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Full Length Article

Orbital roof fractures: Considerations for reconstruction

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ABSTRACT

Purpose: This paper aims to update current knowledge on orbital roof fractures and their reconstruction techniques through a multicenter experience, a literature review and detailing two cases involving autologous and heterologous bone grafts.

Methods: A Medline search from 2018 to 2023 was conducted, alongside a retrospective review of similar cases treated across four Italian hospitals. Inclusion criteria required all clinical and radiological data to be available, with a minimal follow-up of 6 months.

Results: Coronal incision was most common in the 16 studies analyzed, with titanium mesh or plates as primary reconstruction materials. Only four cases utilized autogenous bone, and dislocated bone fragment removal occurred in four patients. Early treatment was prioritized for emergencies, with 70 % of cases undergoing coronal incision. Most cases required defect reconstruction, primarily with titanium mesh. One patient experienced late rhinoliquorrhea, and only one required revision surgery.

Conclusion: Conservative approaches were mostly favored, with early intervention reserved for enophthalmos and ocular movement impairment. Upper eyelid blepharoplasty approach was considered safe for cases without intracranial injuries or frontal bone fractures. Heterologous bone grafts emerged as a potential alternative to titanium mesh, while autogenous bone harvested from the frontal box reduced operative time and complications in delayed treatments. VSP custom-made prosthesis can be utilized in complex fractures.

1. Introduction

Even if infrequent (1–5%), orbital roof fractures represent a challenge for the maxillo-facial surgeon, due to concomitant trauma and risks to the eye and orbital contents [1–4]. Obviously, their management is secondary to stabilization of life-threatening injuries, but in presence of visus impairment (9.1 % of cases) as consequence of optic nerve compression early treatment is advocated. In addition, in order to prevent potentially fatal complications such as meningitis, brain abscess formation and encephalocele, surgical intervention shouldn't be delayed, as reported by a recent systematic review [1,5]. Orbital roof fractures are most frequent in young males (mean age: 25,5yrs), and main causes are motor vehicle accidents. Where indicated, most of these patients undergo surgical repair through coronal approach, and

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titanium mesh and bone grafts are mostly used for reconstruction. An ideal grafting material has to be simple and ready to use, has to guarantee aesthetical and functional results and should not be reabsorbed, infected or extruded. Obviously, autogenous bone represents the best choice from this point of view [6], but replacement of dislocated fragment, eventually rotated, is not always possible, and bone (or cartilage) grafting leads to an increased surgical time and eventually to further complications. Reviewing most recent literature about this topic, the aim of this paper is to update these data with a multicenter experience over the last years, also describing one case of reconstruction using heterologous bone graft, routinely used for orbital floor reconstruction [7], that can be considered as a possible alternative to titanium mesh, and one case in which autogenous bone graft was harvested directly from frontal box.

2. Material and methods

Medline search on Pubmed searching for "orbital roof fracture" was performed. Inclusion criteria were articles discussing management of orbital roof fractures in adult patients in order to update the data reported by Lucas et al., in 2020 [1]. Titles and abstracts of all initial studies collected from 2018 to 2024 in English literature were screened for inclusion and the full texts were evaluated by three independent reviewers. All studies were allocated a quality score for level of evidence using the Grades of Recommendation, Assessment, Development and Evaluation criteria.

In addition, retrospective review of adult patients (>18 yrs) affected by orbital roof fractures that underwent surgery at S.M. Goretti Hospital, Latina (2020–2023), Policlinico Umberto I, Rome (2011–2023), Policlinico Le Scotte, Siena (2021–2023) and San Salvatore Hospital, L'Aquila (2021–2023) were identified. All patients were managed by maxillofacial surgeons, eventually in association with neurosurgeons for those cases having neurosurgical symptoms or requiring a transcranial approach. To be included, for all patients all clinical and radiological data had to be available, and a minimal follow-up of 6 months was required.

The study is HIPAA compliant and adheres to the ethical principles as outlined in the Declaration of Helsinki as amended in 2013. Informed consent was not obtained as most of these subjects would likely not be locatable or contactable following their discharge, and data was de-identified during the collection process.

3. Results

In total, 15 studies were deemed to meet inclusion criteria. Main findings are illustrated in Table A and B [8–23].

Considering only 13 papers that describes 26 surgical cases (Table B), coronal incision was the most used approach (16 pts, 61,5 %), and in most cases reconstruction was achieved using titanium mesh or plates (respectively 8 and 3 pts, 42,3 %), while in 4 cases bone autogenous graft harvesting was performed. In 4 patients only dislocated bone fragment removal was performed [8–20]. Only one case of combined transnasal transorbital approach was described, and reconstruction was performed using fascia lata [14]. Conclusions were similar to those previously described (Table A) [1].

Regarding our experience, a total of 20 adult patients affected by orbital roof fractures were identified according to inclusion criteria (17 males and 3 females). Median age was 44,5 yrs (range:20–71) and main cause was road accident (65 % of cases). Details are reported in Table C.

In 75 % of cases patients (n = 15) were conscious at examination and 8 of them underwent surgery more than 48 h after trauma (40 % of cases). Early treatment (<12 h) was reserved to 6 pts because of ophthalmological or neurosurgical emergency (in one case neurosurgical procedure was performed at admission, but orbital roof reconstruction using custom-made titanium prosthesis was delayed). The most common associated fractures were frontal bone fractures, and main

Table A
Level of evidence and conclusion of studies.

Authors	Study year	LOE	Study design	Conclusions
Shah et al. [8]	2018	4	CR	Access to the orbital roof can make accurate edge-to-edge alignment of the fragments difficult and they can slip. Our simple simple three-pronged technique was easy to do and there was little morbidity
Klančnik et al. [9]	2018	4	CR	Penetrating orbitocranial wound is a life-threatening condition that demands interdisciplinary approach and treatment.
Liu et al. [10]	2020	4	CR	In this case, early diagnosis and proper globe repositioning with reconstruction of the orbital roof could allow recovery of vision, as well as prevention of intracranial infection.
Hwang et al. [11]	2020	4	CR	Through this case of blowout fracture of the orbital roof with an intact orbital rim, found after craniotomy, we should be aware of the possibility that an orbital roof fracture can be missed on conventional brain computed tomography.
Caras et al. [12]	2020	4	CR	Rapid reconstruction following massive cranial trauma in the presence of multiple ICHs can be effectively managed with good gross neurological outcome. The role and specific characteristics of orbital reconstruction to minimize focal neurological deficits in similarly complex trauma remain to be elucidated.
Pereira et al. [13]	2020	4	CR	It is preferable, and in most cases extremely necessary, that the surgical decompression and rigid internal fixation and/or surgical reconstruction could be performed first for later ophthalmic follow-up.
Pereira et al. [16]	2020	4	CR	Evan the meshes being easier to handle, it is important to evidence the possibilities of futures complications and the requirement to remove the biomaterial which can cause damage to brain tissue. Although, the autogenous bone graft it is the most predictable for orbital reconstruction as well as being the gold standard due to its osteogenic, osteoinductive and osteoconductive properties.
Lofrese et al. [21]	2020	4	CR	A wait-and- see approach could represent a reasonable safe and effective option, but at the condition of an aggressive clinical and radiological follow- up. A conservative strategy could help in avoiding precocious and sometimes unnecessary procedures, presumably granting time for the development of an advantageous intraorbital/ intracranial pressure gradient to trigger a spontaneous realignment of the displaced fragment.
Baviskar et al. [22]	2021	4	POS	The use of VSP in orbital fractures is feasible. The surgical jig facilitates precise, near-normal OV restoration as an inexpensive adjunct to routine ORIF. To achieve optimum results, tailor-made implants should be focused upon to enable structural OV reconstruction.

(*continued on next page*)

Table A (*continued*)

Authors	Study year	LOE	Study design	Conclusions
Gebran et al. [17]	2021	4	RCS	Most orbital roof fractures can be managed conservatively. Early fracture treatment is safe and may be beneficial in patients with vertical dysmotility, globe malposition, and/or a defect surface area larger than 4 cm [2]. Ophthalmologic prognosis is generally favorable; however, traumatic optic neuropathy is major cause of worse visual outcome in this population.
Dubey et al. [24]	2022	4	CR	Unique presentation of orbital roof fracture resulting in both superior oblique palsy and acquired Brown syndrome.
Mukit et al. [18]	2023	4	CR	This is the first reported penetrating globe injury from a vape pen explosion.
Park et al. [19]	2023	4	RCS	Globe indentation from blow-in fractures are rare. Clinicians should be suspicious in cases of high-velocity trauma to the superolateral orbit with hypoglobus, motility limitation, and indentation of the globe upon dilated exam. Prompt diagnosis and early surgical removal of the compressive orbital bone fragments in a multidisciplinary fashion can lead to good visual, functional, and cosmetic outcomes.
Jamali et al. [20]	2023	4	POS	Early definite management of displaced orbital roof fractures secures reliable functional and cosmetic results and reduces the incidences of intracranial and ocular complications.
Park et al. [23]	2023	4	CR	Conservative treatment can acquire the best outcome regarding cosmesis and function unless the patient requires an emergent operation for other medical conditions. This is key for successfully returning the patient's form and function.

LOE: Level of evidence; CR: Case report; POS: prospective observational study; RCS: Retrospective case series.

symptoms included periorbital hematoma and diplopia.

In one case, previously described, in which only exploration of orbital roof was performed, globe explosion was observed [2].

Coronal incision was performed in 14 cases, resulting the most used surgical approach; trans-lesional approach was used in 5 cases.

Endoscopic combined transorbital-transnasal approach was used in one case only in order to evaluate the presence of CSF leak and no reconstruction was performed.

Defect reconstruction (using implant or bone graft) was necessary in 13 cases, and titanium mesh was the most used graft material (7 pts, 54 % of cases). Bone graft was harvested from calvaria in one case, while in another one (Fig. 1) it was obtained from the inner part of frontal box. In the remaining cases only exposure and reduction without fixation was performed, eventually with bone fragment repositioning, while in 1 case heterogenous bone graft has led us to obtain good results (Fig. 2). No patients experienced encephalocele; only one (4,1 %) experienced late rhinoliquorrhea (3 months after surgery). Revision surgery was performed in one patient only on the 7th post-operative day; residual diplopia was observed in only one patient, but has to be related to strabismus consequent to cranial nerve damage.

Table B
Surgical approaches of studies.

Authors	N° pts	Ethiology	Surgical approach	Recontruction
Callahan et al. [15]	1	Gunshot	Upper blepharoplasty incision	Titanium mesh
Hwang et al. [11]	1	Precipitation	Coronal incision	Titanium mesh
Liu et al. [10]	1	Blunt body trauma	Coronal incision	Bone fragment reposition
Caras et al. [12]	1	assault	Coronal incision	Titanium plates
Pereira et al. [13]	1	Road accident	Coronal incision	Titanium mesh
Vedhapoodi et al. [14]	1	Road accident	Transorbital transnasal endoscopic approach	Fascia lata
Pereira et al. [16]	1	Road accident	Coronal approach	Bone graft
Mukit et al. [18]	1	Penetrating injury	Coronal approach	Bone graft
Park et al. [19]	3	1 Train 1 sport accident 1 assault	1 extended eyelid incision 1 brow laceration 1 brow laceration	Bone fragment removal (no reconstruction)
Gebran et al. [17]	8	4 road accident 2 fall 1 assault 1 gunshot	7 coronal approach 1 orbital, brow incision	4 titanium mesh 1 titanium plates 1 bone graft 1 temporalis muscle/fascia 1 no reconstruction
Klančnik et al. [9]	1	Penetrating injury	Coronal approach	Titanium plates
Shah et al. [8]	1	Falling masonry	Coronal approach	Bone graft
Jamali et al. [20]	5	Road accident	Coronal approach	Titanium mesh

4. Discussion

Indications for emergency repair of an orbital fracture are rare; immediate surgical repair is indicated when the oculocardiac reflex (bradycardia, nausea and vomiting, syncope, and potential asystole, that is commonly caused by entrapment of extraocular muscles) is present, or in case of fragment compressing the optic nerve, retrobulbar hematoma, eye perforation or in the presence of severe traumatic brain injury with clinical and radiographic signs of herniation [3,20]. Early surgical intervention (<48 h) is indicated in case of muscle entrapment and significant enophthalmos. In most cases, delayed treatment can be performed after observation (<2 weeks) [3]. Orbital roof is involved in 12–19 % of orbital wall fractures, and represents one of the main emergent features associate with orbital fractures [3,24]. They are usually related to adjacent trauma to the orbital rim but can occur from hydraulic forces within the cranial vault resulting in a "blow-in" fracture (Fig. 2) eventually leading to diplopia, globe malposition, cerebrospinal fluid (CSF) leak, rectus impingement, optic neuropathy [2,4]. Eventually, "blow-out" fractures of the orbital roof have been described (Fig. 1): in this case they are consequent to increased intraorbital pressure, when blunt forces to either the orbital rim or the globe itself push the orbital tissue posteriorly, as resulting in orbital bones breaking or buckling at their weakest point. As universally known, usually the posterior aspect of the orbital floor, medial to the infraorbital canal and the lamina papyracea of the ethmoid bone, are involved, but rare cases of displaced "blow-out" fractures of orbital roof are described, eventually with associated globe dislocation [7–9]. While for asymptomatic cases a conservative approach is indicated, in case of displaced symptomatic fractures early treatment is mandatory to prevent complications such as sight loss, encephalocele, meningitis, CSF leaks, diplopia and

Table C
Clinical data of patients treated a tour centers.

Sex	Age	Etiology	Associated fractures	Consciousness status at admission	symptoms	Time of surgery	Surgical approach	Reconstruction	Complications
F	30	Road accident	Le Fort II, fronto-temporo-parietal bone	unconscious	Rhinoliqorrea, exophtalmos	<48 h	Coronal approach	None, galea flap	None
M	30	Road accident	fronto-temporo-parietal bone	unconscious	Massive exophthalmos, Chemosis, Optic nerve compression	<12 h	Coronal approach	Heterologous bone, galea flap	None
M	43	Road accident	NOE, ACB (eye explosion), zygoma	conscious	Rinoliquorrea	<48 h	Coronal approach	None, galea flap	None
M	20	Road accident	NOE, frontal bone	conscious	Chemosis, diplopia	<48 h	Coronal approach	None, galea flap	None
M	71	Accidental fall	NOE, frontal bone	conscious	Periorbital hematoma	>48 h	Upper blepharoplasty incision	Titanium mesh	V1 deficit
M	24	Aggression	Frontal bone	conscious	Periorbital hematoma	>48 h	Coronal approach	None	None
M	53	Road accident	None	conscious	Periorbital hematoma, suspect CSF leack	<48 h	Combined endoscopic approach	None	None
M	48	Road accident	Frontal and malar bone	unconscious	Periorbital hematoma, CSF leack	<12 h	Coronal approach	Titanium mesh, galea flap	None
M	44	Road accident	Frontal bone, ACB	unconscious	Periorbital hematoma, CSF leack	<12 h	Coronal approach	Titanium mesh, galea flap	Rhinoliquorrea 3 months after surgery
M	36	Aggression	Frontal bone	conscious	Periorbital hematoma, diplopia	<48 h	Coronal approach	Titanium mesh, galea flap	None
M	49	Aggression	Fronto-orbital fracture, Fontal sinus, epidural hematoma	conscious	Periorbital hematoma, diplopia	<12 h	Coronal approach	Titanium mesh, galea flap	Diplopia
F	67	Accidental fall	Upper orbital margin	conscious	Periorbital hematoma	>48 h	Trans-laceration	Adsorbable dura substitute	None
M	45	Aggression	Frontal sinus, orbit	conscious	Diplopia	>48 h	Coronal approach	Autogenous bone	Minimal enophthalmos
M	33	Road accident	zygoma	conscious	Periorbital hematoma, diplopia	>48 h	Trans-laceration	Titanium mesh	None
M	60	Road accident	Upper orbital margin	conscious	Periorbital hematoma	>48 h	Trans-laceration	None	None
M	34	Aggression	Frontal bone, COMZ	conscious	Periorbital hematoma, III c.n. deficit	<12 h	Coronal approach	Bone repositioning, galea flap	Revision surgery (bone repositioning)
M	54	Road accident	fronto-temporo-parietal bone, Le Fort III, NOE, zigomatic arch,	unconscious	Rhinoliqorrea, esophtalmos, Periorbital hematoma	>48 h[a]	Coronal approach	Patient-Specific Titanium Mesh, galea flap	Endocranic Hypertension
F	35	Road accident	Le Fort II, frontal bone	conscious	Esophtalmos, Chemosis, Periorbital hematoma	<12 h	Coronal approach	Titanium Mesh, galea flap	None
M	68	Road accident	Frontal-temporal Bone, COMZ, Le Fort II	conscious	Chemosis, Periorbital hematoma	<48 h	Coronal approach	Galea flap	None
M	45	Road Accident	Frontal Bone	conscious	Chemosis, Periorbital hematoma	<24 h	Trans-laceration	Adsorbable dura substitute	None

[a] Patient underwent decompressive craniectomy <12 h after admission, and orbital floor reconstruction was delayed.

enophthalmos/exophthalmos [1,17,20,23,26]. On the basis of their experience with 225 cases of orbital roof fractures, Gebran et al. found that surgical indication is not so strictly related to the presence of blow-in or blow-out fracture or to the extent of frontal bone fractures, instead an orbital wall defect size larger than 4 cm^2, acute vertical dysmotility, and globe malposition best determines treatment recommendations [17]. Most controversies obviously arise in "borderline" cases, in presence of evident displaced fractures with or without minimal symptoms. As previously described, a "spontaneous" reduction of the fracture (related to the resolution of edema and/or hematoma) can be sometimes observed, so that a wait-and-see approach with a strict clinical and radiological follow-up could represent a reasonable safe and effective option [21,23]. On the base of this assumption, in the case described in Fig. 2 we decided not to fix the heterologous bone graft, since it was considered large enough to cover the entire defect and the reduction of intraorbital edema and tissue expansion would be sufficient to maintain it in the correct position.

Orbital roof fractures are associated to an increased risk of concomitant ocular injuries, that varies from 20 to 34 % [27]; fortunately, traumatic optic neuropathy (damage to the optic nerve secondary to trauma that may occur primarily or secondarily to the initial insult) is a rare sequalae of blunt and penetrating craniofacial trauma, with an incidence of 2–5 % (even if Gebran et al. reported an incidence of 12,4 %), while open globe rate varies from 4 to 9 % [17,25,28]. In general, long-term visual deficit is reported from 0,32 to 10,3 % of cases [17]. Diplopia and deficit of ocular movement are related to rectus muscle entrapment or compression, or consequent to fracture involving the site of the troclea that can cause both direct damage to the muscle and superior oblique palsy [24]. Nevertheless, ophthalmologic evaluation is challenging since a significant number of patients are intubated

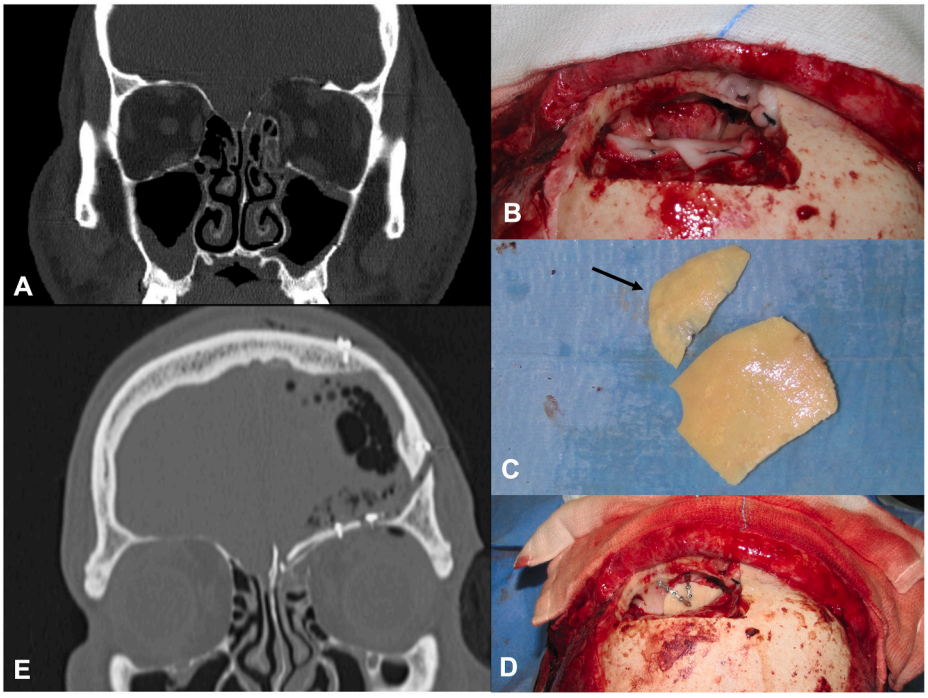

Fig. 1. 45 years-old male, after aggression reported a "blow-out" orbital roof fracture associated with anterior and posterior frontal sinus wall fracture resulting in diplopia. A) pre-operative CT-scan, coronal view; B) intraoperative view showing the defect; C) intraoperative view of the posterior wall of the frontal sinus harvested from the frontal box (black arrow); D) bone graft fixation using titanium miniplates; E) post-operative CT-scan, coronal view, after orbital roof reconstruction, frontal sinus cranialization with galea flap (Policlinico Umberto I, Roma).

Fig. 2. 30-years-old male, road accident victim, with a complex dislocated fronto-parietal-orbito-maxillo-malar fracture with a blow-in fracture as confirmed by 3D CT scan (A–B) resulting in important exophthalmos and rhinoliquorrhea (C–D). Surgical interventation was performed <12 h after trauma through coronal approach. Reduction and fixation of craniofacial fractures was performed (E) and a galea flap was performed to reconstruct ACB, while a heterologous bone graft was used to restore orbital roof after bone fragment removal as illustrated in post-operative CT scan-sagittal view (F) (S.M. Goretti Hospital, Latina).

and sedated at the time of consultation. The exact incidence of orbital encephaloceles is not easy to identify, since they are documented almost exclusively in isolated case reports [29]. When surgical intervention is indicated, there are several surgical approaches and reconstruction options available to the surgeon: classically, a coronal incision and frontal craniotomy is performed in case of intracranial injuries or associated extensive frontal bone fractures, while a subcranial approach through a superior blepharoplasty incision is appropriate in other cases, in order to reduce complications such as long scars, and probably, extensive alopecia, and sensory skin deficits. Other periorbital transcutaneous incisions such as gull wing, open sky (H-shaped), butterfly, and Lynch incisions usually residuate in large, central scars/defects significantly affecting patient's quality of life [17,30]. Main contraindications to superior blepharoplasty incision are obviously the presence of complex and severely dislocated fractures [30]. In addition, the concept of minimal access multiportal endoscopic surgery is rapidly evolving in managing complex skull base lesions, leading to satisfactory results [14,31]. In these cases, fascia lata represents an optimal material to repair tissue defect with negligible donor site morbidity, but in case of large orbital defects it is not sufficient to prevent encephalocele [14,32]. It is universally known that endonasal repair of CSF leaks has gained significance in last years, but the endoscopic endonasal corridor used alone has limited access to far lateral supraorbital defects of the anterior cranial fossa (ACF) alone. On the other side, the superior transorbital portal gives access to the lateral frontal sinus lesions, superior and posterior orbital lesions, and ACF CSF leaks, so that the combination of these two accesses seems to lead to satisfactory results [14,31]. Nevertheless using those accesses it is possible to reconstruct only limited defects, since only available graft materials include fascia lata, middle turbinate mucosa, and septal mucosa. Transorbital neuroendoscopic surgery (TONES) is useful to remove fracture fragments of the orbital roof which are impinging on the superior rectus muscle, while transnasal corridor can be used to visualize the medial margin of the defect, delineating the entire dural and bony defect [14]. In our experience, endoscopic approach was used in one case of isolated orbital roof fracture to exclude CSF leak using a combined transorbital-transnasal corridor: in this occasion no reconstruction was required.

After fracture reduction, if necessary autologous bone grafts, titanium mesh, or alloplastic materials such as polytetrafluoroethylene have been shown to provide successful stabilization or reconstruction (Table B) [8–20]. Obviously, autogenous bone graft represents an optimal choice, and parietal bone graft can easily be harvested through coronal approach [6]. On the other side, it leads to increased surgical time and eventual aesthetic sequelae in bald patients. For example, an alternative to overcome the increased surgical time and complications could be the use of autogenous bone harvested from the frontal box (Fig. 1), but it could obviously be performed only in those cases requiring a combined craniofacial approach [29]. Heterologous bone grafts have been widely used in maxillo-facial surgery, and their use in the reconstruction of orbital floor defect is consolidated [2,33–35]. Nevertheless, at our knowledge it hasn't been previously described for orbital roof reconstruction: in one case (Fig. 2) we used this material achieving a satisfactory result. We decided to not fixate the implant, and no residual exo/enophthalmos or diplopia were observed, since, as observed, in dislocated fractures the reduction of intraorbital pressure due to edema leads to graft's correct alignment [21,23]. In other cases titanium mesh has been demonstrated to be the most used graft material.

As of today neuronavigation, intraoperative imaging, custom-made implants use, and virtual surgical planning (VSP) are demonstrated to have advantages in maxillo-facial and orbital surgery [35–38]. In particular, the use of VSP in orbital fractures has demonstrated to be feasible, since the use of surgical jig to obtain intraoperatively tailor-made implants facilitates precise, near-normal OV restoration as an inexpensive adjunct to routine ORIF [22]. In our experience, we report the case of a patient with complex facial fractures: their treatment had to be delayed in order to stabilize the patient, so that it was possible to use a custom-made prosthesis.

5. Conclusions

Even if most orbital roof fractures can benefit of a conservative approach, early treatment (<48 h) has to be considered in those patients experiencing massive enophthalmos and ocular movement impairment, while emergency treatment has to be reserved in case of optic nerve compression or neurosurgical complications. Coronal incision is the approach of choice if intracranial injuries/frontal bone fractures are present or in case of extensive CSF leak in complex fractures, while in other cases upper eyelid blepharoplasty incision can safely be performed. Endoscopic combined approach is useful in case of smaller defects, but obviously the technique has a steep learning curve. As of today heterologous bone graft represents a potential alternative to titanium mesh, while, when possible, the autologous bone graft should be harvested from the frontal box in order to reduce operative time and potential complications. Since most fractures can undergo delayed treatment, VSP and the use of custom-made prosthesis can be considered in complex orbital roof fractures to improve results and to reduce surgical time.

Consent to participate

Informed consent was not obtained as most of these subjects would likely not be locatable or contactable following their discharge, and data was de-identified during the collection process.

Consent to publish

Informed consent was not obtained as most of these subjects would likely not be locatable or contactable following their discharge, and data was de-identified during the collection process.

Data availability standards

Data cannot be shared for confidentiality reasons. Queries about the data should be directed to the corresponding author.

Compliance with ethical standards

The study is HIPAA compliant and adheres to the ethical principles as outlined in the Declaration of Helsinki as amended in 2013.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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