Original Article

Surgical Repair of Orbital Blow-Out Fractures: Outcomes and Complications

Ⓘ **Can Ozturker,** Ⓘ **Yasin Sari,** Ⓘ **Kemal Turgay Ozbilen,** Ⓘ **Nihan Aksu Ceylan,** Ⓘ **Samuray Tuncer**

Department of Ophthalmology, Istanbul University, Istanbul Faculty of Medicine, Istanbul, Türkiye

Abstract

Objectives: The purpose of this study is to evaluate the demographics of patients with orbital blow-out fractures, as well as the success and complications of surgical repair with porous polyethylene membrane sheet implants through transconjunctival technique and to compare the results to previously published studies.

Methods: This retrospective study included 57 patients diagnosed with orbital blow-out fractures referred to our clinic between 2018 and 2022. Seventeen patients (29.8%) underwent orbital fracture repair through a transconjunctival technique employing porous polyethylene membrane sheets. The indications for surgery were enophthalmos >2 mm and persistent ocular motility restriction, diplopia, and strabismus. The success criteria were <2 mm of enophthalmos and complete correction of eye motility, diplopia, and strabismus.

Results: The study group consisted of ten females and 47 males with a mean age of 31.12 years. The most common cause of injury was assaults (50.9%), followed by falls (38.6%), traffic accidents (5.3%), and accidental impacts (5.3%). The inferior wall (61.4%) was the most common fracture site, followed by the medial wall (21.1%) and a combination of the inferior and medial walls (21.1%). The surgically treated group showed a significant improvement in ocular motility restriction (88.2–23.5%, p=0.002), diplopia (70.6–23.5%, p=0.008), and enophthalmos (1.41 mm to 0.82 mm, p=0.012) after surgery. The surgery was successful in ten of 17 cases (58.8%), and the success rate was higher in patients who were treated early (77.8% vs. 37.5%), but the difference was not statistically significant (p=0.092).

Conclusion: Orbital blow-out fracture repair using porous polyethylene membrane sheets through a transconjunctival approach is a safe and effective surgical technique for orbital blow-out fracture repair. Although patients who had early surgery had a higher success rate in our study group, larger study groups are needed to assess the effect of surgical timing on success.

Keywords: Blow-out, fracture, membrane sheet implant, orbit, porous polyethylene, transconjunctival

Introduction

Blow-out fracture of the orbit is a common type of injury that can have functional and cosmetic consequences if left untreated. Both the buckling theory and the hydraulic theory describe how the orbital blow-out fracture occurs: In the former, force applied to the orbital rim is passed through the bone to the weaker portions of the orbit, producing fracture; in the latter, blunt trauma pulls the globe backwards in orbit, resulting in an outward fracture of the thin floor, or medial wall (1).

Orbital blow-out fractures may cause progressive and long-term morbidity. Minor fractures may entrap herniated soft tissues, causing orbital fat and inferior rectus ischemia.

Large fractures may cause inferior and posterior globe displacement, leading to esthetically undesirable enophthalmos. Significant soft-tissue displacement into the fracture site may cause hypoglobus, a limited range of globe supraduction or abduction, and symptoms of double vision (2).

Treating these fractures are frequently challenging since not all fractures necessitate surgery, and some patients may have symptoms that disappear or never develop. Due to a lack of data, there are still significant discrepancies in opinion regarding the surgical criteria. A complete multidisciplinary clinical assessment and an evaluation of the orbital injury on a computed tomography (CT) scan are used to determine whether surgery is indicated (3).

Surgical treatment aims to release entrapped tissue, cover the bony defect, and restore orbital volume. While various surgical approaches to the orbital floor and medial wall, such as subciliary, subtarsal, and transconjunctival, are described, the latter leaves no visible scarring and has a low complication rate. Using the transconjunctival approach, instead of the subciliary approach reduces the incidence of ectropion and lower eyelid retraction. The most common complication after open reduction of orbital fractures is initial diplopia, which usually resolves within a few weeks. Ocular dystopia is another common post-operative complication that may necessitate additional surgery to correct or enhance the implant. Even though it is rare, the orbital compartment syndrome must be treated immediately. As a result of the intervention, the most severe complication is vision loss (4).

Therefore, the purpose of this study was to evaluate the demographics of patients with orbital blow-out fractures and the success and complications of surgical repair with porous polyethylene membrane sheet implants through transconjunctival technique and compare the results to previously published studies.

Methods

This study was carried out retrospectively, using data from 57 patients referred to our Ophthalmic Plastic and Reconstructive Surgery Department diagnosed with orbital blow-out fractures between March 2018 and January 2022. The 1964 Helsinki Declaration and its following amendments, or comparable ethical norms, were followed in this study for all procedures involving human volunteers. All participants in the study gave their informed consent, and the study was authorized by the Institutional Ethics Committee (Number: 25.04.2022–862113).

All patients with a history of eye injury had a thorough clinical and ophthalmic examination. Diplopia and ocular movements were tested in all cardinal positions of gaze. Before and after surgery and during the follow-up period, enophthalmos was evaluated using a Hertel exophthalmometer. Two surgeons (CO, KTO) conducted all the exophthalmometry measurements during the ophthalmic examinations. Orbital CT images with slice thicknesses ranging from 0.5 mm to 2 mm were obtained to confirm the diagnosis of blow-out fracture (Fig. 1).

Ocular movements were evaluated on a nine-point scale ranging from −4 to +4. Normal complete movement is represented by zero. Negative numbers represent underactions or limits, whereas positive numbers represent overactions. −4 denotes no movement of the eye beyond the midline. The patients were asked if they had any diplopia in nine cardinal positions of gaze, and strabismus was documented in these positions using Hirschberg's test and Krimsky test. The change in the number of patients without any ocular motility, diplopia, or strabismus after the surgery was assessed to determine the success of the procedure in treating the motility restriction. The change in the degree and direction of restriction, diplopia, or strabismus was not evaluated, and only complete resolution of these findings was accepted as success.

Of 57 patients diagnosed with a blow-out fracture, 17 underwent orbital fracture repair through a transconjunctival technique employing porous polyethylene membrane sheets. All of the surgeries were done under general anesthesia by two surgeons (CO, KTO) who were experienced in the surgical technique. The indications for surgery were enoph-
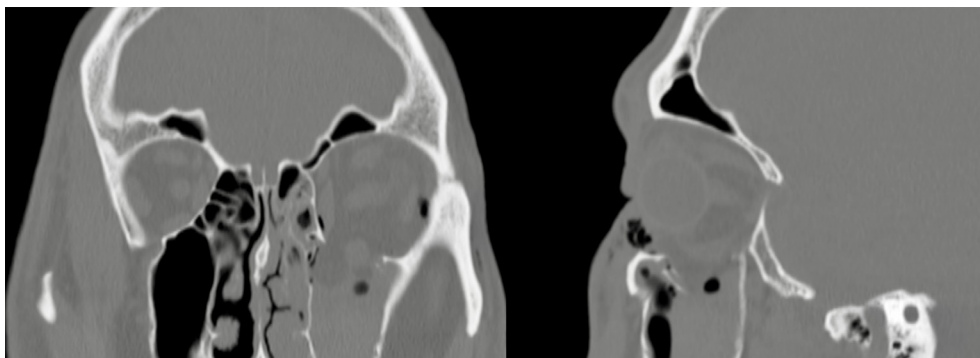
Figure 1. A patient with a large orbital floor fracture is shown in both coronal and sagittal CT images.

thalmos >2 mm and ocular motility restriction, diplopia, and strabismus persisting after 2 weeks of systemic anti-inflammatory therapy. Patients with a defect larger than 50% of the orbital floor or an entrapped muscle were intended to be operated on earlier than 2 weeks. Late surgery was either related to the patient's late admission to our clinic or a time delay in the supply of the implants.

Before and after the surgery, a forced duction test was performed to demonstrate the presence of muscle restriction. A transconjunctival incision was performed below the inferior border of the tarsus following a lateral canthotomy and inferior cantholysis. Traction is applied by inserting 4–0 silk sutures through the conjunctiva and the cut ends of the lower lid retractors (Fig. 2a). The dissection was performed bluntly between the orbicularis muscle and the septum using sterile cotton tips. The periosteum is incised with the needle tip cautery 2 mm below the inferior orbital rim. The periosteum was lifted from the orbital floor using a Freer periosteal elevator. The orbital fracture was subsequently exposed, and the fracture's posterior extent was identified (Fig. 2b). After exposing all borders of the fracture and the herniated soft tissues were released, the defect was measured using a periosteal elevator. A paper suture pack

was initially trimmed and placed on the defect to determine the size of the required implant. The membrane sheet (Su-Por® Surgical Implants by Poriferous®, USA) was then trimmed to match the pattern of the paper, and the implant was placed without fixation in the subperiosteal plane (Fig. 2c-d). The lateral cantholysis was then repaired by suturing the tarsus of the lateral lower eyelid to the tarsus of the superior lateral eyelid, and the transconjunctival incision was closed with 6–0 Vicryl sutures. The skin and orbicularis on the lateral canthus were closed separately with the same suture.

Post-operative treatment consisted of oral antibiotics for the post-operative 1st week; antibiotic steroid combination eye drops q.i.d. for 2 weeks; and a topical antibiotic ointment t.i.d. to be applied for 2 weeks on the skin incision to keep it clean and moist. After 2 weeks, the skin sutures were removed, and the antibiotic ointment was replaced with a steroid ointment b.i.d. for another 2–4 weeks.

Post-operative follow-up visits were scheduled for the 1st day, the 1st week, the 1st, 3rd, and 6th months, and the 1st year. After the surgery, the success criteria were <2 mm of enophthalmos and complete correction of eye motility, diplopia, and strabismus.
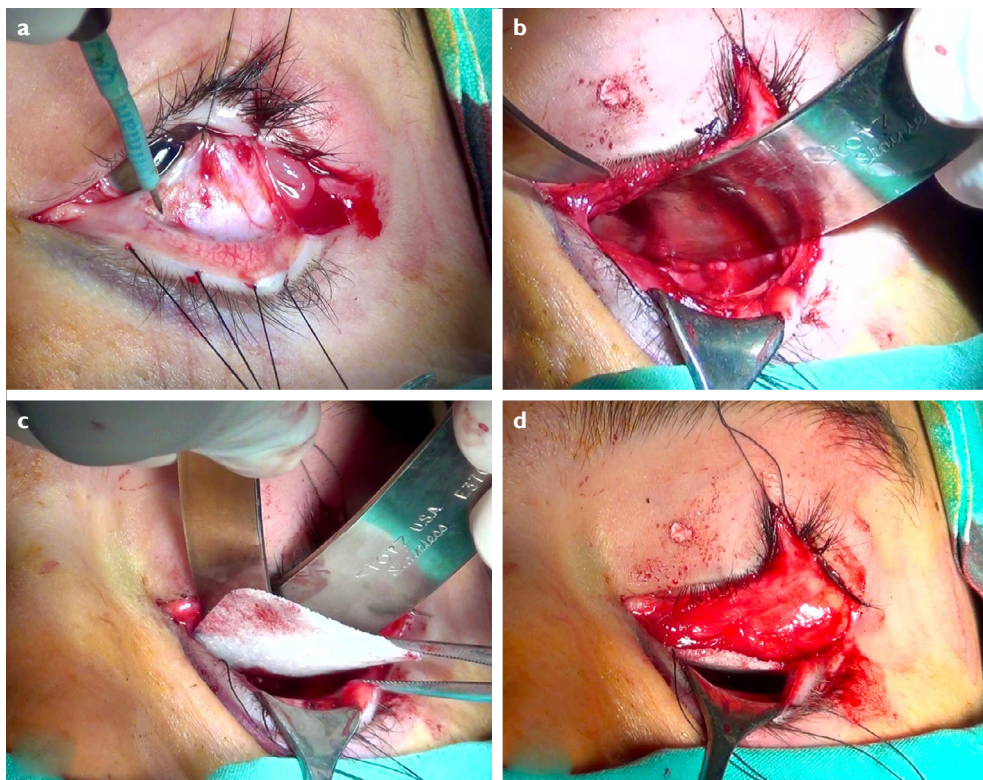
Figure 2. A transconjunctival incision was made beneath the inferior border of the tarsus. The dissection was done between the orbicularis muscle and the septum. **(a)** Soft tissues that have herniated are released and retracted from the fracture site. **(b)** A membrane sheet implant is inserted subperiosteally to cover the defect **(c and d).**

Statistical Analysis

The Saphirpo–Wilk test and histogram graphics were used to assess the normality distribution among the study group. The Independent Samples t-test was the primary statistical test used to compare the means of various variables between surgically and non-surgically treated patients. The Pearson Chi-square test was used to compare the distribution of variables between groups. In contrast, the McNemar Chi-square Test was used to compare the distribution of variables before and after surgery. The Spearman-Rho Test was used to assess the correlation between age and success. The IBM SPSS Statistics 21.0 software (IBM Corp. Armonk, NY, USA) was used for all statistical analysis, and $p<0.05$ were considered statistically significant.

Results

This study included 57 eyes from 57 patients (ten females and 47 males) who had orbital blow-out fractures and had a mean age of 31.12 years (2–77). Only 17 of the 57 patients (29.8%) required surgery, and the remaining 40 (70.2%) were treated with palliative medical care, including anti-inflammatory medication, antibiotics, and observation. The average duration of follow-up was 7.44 months (1–36 months). The parameters age ($p=0.033$), gender ($p<0.001$), the surgical requirement ($p<0.001$), injured side ($p<0.001$), and fractured orbital wall ($p<0.001$) were not distributed normally within the research group (n=57). The mean ages and gender distribution variance among surgically and non-surgically treated patients were comparable ($p=0.68$, $p=0.99$) (Table 1).

The most common cause of injury (50.9%) was an assault, followed by falls (38.6%), traffic accidents (5.3%), and accidental impacts (5.3%). The inferior wall (61.4%) was the most common fracture site, followed by the medial wall (21.1%) and a combination of the inferior and medial walls (21.1%). Although the injury causes were identical in both groups ($p=0.484$), the fracture sites were significantly different between surgically and non-surgically treated patients, indicating that fractures limited to the medial orbital wall in our study group never required surgical procedures treatment ($p=0.009$) (Table 2). There was no correlation between the fracture site and pre-operative ocular motility, diplopia, strabismus, enophthalmos, or surgical success ($p=0.643$, $p=0.394$, $p=0.115$, $p=0.622$, and $p=0.585$).

Table 1. Demographic data of patients treated with or without surgery

	Surgical Treatment	Non-surgical Treatment	p
Number of patients	17 (29.8%)	40 (70.2%)	N/A
Age	32.65 (3–77)	30.48 (2–67)	0.678
Gender (F/M)	3/14 (17.6%)	7/33 (17.5%)	0.989

Table 2. Clinical data of patients treated with or without surgery at the time of

	Surgical treatment	Non-surgical treatment	p
Type of trauma			
Assault	41.2%	55.0%	0.484
Fall	41.2%	37.5%	
Traffic accident	5.9%	5.0%	
Accidental Impact	11.8%	2.5%	
Fracture Site			
Inferior	64.7%	60%	0.009
Medial	0%	30%	
Inferior and medial	35.3%	10%	
Concomitant Injuries	29.4%	10.0%	0.066
Ocular motility restriction	88.2%	0%	N/A
Diplopia	70.6%	0%	N/A
Strabismus	35.3%	0%	N/A

Concomitant injuries occurred in nine patients (15.8%), including isolated eyelid lacerations in five patients (8.8%), fracture of the anterior wall of maxillary bone in two patients (3.5%), eyelid laceration with canalicular injury in one patient (1.8%), eyelid laceration with intravitreal hemorrhage in one patient (1.8%), and eyelid laceration with retrobulbar hemorrhage in one patient (1.8%) (Fig. 3). These injuries were more

Figure 3. Before **(a)** and after **(b)** pictures of a patient with an orbital floor fracture and lower eyelid laceration involving the canaliculus.

common in surgically treated patients (29.4% vs. 10.0%), but the difference was not statistically significant (p=0.066).

Diplopia and strabismus due to ocular motility restriction were the most common reasons for surgical repair in 13 patients (76.5%), enophthalmos in one patient (5.9%), and both motility restriction and enophthalmos in three patients (17.6%). The average time from trauma to surgical repair was 31.59 days (2–126). Among the surgically treated patients, 9 (52.9%) had surgery within the first 2 weeks of the trauma (8.22 days, 1–13), and 8 (47.1%) had surgery later than 2 weeks (mean 57.88 days, 20–126).

Pre-operative ocular motility restriction in 15 patients (88.2%), diplopia in 12 patients (70.6%), and strabismus in six patients (35.3%) were reduced to 23.5%, 23.5%, and 11.8%, respectively, following surgery. Only the post-operative changes in motility and diplopia were statistically significant (p=0.002, p=0.008); however, the reduction in strabismus was not (p=0.219). While four patients (23.5 %) had enophthalmos >2 mm before surgery, all were corrected after the reconstruction, and no patients had enophthalmos following surgery. The mean pre-operative Hertel exophthalmometer reading of 16.18 mm (12–21 mm) increased to 17.41 mm (12–22 mm), and the mean pre-operative enophthalmos of 1.41 mm (0–5 mm) decreased to 0.82 mm (0–2 mm). The mean change in enophthalmos was 0.53 mm after surgery. The difference between pre-operative and post-operative Hertel exophthalmometer readings was statistically significant, as was the change in the amount of enophthalmos. (p=0.012, p=0.012) (Fig. 4). The surgery was successful in ten of 17 cases (58.8%), and the success rate was higher in patients who were treated early (77.8% vs. 37.5%), but the difference was not statistically significant (p=0.092) (Fig. 5). The age of the patients did not affect the surgical outcome (p=0.077).

There was no surgery-related visual loss in any of the cases, and 14 patients (82%) had 20/20 vision after the surgery. The visual acuity was the same as or better than the pre-operative level in all cases. Before surgery, two patients (11.8%) had vision loss due to traumatic optic neuropathy (final visual acuity 0.8 and 0.5, respectively), and one patient (5.9%) had vision loss due to vitreous hemorrhage and retinal atrophy (final visual acuity counting fingers from 50 cm). The only perioperative complication was a rupture of the medial rectus muscle in a case with inferior and medial wall fractures (5.9%), which occurred, while the muscle was released from the ethmoidal sinus. The remaining peripheral muscle stump attached to the eye was sutured to the medial periorbita during the surgery to correct the exotropia. Postoperatively, the patient still had a 15° exotropia on the Hirschberg Test, and ocular movements were restricted in

Figure 4. A 15-year-old boy with a fracture of the left orbital floor. Before surgery, the patient had a limited up gaze and a 3 mm enophthalmos on the left eye **(a-c)**. The improvement can be seen in the post-operative pictures **(d-f)**.
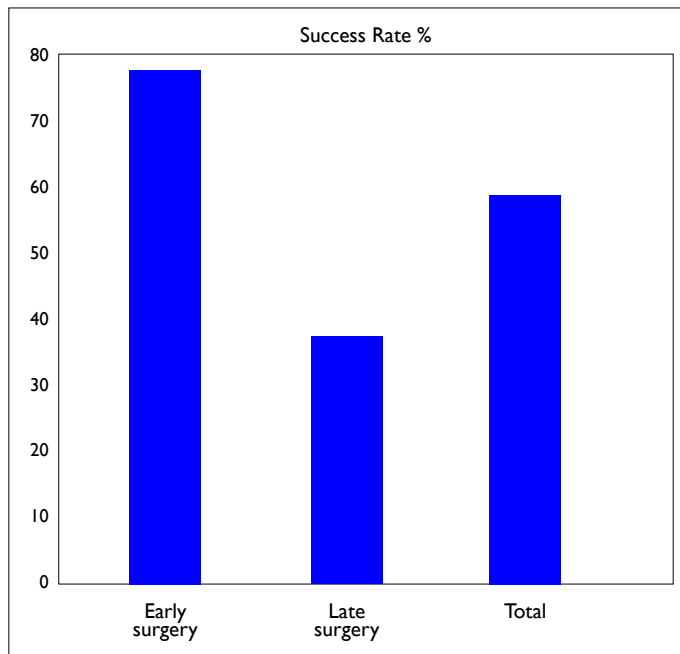
Figure 5. Although the statistical significance could not be proven; the early treatment group had a higher success rate when compared to late treatment patients.

all directions (Fig. 6). One month after the surgery, the patient was lost to follow-up. The rest of the study group experienced no perioperative or post-operative complications other than residual diplopia or motility restriction.

Discussion

The patient population in this study is similar to that of the previous studies, with orbital floor fractures occurring primarily in patients aged 20–40 (mean age 31.12), with a male predominance (82.5%) and interpersonal violence being the most common cause of injury (50.9%) (5-7). A recent retrospective study conducted on 1594 patients by Seifert et al. revealed comparable findings to ours, namely, that the majority of fractures (37.5%) happened between the ages of 16 and 35, 72% of patients were male, and physical assault was the leading cause of injury (32.0%) (8).

According to the literature, simple orbital blow-out fractures limited to the orbital walls most commonly affect the orbital floor, particularly the nasal part of the floor medial to the infraorbital nerve (9,10). Despite being thinner than the orbital floor, the medial orbital wall is supported by ethmoid air cell septa, making this site less prone to fractures than the orbital floor. Furthermore, the orbital floor medial to the infraorbital nerve is thinner than the orbital floor lateral to it. As a result of the lack of supportive structures in this area, fractures in the orbital floor medial to the nerve are more likely to occur (10). Consistent with the literature, we found that the orbital floor (61.4%) was the most common location of the fracture, followed by the medial wall (21.1%) and a combination of the inferior and medial walls (21.1%). None of the isolated medial wall fractures in our study group
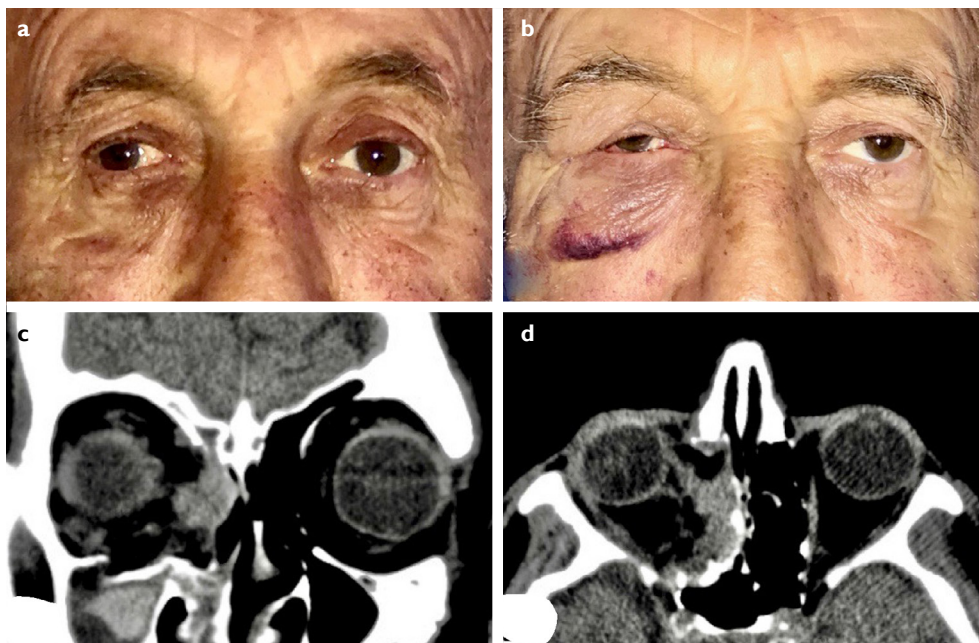
Figure 6. In the study group, the only perioperative complication was medial rectus muscle rupture in a 68-year-old man with medial and inferior wall fractures on the right. **(a)** The remaining peripheral muscle stump attached to the eye was sutured to the medial periorbita. After surgery, the patient still had a 15° exotropia on the Hirschberg Test. **(b)** Pre-operative coronal and sagittal CT images revealed medial and inferior wall fractures **(c and d).**

required a surgical repair. The difference between surgically and non-surgically treated patients regarding the fracture site was statistically significant (p=0.009). This finding can be explained in part by the fact that isolated medial wall fractures were smaller than fractures of the weaker inferior wall and did not result in severe muscle entrapment or soft-tissue herniation.

Most studies examining the outcomes of orbital fracture surgery focus on the correction of diplopia, ocular motility restriction, and enophthalmos separately (7,11-13). In our study group, as in other studies, there was a significant improvement in ocular motility restriction (88.2–23.5%, p=0.002), diplopia (70.6–23.5%, p=0.008), and enophthalmos (1.41 mm to 0.82 mm, p=0.012) after surgery. To evaluate success using stricter criteria, complete resolution of all these symptoms was classified as a success, and the overall success rate among the 17 patients who were operated on was 58.8%.

Various studies made widely divergent recommendations about the timing of blow-out fracture surgery and its effect on post-operative diplopia. Despite previous research advocating for earlier surgery to avoid scarring and fat atrophy leading to restriction and diplopia, (11,14-16) Dal Canto and Linberg discovered no significant difference in post-operative diplopia between early fracture repair (within 14 days of trauma) and late fracture repair (within 29 days after trauma) (12). Likewise, Simon et al. found no difference in post-operative outcomes between early (within 14 days of trauma) and late repair (1 month–3.5 years after trauma) (17). Similar to these studies, we focused on the 14-day cut off as the traditional separation point between early and late surgery. The early surgery group had a higher success rate than the late surgery group (77.8% vs. 37.5%), but the difference was not statistically significant (p=0.092). Due to the small size of our study group, it is not easy to make a conclusive statement about the relationship between surgical time and success based on the data of our study.

Concomitant injuries, such as eyelid lacerations and ocular injuries, were more common in our surgically treated patients (29.4% vs. 10.0%, p=0.066), and they were most frequently associated with falls (44.4%) (p=0.039). This data reveals that patients who experienced more severe traumas had more injuries and were more likely to have damage that necessitated surgery.

Initial diplopia is the most common consequence after orbital floor fracture repair, with a reported prevalence of up to 86%. Most cases of initial diplopia resolve after a few weeks, although chronic subjective diplopia remains a problem with an incidence rate of up to 10%. Orbital dystopia is a common long-term post-operative consequence, with an incidence of up to 27%, and is frequently addressed with a

secondary operation to revise or augment the implant. The ocular compartment syndrome is an uncommon condition that requires immediate treatment. The most severe effect is vision loss due to the technique, documented in up to 3.1% (4). The only perioperative complication in our study group was a medial rectus muscle rupture in one case. None of the other cases had any perioperative or post-operative problems other than persistent diplopia or ocular motility restriction, consistent with the literature. There was no vision loss as a result of the procedure.

Conclusion

Our findings indicate that orbital blow-out fracture repair through the transconjunctival approach is a safe and effective surgical technique for orbital blow-out fracture repair. Although patients who had early surgery had a higher success rate in our study group, larger study groups are needed to assess the effect of surgical timing on success.

References

1. Damgaard OE, Larsen CG, Felding UA, Toft PB, von Buchwald C. Surgical timing of the orbital "Blow-out" fracture: A systematic review and meta-analysis. Otolaryngol Head Neck Surg 2016;155:387–90. [CrossRef]

2. Homer N, Huggins A, Durairaj VD. Contemporary management of orbital blow-out fractures. Curr Opin Otolaryngol Head Neck Surg 2019;27:310–6. [CrossRef]

3. Felding UN. Blow-out fractures-clinic, imaging and applied anatomy of the orbit. Dan Med J 2018;65:B5459.

4. Hartwig S, Nissen MC, Voss JO, Doll C, Adolphs N, Heiland M, et al. Clinical outcome after orbital floor fracture reduction with special regard to patient's satisfaction. Chin J Traumatol 2019;22:155–60. [CrossRef]

5. Kasaee A, Mirmohammadsadeghi A, Kazemnezhad F, Eshraghi B, Akbari MR. The predictive factors of diplopia and extraocular movement limitations in isolated pure blow-out fracture. J Curr Ophthalmol 2017;29:54–8. [CrossRef]

6. Ramphul A, Hoffman G. Does preoperative diplopia determine the incidence of postoperative diplopia after repair of orbital floor fracture? An institutional review. J Oral Maxillofac Surg

2017;75:565–75. [CrossRef]

7. Higashino T, Hirabayashi S, Eguchi T, Kato Y. Straightforward factors for predicting the prognosis of blow-out fractures. J Craniofac Surg 2011;22:1210–4. [CrossRef]

8. Seifert LB, Mainka T, Herrera-Vizcaino C, Verboket R, Sader R. Orbital floor fractures: Epidemiology and outcomes of 1594 reconstructions. Eur J Trauma Emerg Surg 2022;48:1427–36.

9. Carinci F, Zollino I, Brunelli G, Cenzi R. Orbital fractures: A new classification and staging of 190 patients. J Craniofac Surg 2006;17:1040–4. [CrossRef]

10. Valencia MR, Miyazaki H, Ito M, Nishimura K, Kakizaki H, Takahashi Y. Radiological findings of orbital blow-out fractures: A review. Orbit 2021;40:98–109. [CrossRef]

11. Matteini C, Renzi G, Becelli R, Belli E, Iannetti G. Surgical timing in orbital fracture treatment: Experience with 108 consecutive cases. J Craniofac Surg 2004;15:145–50. [CrossRef]

12. Dal Canto AJ, Linberg JV. Comparison of orbital fracture repair performed within 14 days versus 15 to 29 days after trauma. Ophthalmic Plast Reconstr Surg 2008;24:437–43. [CrossRef]

13. Gonzalez MO, Durairaj VD. Indirect orbital floor fractures: A meta-analysis. Middle East Afr J Ophthalmol 2010;17:138–41.

14. Converse JM, Smith B, Obear MF, Wood-Smith D. Orbital blow-out fractures: A ten-year survey. Plast Reconstr Surg 1967;39:20–36. [CrossRef]

15. Whyte DK. Blow-out fractures of the orbit. Br J Ophthalmol 1968;52:721–8.

16. Burnstine MA. Clinical recommendations for repair of isolated orbital floor fractures: An evidence-based analysis. Ophthalmology 2002;109:1207–10; discussion 10–1; quiz 1212–3.

17. Simon GJ, Syed HM, McCann JD, Goldberg RA. Early versus late repair of orbital blow-out fractures. Ophthalmic Surg Lasers Imaging 2009;40:141–8. [CrossRef]