital nerve palsy, and diplopia in the majority of the cases.

Ocular movement limitation and diplopia may present early after trauma and are related to soft-tissue edema, retrobulbar hematoma. These symptoms disappear with time as the soft-tissue changes resolve; thus, do not indicate the need for surgical intervention. The indications for surgery are enophthalmos more than 2mm, fractures that occupy more than one-fourth of the orbital wall, diplopia, presence of oculocardiac reflex, extraocular movement limitation due to rectus muscle incarceration, hypo-ophthalmos, and infraorbital nerve palsy. These are the surgical indications we used in this study.

The main goals of reconstructive surgery of orbital wall are: 1) to release incarcerated rectus muscle and soft tissues 2) to restore orbital wall defect 3) to reduce the inflammation of ethmoid and maxillary cavity 4) to restore normal function of rectus muscle 5) to reposition of facial bones, and 6) to restore orbital volume.

Surgeons choose their surgical approach depending on fracture location and features, their experience, and the availability of technical supplies. In a review of the rate of complications after surgery using subciliary and transconjunctivial approach in orbital reconstructive surgery, 12 studies conducted in different found that eyelid retraction was statistically lower in 922 cases in the transconjunctivial approach group compared with 1719 cases of subciliary approach with a mean follow-up period of 3-13 months.

In our study, we performed 18 cases using the subciliary approach, out of which 13 (72.2 %) cases had an uncomplicated scar, 3 (16.6%) cases had severe scaring with eyelid retraction, which was a higher rate than the results of other studies. This may be explained by the fact that such surgical complications are more common among Asians[22]. In the cases using the transconjunctival approach, 1 case (4.2%) had a prolapse of the orbital soft tissues, and there were no cases with visible scars and or eyelid retraction. Many studies emphasize that the transconjunctival approach has fewer complications (< 1%) and better cosmetics, which are similar to the results in our study[23]. Thus, the transconjunctivial approach has advantages such as fewer complications and better cosmesis in reconstructive surgery for isolated orbital wall fracture, but the subciliary surgical approach is better in combined orbital and facial fractures.

Ten patients (16.7%) in our study had diplopia, possibly due to surgical timing, orbital soft-tissue incarceration, scarring of orbital fat tissue, and local inflammatory reaction during the healing period. Many studies mentioned that diplopia after surgery is one of the more common complications, which usually improves within a few weeks of the surgery, but may persist in 8-42% of patients[24,25]. This complication may arise because of the displacement of the implants, even if the implant has been placed properly, or may arise due to muscle damage, soft-tissue fibrosis or nerve palsy. Hosal and Beatty noted that diplopia might be present after surgery in older patients as well as in cases of delayed surgeries, or even in the cases of urgent surgery, diplopia might still occur due to muscle damage and incarceration of orbital soft tissues. We analyzed 10 cases with post-surgical diplopia and ocular movement limitation and found out that 80% of the cases had delayed surgery (≥4 weeks), possibly due to the patient experiencing less pain or no visual disturbance after the injury. Five cases with incarcerated orbital soft tissues pre-op had delayed surgery, due to persistent diplopia and ocular movement limitation. Post-surgical enophthalmos was present in 23.3% of the cases, and we theorize that its rate might be relevant to resorption of the PCL implant and scarring of orbital fat tissue surrounding the implant after surgery. In the group treated with the silastic sheet, we believe that enophthalmos was due to the scarring of implant surrounding orbital fat tissue around the silastic sheet implant, which was non-absorbable. As noted by other studies, post-surgical enophthalmos may result in 7-27% of patients, which is comparable to the outcome of our studies[26,27]. Enophthalmos post-surgery may also arise due to orbital soft-tissue atrophy, and insufficient reconstruction of orbital cone. Fortunately, these complications may be corrected through repeat surgery three months after the operation with the insertion of an additional implant or repositioning a displaced implant.

The most severe complication is blindness, and this may occur in 0-0.4% of cases. Retrobulbar hemorrhage has been identified as the most common cause There were no cases of blindness in our study[28-31].

Our relatively small patient population limited our study, and the absence of long term follow up. This limits our ability to evaluate the factors affecting our surgical outcomes and complications. Therefore, these factors need to be studied in detail in the future.

Conclusion

In Mongolia, an assault was the leading cause of orbital fractures and occurred mostly in young males. Common signs and symptoms of orbital fractures were enophthalmos, diplopia, and ocular movement limitation. Our range of post-surgical enophthalmos, diplopia, and implant-related complications are consistent with those reported by other studies.

Conflict of Interest

The authors report no conflict of interest.

Acknowledgments

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