CASE REPORT

Orbital reconstruction in an adolescent using autologous bone grafting and three-dimensional virtual planning: a case report

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ABSTRACT

Background: Orbital fractures in the pediatric population have particular characteristics that distinguish them from those in adults, both in clinical presentation and management. Treatment may consist of observation or surgical management, usually during the acute phase; however, management of sequelae represents a clinical challenge.
Case description: An 11-year-old female patient presented with limited adduction of the right eye and enophthalmos, with a history of untreated facial trauma 9 years earlier. Orbital floor reconstruction was performed using an autologous calvarial bone graft. Preoperative planning was performed using three-dimensional virtual modeling, which allowed estimation of the bone graft dimensions as 15 × 18 mm and enabled three-dimensional printing of the orbital region. The procedure aimed to correct enophthalmos and improve aesthetics, resulting in favorable clinical and aesthetic outcomes.
Conclusions: Management of orbital trauma sequelae is challenging, especially in growing patients, in whom resorbable materials should be prioritized, although these are not always available. In this case, the use of an autologous bone graft, combined with three-dimensional virtual planning, represented an accessible reconstructive alternative with satisfactory clinical outcomes.

Keywords: Enophthalmos; Fractures, Bone; Orbit; Bone Transplantation (Source: MeSH)

Reconstrucción de órbita en adolescente mediante injerto óseo autólogo y Planificación virtual tridimensional: reporte de caso

RESUMEN

Antecedentes: Las fracturas orbitarias en la población pediátrica presentan características particulares que las diferencian de la población adulta, tanto en su presentación clínica como en su manejo. El tratamiento puede consistir en observación o manejo quirúrgico, generalmente en la fase aguda; sin embargo, el tratamiento de sus secuelas representa un desafío clínico.
Descripción del caso: Paciente femenina de 11 años con limitación de la aducción del ojo derecho y enoftalmos, con antecedente de trauma facial no tratado ocurrido 9 años antes. Se realizó reconstrucción del piso orbitario mediante injerto óseo autólogo de calota craneal. La planificación preoperatoria se efectuó mediante modelado virtual tridimensional, lo que permitió estimar las dimensiones del injerto óseo en 15 × 18 mm y realizar la impresión tridimensional de la región orbitaria. El procedimiento tuvo como objetivo corregir el enoftalmos y mejorar la estética, obteniéndose resultados clínicos y estéticos favorables.
Conclusiones: El tratamiento de las secuelas del trauma orbitario constituye un reto, especialmente en pacientes en crecimiento, en quienes debe priorizarse el uso de materiales reabsorbibles, no siempre disponibles. En este caso, el uso de injerto óseo autólogo asociado a planificación virtual tridimensional representó una alternativa reconstructiva accesible, con resultados clínicos satisfactorios.

Palabras clave: Enoftalmia; Fracturas Óseas; Órbita; Trasplante Óseo (Fuente: DeCS)

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INTRODUCTION

Orbital fractures in the pediatric population have characteristics that distinguish them from those in adults (1), both in clinical presentation and treatment. The immaturity of the pediatric skeleton partially protects it from this type of fracture because of the greater proportion of cancellous bone, greater bone elasticity, and the persistence of cartilage at the sutures, which allows the child's skeleton to withstand higher-energy trauma without necessarily causing a fracture (1,2). Orbital fractures in the pediatric population account for 20–30% of all facial fractures (3). Symptoms vary according to patient age (4).

In very young patients, assessment of diplopia and limited ocular movements may be difficult. In these cases, the main symptom is usually enophthalmos, which is not always present at the time of trauma. Some series report that up to 25% of patients present with this condition (5).

Treatment may consist of observation or surgery, depending on the patient's symptoms and computed tomography findings (6). In the pediatric population, selection of reconstructive material should consider facial growth, orbital support stability, biocompatibility, and defect characteristics. The alternatives described include resorbable materials, alloplastic materials, and autologous grafts, and the choice should be individualized according to the case and resource availability (7).

It is important to note that findings in patients with recent facial trauma differ from those in patients with posttraumatic sequelae. In the acute setting, treatment consists of repositioning the bone tissue and ensuring its consolidation with osteosynthesis material; by contrast, in sequelae, there is no fracture requiring open reduction, but rather bone that has consolidated in an abnormal position.

This report describes the case of a patient with sequelae of a right orbital floor fracture, resulting in increased orbital volume and visual disturbances. This clinical scenario is uncommon; most sequelae are managed in adulthood, when personalized prosthetic options can be placed once facial skeleton growth is complete.

This case presents an alternative for orbital reconstruction in growing pediatric patients using an autologous bone graft and three-dimensional virtual planning, highlighting its potential usefulness as an accessible technique in settings where resorbable materials are not readily available.

The presentation of this case was authorized by the patient's mother through signed informed consent.

CASE DESCRIPTION

We describe the case of an 11-year-old female patient referred from Piura to a national referral pediatric institute in Lima because of strabismus and visual disturbance. The patient was initially evaluated by the Ophthalmology Service, where physical examination revealed limited adduction of the right eye and enophthalmos, associated with a history of untreated facial trauma 9 years earlier. Evaluation by the Head and Neck and Maxillofacial Surgery Service confirmed significant enophthalmos of the right eye, as well as limited ocular globe movement.

Computed tomography of the orbits with three-dimensional (3D) reconstruction (Figure 1) showed asymmetry at the level of the right orbital floor compared with the healthy contralateral side. Given the time elapsed since the facial trauma, no fracture line could be identified because the bone had consolidated in malposition; however, the right orbit had a greater volume than the contralateral side, which explained the enophthalmos.

Because the patient met the criteria for orbital floor reconstruction, the procedure was proposed using autologous material, and a calvarial bone graft was selected. Preoperative planning was performed using three-dimensional virtual planning to calculate the graft dimensions required to achieve the proposed objectives.

During this stage, it was determined that the orbital floor was 7 mm below its normal position, with the depression beginning 15 mm posterior to the orbital rim. Based on these findings, harvesting of a 15 × 18 mm graft was planned, corresponding to 15 mm anteroposteriorly and 18 mm mediolaterally.

Segmentation of the tomographic images was performed using 3D Slicer software. Subsequently, Blender software was used for 3D design, and the Ultimaker S3 3D printer was used to fabricate the anatomical model of the orbital region, thereby allowing verification of the appropriate graft position before the surgical procedure (Figure 2).

The graft was preadapted to the 3D anatomical model. During the surgical procedure, a transconjunctival approach was used (Figure 3), allowing exposure of the orbital floor region and confirmation of the tomographic findings. No fracture line could be identified. The tissues in the area were released, and the calvarial bone graft was harvested through an incision in the right parietal region.

Once placed in the surgical bed, it was fixed with an L-shaped plate at the level of the orbital rim. Before closure, a forced duction test was performed, and adequate ocular globe mobility was verified.

The patient had no postoperative complications. Eyelid edema was mild, and the scalp incision was imperceptible. During inpatient recovery, the Ophthalmology team evaluated the patient and, because there was no evidence of diplopia or altered ocular movements, determined that she could continue evaluation for strabismus surgery.

A follow-up computed tomography scan performed at 2 months confirmed the correct position and size of the graft (Figure 1). The patient continued follow-up with the Head and Neck and Maxillofacial Surgery team.

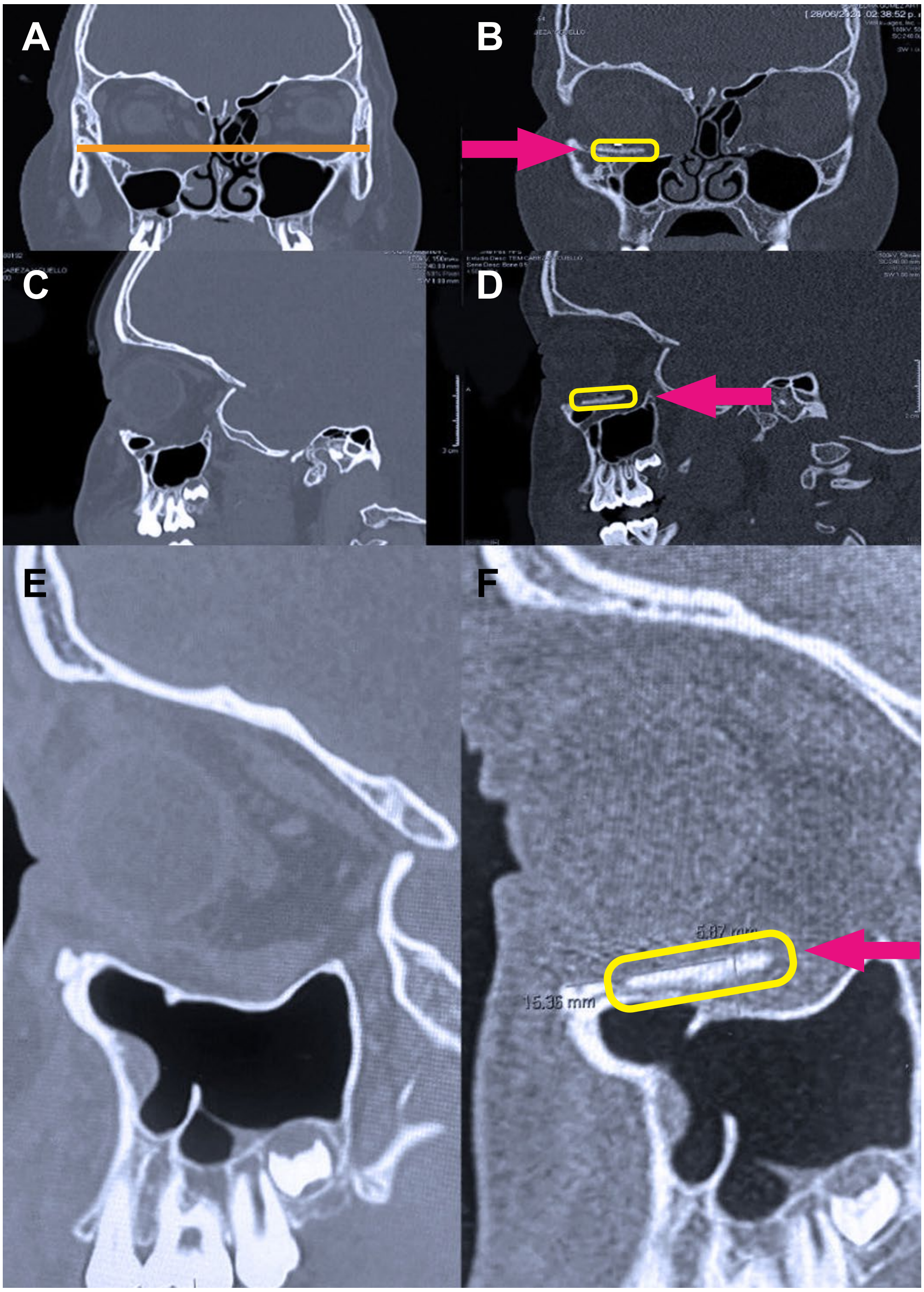

Figure 1. Computed tomography of the orbits in coronal (A, B) and sagittal (C–F) sections

The preoperative images (A, C, and E) show the right orbital floor defect and the height difference relative to the contralateral orbit. The postoperative images (B, D, and F) show orbital floor reconstruction and adequate positioning of the autologous bone graft. In the preoperative coronal section (A), the horizontal line indicates the height difference of the right orbital floor relative to the contralateral side. In the postoperative images, the blue arrows and red ovals indicate the location of the bone graft. According to preoperative planning, the graft measured 15 × 18 mm, corresponding to 15 mm anteroposteriorly and 18 mm mediolaterally. In the postoperative sagittal section (F), the measurement of 5.87 mm corresponds to the height of the reconstructed orbital floor.

Figure 2. Patient-specific anatomical model, 3D printed and used during the surgical procedure to verify graft position

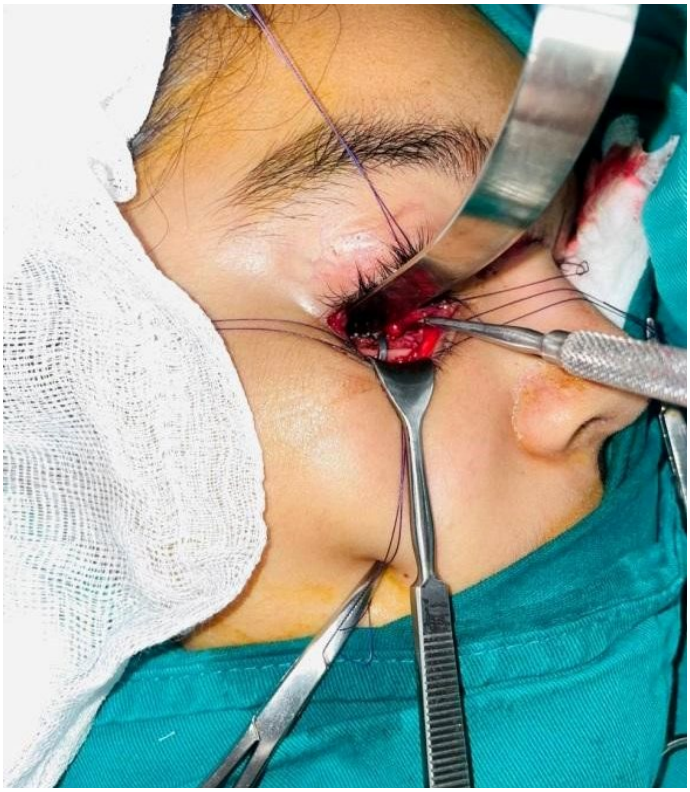

Figure 3. Bone graft placed and fixed to the orbital floor through a transconjunctival approach

DISCUSSION

This report describes the case of a patient with sequelae of a right orbital floor fracture, treated with orbital floor reconstruction using an autologous bone graft supported by three-dimensional virtual planning and a 3D-printed anatomical model.

Pediatric patients with sequelae of orbital trauma are uncommon. In these cases, when planning reconstruction, it should be considered that the patient is still growing, and therefore, the material used should not interfere with this process. Treatment of orbital fractures in pediatric patients represents a surgical challenge, from the initial decision between observation and surgical treatment to the selection of the material for reconstruction.

In a retrospective cohort of pediatric patients with orbital fractures, Boniao et al. (8) reported that 65% required surgical intervention, with indications such as orbital tissue entrapment with diplopia, vasovagal response, or enophthalmos. They also reported frequent use of bioresorbable implants among patients who underwent surgery, reflecting the importance of selecting appropriate materials for the pediatric population. Unlike the cases described in that cohort, the present case corresponded to a late sequela of untreated orbital trauma, with the main surgical indication being significant enophthalmos secondary to increased right orbital volume. Therefore, orbital floor reconstruction with an autologous bone graft was selected, considering local resource availability and the characteristics of the defect. This alternative made it possible to use the patient's own tissue with potential integration into the orbital skeleton; however, possible donor-site morbidity, partial resorption or loss of graft support, and the need for long-term follow-up should be considered (7).

The presence of posttraumatic sequelae adds complexity to the approach, which limits the number of similar case reports. In pediatric and adolescent patients with orbital blowout fractures, Koryczan et al. (9) reported that enophthalmos was present in 66% of cases. Likewise, when analyzing enophthalmos values by fracture location, the authors found that values were higher in orbital floor fractures, which is consistent with the location of the sequela observed in the patient.

In this context, Ahn et al. (10) published a study of patients with late enophthalmos in which they calculated orbital volume using computed tomography and estimated that each 1-cm^3 increase in orbital volume is associated with approximately 0.9 mm of enophthalmos. This relationship is useful because, in patients with limited clinical evaluation, tomographic assessment allows assessment of the need for corrective surgery when an orbital volume difference greater than 1 cm^3 is identified. In the present case, computed tomography showed increased right orbital volume and absence of a fracture line, which guided the diagnosis of posttraumatic sequela and facilitated surgical planning.

Surgery to correct enophthalmos entails risks and possible complications. In a pediatric series of surgical treatment of enophthalmos due to pure blowout fracture, Koryczan et al. (11) reported infrequent complications such as suppuration, hematoma, and dural exposure. Gerber et al. (12), in turn, described postoperative functional outcomes in children with orbital floor fractures, including diplopia, restricted ocular movements, enophthalmos, and paresthesia. Therefore, the selection of reconstructive material is a central aspect of surgical planning. A recent systematic review of reconstructive materials in pediatric orbital fractures identified that the most commonly used materials were polymers, alloplastic materials, and autologous grafts (7). In that review, autologous grafts showed lower reported rates of early diplopia (<2 weeks after surgery), late diplopia, and restriction of extraocular movements; however, they showed a higher frequency of postoperative enophthalmos (8.4%) compared with alloplastic and polymeric materials (0% and 3.6%, respectively). In settings where autologous bone grafting is an available and appropriate alternative, postoperative enophthalmos should be considered a possible clinical outcome because it may cause visual disturbances and aesthetic deformity, which is especially relevant during adolescence.

In delayed surgery, clinical findings may be more evident; however, the reconstructive approach may be more complex due to abnormal bone consolidation, adhesion formation, and scar fibrosis. From a radiologic standpoint, a fracture is no longer identified as such; instead, an orbit with increased volume is observed, which results in an inadequate position of the ocular globe. Although the available evidence is limited, Yalcin et al. reported functional improvement in patients who underwent delayed orbital floor reconstruction using autologous grafts, suggesting that this approach may be useful in selected cases of posttraumatic sequelae (13).

Technological tools are currently available that allow more precise preoperative planning. Virtual planning and 3D printing complement conventional tomographic evaluation by enabling a better understanding of defect morphology and facilitating adaptation of the reconstructive material before surgery.

Ahmed et al. (14) used virtual planning and 3D printing to adapt a calvarial graft to the orbital floor defect before placement. In their series, the authors reported the absence of postoperative enophthalmos or diplopia and comparable orbital volumes between the reconstructed and healthy orbits; therefore, they considered this strategy promising. Ferretti et al. (15) used virtual surgical planning and 3D printing to guide bone repositioning in a case of posttraumatic enophthalmos; the authors reported aesthetic and functional improvement, preservation of ocular movements, and absence of diplopia, and concluded that combining these tools may improve treatment of posttraumatic enophthalmos. In the present case, three-dimensional virtual planning and 3D printing allowed visualization of the defect, estimation of the dimensions of the autologous calvarial bone graft, and verification of its adaptation before the surgical procedure.

Having an exact reference for the desired dimensions is essential because, in the orbit, every millimeter is key to achieving both functional and aesthetic outcomes. The use of anatomical models obtained by 3D printing allows the structural defect to be observed from multiple angles, offering a virtual representation that provides the surgeon with visual insight before surgery. This facilitates preoperative planning, estimation of defect dimensions, and the possibility of making adjustments before surgery (16).

The outcomes were satisfactory and are consistent with other reports, such as that by Vega Lagos et al. (17), who also used bone grafts in patients with enophthalmos. However, unlike that report, the usefulness of virtual planning used in the present case is emphasized.

The objective of surgery, in addition to correcting enophthalmos, is to achieve aesthetic improvement. In pediatric and adolescent patients, facial asymmetries may affect body image perception. In this regard, it is important to consider patient and family satisfaction with the final surgical outcome. In the present case, the patient and her family reported satisfaction with the outcomes achieved after surgery.

This case report has limitations, including the short follow-up period, limited availability of objective pre- and postoperative ophthalmologic measurements, and lack of medium- and long-term functional ophthalmologic follow-up. In particular, complete records of pre- and postoperative visual acuity, Hertel exophthalmometry, objective measurement of strabismus, intraocular pressure, fundus examination, detailed assessment of diplopia, or sufficient documentation to objectively establish whether the eye had low vision or poor visual potential were not available. Pre- and postoperative volumetric measurements of both orbits were also not performed. In addition, because this is a case report, the results cannot be generalized or directly compared with other reconstructive materials or surgical planning methods. It should also be considered that the patient was deemed a candidate for subsequent strabismus surgery. Therefore, the final functional outcomes will depend on ophthalmologic evolution and any complementary management that may be required.

Because the patient is still growing, medium- and long-term clinical, ophthalmologic, and imaging follow-up is necessary to evaluate reconstruction stability, ocular globe position, and changes associated with growth and orbital bone remodeling, as described in pediatric patients after surgical correction of orbital fractures (18).

CONCLUSION

This report describes the case of an 11-year-old patient who presented with enophthalmos secondary to an orbital floor fracture and was treated with reconstruction using an autologous bone graft. This case shows the feasibility of orbital floor reconstruction in growing pediatric patients using an autologous graft and three-dimensional virtual planning, with satisfactory outcomes.

In the context of the Peruvian health system, where resorbable materials for treating pediatric orbital trauma are not always available, this case demonstrates that orbital floor reconstruction with autologous tissue is feasible and could represent an accessible alternative for pediatric patients.

When there is uncertainty regarding the need for surgery for orbital fractures, whether early or late, timely referral to a specialist should be considered, as a shorter interval between the event and reconstruction may be associated with better outcomes.

Author contributions

ESG: Conceptualization, Data curation, Writing – review and editing. JCA: Methodology, Data curation. RUQ: Investigation. All authors approved the final version of the manuscript.

Conflicts of interest

The authors have no relevant financial or nonfinancial interests to disclose.

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Data availability

The data supporting the findings of this report are available upon request from the corresponding author.

Ethical considerations

Written informed consent for publication of this case report was obtained from the patient's mother.

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