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ORIGINAL ARTICLE

Retrospective analysis of orbital floor fractures—complications, outcome, and review of literature

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Abstract This retrospective study aimed at investigating indications, surgical approaches, and the materials used for orbital floor reconstructions, as well as the clinical follow-up, particularly with regard to postoperative complications. This study comprised 189 patients who underwent surgery for fractures of the orbital floor between 2003 and 2007. Diagnosis and treatment were based on both physical examination and computed tomography scan of the orbit. Patients were retrospectively analyzed for data, such as mechanism of injury, classification of fracture, and complications. The most common cause of injury was physical assault followed by traffic accidents. Surgery was conducted with a mean delay of 2.9 days after the incident. Mid lower eyelid incision was the most common surgical approach to the orbital floor. For orbital floor reconstruction, polydioxanone sheets (70.5%) were mainly used, followed by Ethisorb Dura (23.3%) and titanium mesh (6.2%). There were 19.0% of patients who showed postoperative complications: 5.8% suffered from persisting motility impairment, 3.7% from enophthalmos, 3.2% from consistent diplopia, 2.6% from ectropion, and 0.5% from orbital infection. Intraorbital hematoma (3.2%) represented the most severe complications, one patient suffered lasting impairment of sight and another one, complete blindness of the affected eye. If postoperative impairment of vision becomes evident, immediate surgical intervention is mandatory. Retrobulbar hematoma is more likely to occur in heavily traumatized patients with comminuted fractures and also in patients taking anticoagulative medication. The subciliary approach to the orbit and repeated operations by the same approach are associated with a higher risk of developing ectropion.

Keywords Orbital floor fractures · Amaurose · Enophthalmos · Retrobulbar hematoma · Ectropion

Introduction

The orbit is particularly susceptible to fractures because of its exposed position and its thin bones. External impact to this area may cause a blowout or zygomatico-maxillary fractures, which may be both accompanied by orbital floor defects. Diplopia is the most frequent complication of orbital floor defects. Others include limitation of ocular movement, infraorbital numbness, enophthalmos, and reduced vision. Immediate surgical intervention to restore the anatomic structure of the orbit is therefore essential for improving visual function and orbital appearance [1–4]. The literature (Table 2) describes different surgical procedures and evaluates various materials for orbital reconstruction. However, therapeutic results are still not always satisfactory, and many different complications may occur after surgery. This study of 189 patients was initiated to review and evaluate indications for surgery, therapeutic principles, surgical approaches, and the selection of restoration materials for managing orbital floor defects.

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Complications due to surgery are described in detail and coherences questioned. This study should help to prevent and understand the cause of severe postoperative complications, such as blindness after surgical orbital floor restoration.

Patients and methods

One hundred eighty-nine patients with orbital floor fractures, either isolated or as part of orbital or midface fractures, were included in this study. All patients underwent primary surgical treatment at the Department of Oral and Maxillofacial Surgery, University Hospital Regensburg, between January 2003 and December 2007. The patients were retrospectively analyzed for gender, age, mechanism of injury, classification of fracture, preoperative symptoms, latency time between trauma and surgery, and postoperative complications. Diagnosis and treatment were based on physical examinations and computed tomography (CT) scans of the orbit in axial and coronal projection (Fig. 1). Since coronal projection requires hyperextension of the neck, axial images were reformatted to provide coronal information in patients with suspected spine injuries. All patients were ophthalmologically examined on the day of admittance, preoperatively, postoperatively after the swelling had ceased, and during follow-up if necessary. Indications for surgery were determined by the presence of symptoms, such as diplopia, enophthalmos, motility disturbance, as well as a fracture size larger than 1 cm in diameter in the CT scan. Four different surgical approaches for orbital reconstruction were used: transconjunctival, subciliar, mid lower eyelid, and infraorbital. All operations were conducted by maxillofacial surgeons. For orbital floor reconstruction, we used polydioxanone sheets (PDS®, Ethicon Products, Norderstedt, Germany), Ethisorb™ Dura patches (Codman, Raynham, MA, USA), and titanium mesh (Leibinger®, Martin®). PDS and Ethisorb were used for standard orbital floor repair. Titanium mesh was inserted in large orbital floor defects (>2 cm^2) or for revision surgeries. Enophthalmos relative to the opposite side was determined by a Hertel exophthalmometer, measuring the difference between the anterior corneal surface and the lateral orbital rim. Diplopia was defined as double vision in the primary position and within a 30° gaze that subjectively interfered with a patient's daily activities. The follow-up duration was calculated from the time point of the first treatment to the last follow-up, up to December 2007.

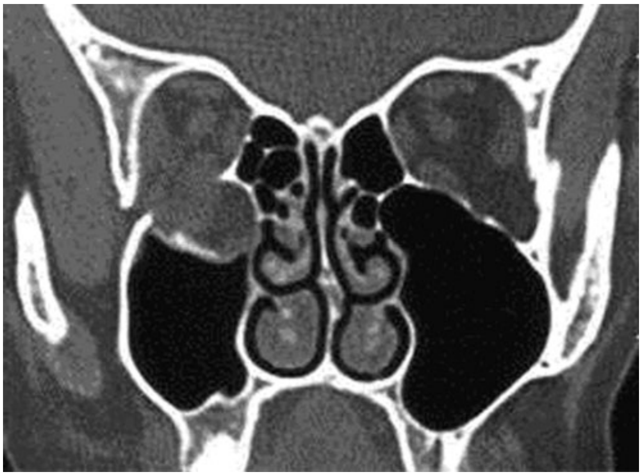

Fig. 1 Preoperative coronal computed tomography scan of a right orbital floor fracture

Results

One hundred eighty-nine patients with orbital floor fractures were enrolled in this study during a 5-year period: 19.6% of patients (n=37) had isolated orbital floor fractures, 53.8% (n=102) had zygomatic fractures with orbital floor affection, and 26.6% (n=50) had complex midface fractures. Follow-up ranged from 3 to 36 months with a mean of 5.7±2.8 months.

One hundred forty-eight (78.3%) men and 41 (21.7%) women were recorded; thus, the gender distribution was 3.6:1. The mean age of patients was 43.7 (range 7 to 94) years. On average, men were 17 years younger than women.

The most common cause of fracture was physical assault (n=47, 24.9%), followed by traffic accidents (n=41, 21.7%), injuries during daily life activities (n=37, 19.6%), sport injuries (n=29, 15.3%), and injuries during work (n=12, 6.3%). For 23 (12.2%) patients, the cause of injury was unknown. The mean time between trauma and surgery was 2.9 days (±2.1 days, range between 0 and 33 days, Fig. 2). There were 50% of patients who had been operated on by

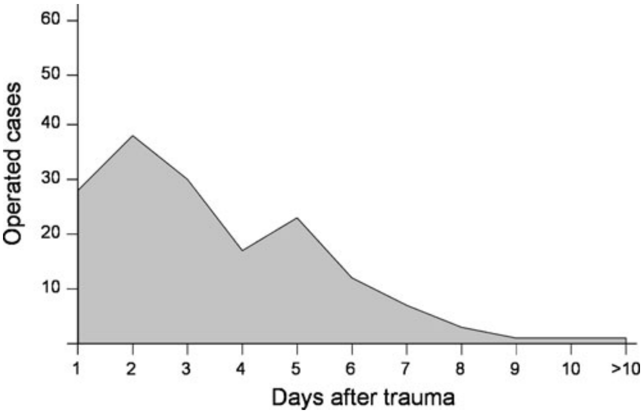

Fig. 2 Date of operation after trauma

the third day after trauma. Usually, the day of trauma was the day of admittance (98.3%).

With regard to surgical approaches, mid lower eyelid incision (*n*=125, 66.1%) was the most common intervention, followed by the infraorbital approach (*n*=42, 22.2%), the subciliary approach (*n*=13, 6.9%), and others (*n*=9, 4.8%, i.e., direct approach via existing wound, transconjunctival).

Of 189 patients (77.2%), 146 received implants, and in 43 patients, open bone repositioning was sufficient because of only minor or fissural fractures. In these 146 patients, orbital floor reconstruction with PDS sheets was conducted in 70.5% (*n*=103), Ethisorb Dura patches were used in 23.3% (*n*=34), and titanium mesh was inserted in 6.2% (*n*=9) (Fig. 3).

There were 19.0% (*n*=36) of patients who showed postoperative complications (Table 1): 5.8% suffered from persisting motility impairment, 3.7% from enophthalmos/hypophthalmos, 3.2% from diplopia, 2.6% from ectropion, and 0.5% from orbital infection. Retrobulbar hematomata (3.2%) represented the most severe complication; one patient suffered lasting impairment of sight and another one, complete blindness of the affected eye.

Discussion

This retrospective analysis was conducted on 189 patients who had been operatively treated for orbital floor fractures. The primary objective of a surgical reconstruction of the orbital floor is to release entrapped soft tissue contents and to restore the original anatomy and orbital volume [5–7]. The results of this study are discussed in the context of an extensive literature research on this subject (Table 2).

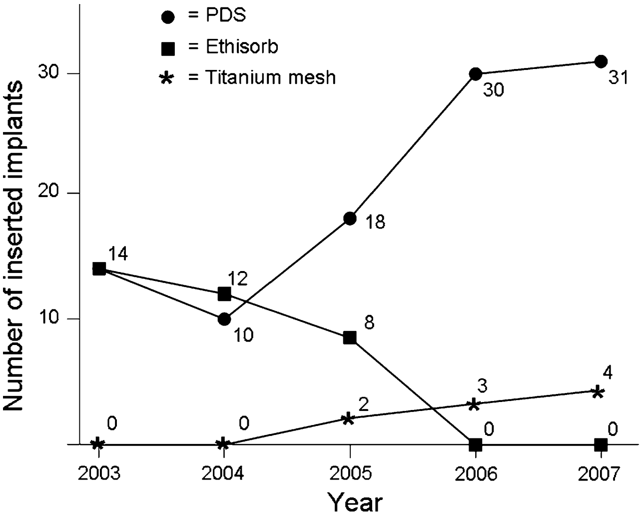

Fig. 3 Number and type of implants used during the study period

Discussion about indications and timing of surgery of orbital floor fractures is controversial. Absolute and immediate indications are retrobulbar hematoma with compression of the globe or the optical nerve in combination with impaired vision [8, 9]. Other indications for an urgent intervention are situations in which muscle is entrapped and possibly ischemic [10–16]. Aesthetically disturbing enophthalmos due to isolated orbital floor fractures should result in early surgical intervention [15]. Complete anesthesia or progressive infraorbital hypesthesia from infraorbital nerve entrapment also favors early intervention, but operative risks, such as persisting paresthesia, visual loss, and diplopia, should be taken into consideration [4, 8, 11, 17, 18]. Other strong indications include enophthalmos larger than 2 mm during the first 6 weeks and significant hypoglobus or diplopia, particularly in the primary field of gaze, that fail to resolve after 2 weeks [10, 11, 19]. Recently, most surgeons have recommended an early operation for better postoperative results and decreased incidences of diplopia and enophthalmos due to less soft tissue scarring [5, 6, 13, 14, 16, 20, 21]. However, Dal Canto and Linberg [22] found similar complication rates comparing orbital fracture repair conducted within 14 days to fracture repair carried out 15 to 29 days after trauma. In our patients, the timing of surgery was decided on approximately 3 days after trauma after periorbital swelling had subsided. We considered this the ideal time for intervention in nonemergency cases.

The type of incision is important in orbit fractures. A literature review shows a continuously increasing use of the transconjunctival approach during the past 10 years and a simultaneous decrease of the mid lower eyelid approach, while the subciliary approach remains equal over time (Table 2). Transconjunctival incision involves a smaller risk of lower eyelid retraction compared to the subciliary approach and offers excellent visualization [23, 24]. However, the additional use of lateral canthotomy results in a higher incidence of entropion and displacement of the lateral canthus [10, 24]. Particularly in older patients with pronounced wrinkling, subtarsal lower eyelid incision (mid lower eyelid) is still an option, offering direct access to the infraorbital rim with a minimal risk of retraction [10, 25]. In our study, mid lower eyelid incision showed favorable cosmetic results without the risk of ectropion development. Of 13 patients (38.5%) operated on via subciliary incision, five developed postoperative lower lid retraction; three of them required surgical intervention with scar release followed by defect filling with a full thickness skin graft. In our study, ectropions may not only have developed due to subciliary incision but due to the fact that three of these five patients had undergone secondary operations because of persisting

Table 1 Complications after surgery

	Complications					
	Diplopia	Motility impairment	Enophthalmos/hypophthalmos	Infection	Intraorbital hematoma	Ectropion
Overall (19%; *n*=36)	3.2% (6)	5.8% (11)	3.7% (7)	0.5% (1)	3.2% (6)	2.6% (5)
PDS	(5)	(9)	(3)	(1)	(5)	
Ethisorb	(1)	(1)	(1)	–	–	
Titanium mesh	–	–	(1)	–	–	
No material	–	(1)	(2)	–	(1)	
Revision surgery	(3)	(1)	(5)		(5)	

enophthalmos before developing ectropion. To avoid ectropions in such a situation, Zide [26] suggested the transconjunctival approach in patients undergoing reoperations. Bähr et al. [25] noticed an incidence of ectropion of 6.4% for subciliary incision compared to 0% for the mid lower eyelid approach; these figures are also reported by other authors [27–29].

For orbital floor reconstruction in our study, the most commonly used implant material was PDS. For smaller fractures (<2.5 cm^2) and in children, resorbable implants such as PDS sheets are recommended [28, 30, 31]. These implants are usually resorbed after 6 months, showing good results without the problems presented by enophthalmos, once the material has been resolved [30, 31] (Fig. 4). Some studies showed less favorable outcomes for the use of PDS. The lack of osteoconductive properties of PDS results in bone healing in areas of the displaced remnants of the periosteum and bone fragments but not in the reconstructed area of the PDS sheet [27, 31, 32]. Late enophthalmos may occur after degradation of the PDS sheet [27, 31]. Orbital floor repair with PDS implants alone is known to be inadequate [32]. Bony floors should at least be elevated and repositioned before the use of PDS [27, 31], which was always done in this study. Furthermore, PDS may provoke adverse foreign body reactions [27, 33] and may result in displacement if not fixed properly. In our study, resuturing of the periosteum after subperiostal insertion of the PDS sheet seemed to be sufficient. According to the literature (Table 2), PDS is used frequently, whereas porous polyethylene (Medpor) is becoming more popular for orbital floor reconstruction. Recently, however, foreign body reaction and focal disintegration of Medpor material have been observed [34–36]. These histological findings should result in a critical investigation of this material to clarify the clinical relevance of the described foreign body reactions. Ethisorb Dura patches have been abandoned. Titanium mesh is preferred for large orbital floor defects and for supporting bone grafts. Although titanium mesh implants are a simple and reliable option for orbital floor repair [32, 37], they also present a risk. In case of a new injury to the orbit necessitating a second intervention, removal of the implant may be extremely challenging because of heavy adhesions of the periorbit tissue to the mesh [38]. Additionally, titanium meshes are very expensive, which make their implementation in times of economic optimization difficult. Although autogenic bone grafts, mainly calvarian bone [39] and iliac bone [40, 41], are still widely and effectively used for orbit reconstruction, they have both advantages as well as disadvantages. Advantageous is that bone grafts are strong, biocompatible, osteoconductive, and osteoinductive. Disadvantages are donor site morbidity, the time-consuming procedure, longer postoperative care and, above all, variable resorption, and a potential for late-occurring enophthalmos [40, 42]. Overall, autogenous bone should be particularly considered in complex orbital fractures [40].

We encountered postoperative enophthalmos/hypophthalmos in seven patients (3.7%) and consistent diplopia in six patients (3.2%); most defects were primarily restored with PDS sheets. Three patients (1.6%) suffered from visible enophthalmos and diplopia. Five patients needed revision surgery, and the defects were secondly repaired with titanium mesh. In other studies, the incidence of enophthalmos ranged from 1.5% to 43.5% and the incidence of consistent diplopia from 1.2% to 32.1% (Table 2). It should be mentioned that a comparison of the complication rate of fractures treated with titanium mesh with those treated with PDS sheets or Ethisorb Dura patches is difficult, because titanium mesh tends to be mostly used for larger defects, for heavily commuted fractures, and for reoperations with an increased risk of complications.

Our overall complication rate of 19.0% was in the medium range of the rates published in the literature, i.e., an overall complication rate between 3.0% and 85.5% (Table 2). Our complication rate might be a little low as we neglected persistent hypesthesia of the infraorbital nerve because of the lack of consistent data. Furthermore, this rate may increase over time, although only a few

Table 2 Review of the literature on epidemiology and correlation of treatment and complication rate of orbital floor fractures

Source	No. of patients	Average age (years)	M:F ratio	Approach	Fracture pattern	Implant material	Complications (%)	Follow-up (months)	Rate of complication (%)
Sargent and Fulks (1990) [59]	54 (66 OP)	36	n.g.	S	Orb (6), Zm (42), O (18)	Titanium	Enophthalmos (1.5), ectropion (1.5)	9	3.0
Hidding et al. (1991) [60]	36	n.g.	n.g.	n.g.	Orb (23), O (13)	PDS	Diplopia (8.3), hypesthesia (16.7)	12	25.0
Iizuka et al. (1991) [61]	20	31	5.7:1	S	Orb (2), Zm (10), O (8)	PDS	Diplopia (10.0), enophthalmos (10.0), hypophthalmos (25.0)	12	45.0
Samek et al. (1991) [62]	293	35.1	3.4:1	Mle	Orb (37), Zm (180), O (76)	Lyodura (247), bone (46)	Diplopia (5.5), enophthalmos (2.4), hypophthalmos (0.7), motility impairment (9.9)	4	19.1
Hessling et al. (1991) [63]	62	n.g.	n.g.	S (59), Mle (3)	Orb (11), Zm (51)	PDS (19), lyodura (19), cartilage (2), silastic (2)	Diplopia (9.7), enophthalmos (43.5), hypophthalmos (32.3)	3	85.5
Hammer (1995) [64]	448	20–30	3.3:1	S, Mle	Orb (15), Zm (357), O (76)	PDS (43), lyodura (77), silastic (17), titanium (9), bone (74), inspection (228)	Diplopia (2.7), enophthalmos (8.0), ectropion (0.7), infection (4.2)	6	15.6
Friesenecker et al. (1995) [65]	74	42.3	2.4:1	S (53), Mle (8), D (13)	Orb (8), Zm (66)	Dura (63), polydioxanone (6), fascia lata (5)	Diplopia (8.1), enophthalmos (5.4), hypophthalmos (2.7), ectropion (1.4), hypesthesia (27.0)	12	44.6
Kinnunen et al. (2000) [66]	28	32	1.5:1	S, T	Orb (15), Zm (13)	Ear cartilage (14), bioactive glass (14)	Diplopia (10.7), enophthalmos (3.6), ectropion (3.6), hypesthesia (10.7)	12	28.6
Guerra et al. (2000) [67]	55	33.6	4:1	S, T, Mle	Orb (21), Zm (34)	Dura	Enophthalmos (5.4), hypesthesia (7.2)	12	12.6
Kontio et al. (2001) [27]	16	36.6	2.75:1	S, T	Orb (10), Zm (6)	PDS	Diplopia (25.0), enophthalmos (37.5), ectropion (12.6), hypesthesia (6.3)	7	81.3
Dietz et al. (2001) [68]	28	30	4.6:1	S, Mle	Orb (13), Zm (7), O (8)	PDS, titanium	Diplopia (3.5), enophthalmos (7.0), ectropion (3.5), hypesthesia (7.0)	6	21.0
Aitasalo et al. (2001) [69]	28	32.6	3:1	S, T	Orb (14), Zm (14)	Bioactive glass	Diplopia (14.3), enophthalmos (10.7), hypophthalmos (7.0), hypesthesia (18.0)	12	50.0
Brady et al. (2001) [70]	59	33	1.8:1	T	Orb	PDS (5), ethisorb (5), dura (24), bone (2)	Diplopia (1.7), hypesthesia (1.7)	9	3.4
Baumann et al. (2002) [31]	32	36.6	3:1	S (16), T (13), Mle (3)	Orb (15), Zm (17)	PDS	Diplopia (31.0), enophthalmos (22.6), infection (3.2), hematoma (6.2)	38	65.6
Villareal et al. (2002) [28]	32	35	3.6:1	S (15), T (9), Mle (2), D (6)	Orb (11), Zm (16), O (5)	PDS	Diplopia (10.7), enophthalmos (28.1), ectropion (15.6), hypesthesia (34.6), infection (12.5), loss of vision (3.1)	8.5	n.g.
Ellis and Tan [46]	58	n.g.	6.25:1	T (26), Mle (32)	Orb (38), O (20)	Titanium (32), bone (26)	Volume change (50.0)	12	50.0
Jank et al. (2003) [71]	435	33.9	4.6:1	S	Orb	PDS (81), ethisorb (136), lyodura (120), exploration (91)	Diplopia (2.1), enophthalmos (1.2), motility impairment (3.9)	12–15	7.1
Büchel et al. (2005) [72]	87	45.2	1.6:1	T	Orb (28), Zm (59)	Ethisorb dura	Diplopia (5.7), enophthalmos (2.3), ectropion (3.4),	3	19.5

Table 2 (continued)

Source	No. of patients	Average age (years)	M:F ratio	Approach	Fracture pattern	Implant material	Complications (%)	Follow-up (months)	Rate of complication (%)
							hypesthesia (8.0)		
Lee et al. (2005) [7]	165	n.g.	n.g.	T	Orb (50), O (115)	Medpor	Diplopia (3.5), enophthalmos (4.1), ectropion (1.8), loss of vision (0.6)	7.4	10.3
Otzturk et al. (2005) [29]	38	28	4.4:1	S	Orb (4), Zm (34)	Medpor	Diplopia (2.6), enophthalmos (7.9), ectropion (7.9), hypesthesia (7.9)	48	26.3
Rinna et al. (2005) [19]	379	n.g.	n.g.	S, T	Orb (125), Zm (182), O (72)	Lyodura (75), Medpor (25), titan (102), ost biol (11)	Diplopia (0.52)	12	0.52
Nam et al. (2006) [6]	405	36	2.0:1	S	Orb (266), O (139)	Medpor (214), biocoral (191)	Diplopia (1.2), enophthalmos (5.4), hypesthesia (2.2)	6–18	8.9
Tuncer et al. (2007) [73]	17	34.2	1.8:1	S (14), T (3)	Orb (6), Zm (11)	Resorbable mesh	Enophthalmos (5.9), ectropion (5.9), infection (5.9)	12	17.6
Lin et al. (2007) [74]	21	24.4	2:1	T (21)	Orb (21)	Medpor (21)	Diplopia (4.7), enophthalmos (14.3)	24	19.0
Wang et al. (2008) [3]	21	34.1	1.3:1	S (16), D (5)	Zm (15), O (6)	Medpor (6), titanium (10), bone (5)	Diplopia (19.0), enophthalmos (9.5), hypesthesia (9.5)	6	38.0
Our Study	189	42	4.9:1		Orb (37)Zm (102)O (50)	PDS (103), ethisorb dura (34), titanium (9), no implant (43)	Diplopia (3.2), ectropion (2.6), enophthalmos (3.7), motility impairment (5.8), infection (0.5), hematoma (3.2) with impaired vision (0.5), loss of vision (0.5)	5.7	19.0

Approach: *S* Subciliar, *T* transconjunctival, *Mle* mid lower eyelid, *D* direct (approach via wound)

Fracture pattern: *Orb* orbital floor only, *Zm* zygomatico-maxillary fracture, *O* others (Le Fort, NOE, Panfacial)

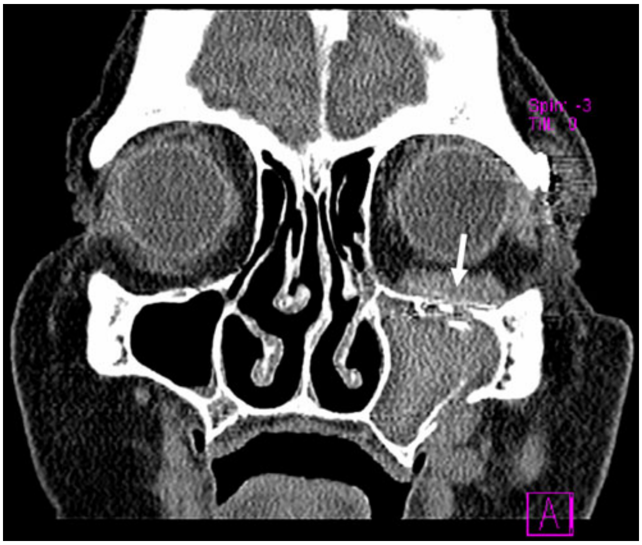

Fig. 4 Postoperative intraorbital hematoma in the left lower orbit after orbital floor reconstruction with polydioxanone sheets (PDS sheet marked by *arrow* below the hematoma)

patients had a short follow-up time (3 to 4 months). Six patients showed retrobulbar hemorrhage after reduction of orbital floor fractures, three of them were taking preoperative anticoagulative treatment. Another two patients suffered complex midface fractures with extensive destruction of the orbital floor. Five patients had increased ocular pressure after surgery with accompanying pain and impaired vision. Intraocular hemorrhage was discovered in one patient during a postoperative control CT, but revision surgery was not required. Three patients gained full vision after immediate surgery, and two patients still had impaired vision or loss of vision after surgery. The patient with the lasting complete loss of vision after orbital floor repair underwent lateral canthotomy and cantholysis, but no recovery of vision could be achieved. This patient had his vision controlled only twice during the first postoperative night, and the last control (2:00 a.m.) was delayed until the next morning (6:30 a.m.). Furthermore, intervention was delayed due to CT examination and preparation for surgery (3 h). The patient with partial recovery was treated with shorter delay, but the time between the onset of symptoms and the surgical intervention (4 h) was still too long.

In other studies, the incidence of visual loss as a complication of surgery of orbital fractures was recorded to range from 0.24% to 3.1% [7–9, 28, 43–45]; blindness was ascribed to retrobulbar hemorrhage in almost 50% of cases [8, 9, 28, 44]. Increased intraorbital pressure due to bleeding or edema is a well-accepted cause of the damage to the visual system [8, 9, 28, 46, 47]. The most critical aspect of orbital hematoma treatment is the quickness of diagnosis and the decision to conduct surgical drainage. Any delay between the onset of symptoms and orbital decompression may harmfully affect the prognosis of the vision [9, 18, 28, 44, 45, 48–50]. Clinical diagnosis is based on the observation of painful exophthalmos with a visual deficit and ophthalmoplegia or, in unconscious patients, loss of the pupillary reflex [9, 18, 44, 45, 48–50]. An emergency multislice orbital CT scan is a fundamental diagnostic aid, but the use of this device is not advisable if treatment will be delayed [9, 51]. As soon as visual deterioration is detected, high-dose steroid therapy should be given to protect the nervous tissues from ischemic insult. Moreover, surgery should be initiated, and postoperative steroid administration should be continued [9, 10, 43, 51]. Medical therapy should only be secondary since patients presenting with increased orbital pressure and reduced vision constitute a surgical emergency [8, 51–53]. For initial orbital decompression, lateral canthotomy with cantholysis is mandatory and can be conducted immediately in local anesthesia [44, 50, 54–56]. Thereafter, orbital decompression should be conducted via lateral orbitotomy or endoscopic, transnasal medial decompression in general anesthesia by an experienced surgeon [9, 49, 53, 57, 58].

Conclusion

Retrobulbar hematomata are a rare but potentially severe complication of orbital floor repair after orbital trauma. Therefore, visual acuity must be carefully monitored over time in all facial trauma patients, and an accurate CT scan assessment should be conducted in any suspected case. Early diagnosis and immediate treatment based on surgical decompression are essential for preventing permanent damage. In case of symptoms such as impaired vision, delay is not acceptable and even CT scanning may be neglected in favor of immediate surgical decompression. Patients with severe trauma are more likely to develop complications, such as retrobulbar hematoma, enophthalmos, or diplopia. The incidence of retrobulbar hematoma increases for patients taking regular anticoagulative medication.

PDS sheets are used for repairing most orbital floor defects and are considered a suitable material for the reconstruction of small to medium orbital floor defects. In larger fractures or for revision surgery, titanium mesh should be used, as done in our study. A higher risk of developing ectropion was found for the subciliary approach and for repeated operations via the same approach. In the subciliary approach, deep lateral dissections should be avoided. Additionally, early massage of the eyelid starting at the tenth postoperative day may help to prevent ectropion development. For reoperations, a transconjunctival approach is preferable.

Conflict of interest None.

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