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Case Report

Maxillary rehabilitation after zygomatic implant sequelae using custom subperiosteal implants: A case study

Frederico Rodger Gomes Rodrigues Cardoso[a], Ricardo Grillo[a,b,*]

[a] Department of Oral and Maxillofacial Surgery, Faculdade Patos de Minas, Brasília-DF, Brazil
[b] Oral and Maxillofacial Surgery Training Program, Foundation of Dentistry - Fundecto, University of São Paulo, São Paulo-SP, Brazil

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ABSTRACT

Despite technological advancements, maxillary rehabilitation remains a significant challenge in Oral and Maxillofacial Surgery. This paper presents the case of a patient who underwent multiple previous procedures for prosthetic rehabilitation without achieving the desired results. The most recent intervention, which resulted in some sequelae, involved the placement of bilateral zygomatic implants. After unsuccessful attempts to maintain these implants, the decision was made to remove them and place a custom subperiosteal implant, produced via additive manufacturing. The patient has now been successfully rehabilitated with these implants for over a year, with no complaints and a notable improvement in her quality of life. The rehabilitation of severely atrophic maxillae using custom subperiosteal implants has proven to be an excellent alternative, offering predictability, the possibility of virtual planning and simulation, and the ability to rehabilitate extensive bone defects.

1. Introduction

Rehabilitating patients with extensive scars, anatomical defects, or sequelae from oncological treatments [1], poses additional challenges, requiring highly personalized and innovative approaches to ensure both functionality and aesthetics [2]. The development of modern implants and the subsequent evolution of implant dentistry have been particularly beneficial in addressing these complex cases. Technological advances in recent decades have further transformed implant dentistry, introducing tools such as virtual planning, 3D printing, and additive manufacturing [3,4]. These innovations allow for increasingly precise and individualized solutions, optimizing surgical planning and improving treatment outcomes. The use of more biocompatible biomaterials and less invasive techniques has expanded the possibilities for successful oral rehabilitation, even in the most challenging cases [5]. Additionally, new materials, in addition to the well-established titanium, offer new opportunities for aesthetic and functional restorations [6,7].

The culmination of these advancements has led to the development of custom subperiosteal implants, fabricated through additive processes [8]. These implants, particularly indicated for patients with severe bone atrophy, provide effective rehabilitation while avoiding the need for more invasive procedures, such as extensive bone grafts [9,10]. By eliminating the reliance on traditional bone grafting techniques, graftless options streamline the surgical process and enhance patient recovery. The ability to produce customized implants tailored to each patient's specific anatomy represents a significant revolution in maxillary rehabilitation.

The objective of this paper is to present the case of a patient who, after multiple unsuccessful procedures, was successfully rehabilitated using custom subperiosteal implants fabricated through additive manufacturing. The positive outcomes and patient experience highlight the importance of this technology as a viable and effective alternative in complex rehabilitation cases.

2. Case report

This case report was conducted in accordance with the CARE (CAse REport) guideline [11]. It describes a female patient with a history of multiple interventions for maxillary rehabilitation, who underwent the removal of zygomatic implants and the placement of a custom subperiosteal implant, manufactured through additive processes, in a single surgical procedure.

2.1. Clinical history

The patient is a 62-year-old female smoker with no comorbidities. She reported early tooth loss following a car accident over 25 years ago. During this time, she underwent multiple denture-supported, mucosa-supported, and implant-supported prosthetic rehabilitations. She expressed concerns about significant bone loss after the

* Corresponding author.
E-mail address: doutorgrillo@uol.com.br (R. Grillo).

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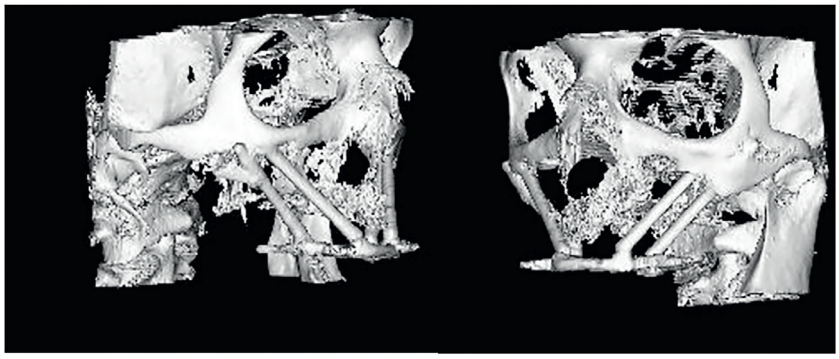

Fig. 1. Three-dimensional tomographic reconstruction showing extensive bone resorption in the maxillo-zygomatic region.

age of 40, which was accompanied by considerable discomfort. Five years ago, during a consultation with a maxillofacial surgeon, she was presented with treatment options that included autogenous bone grafting in the maxillary region (iliac crest) or the alternative use of zygomatic implants. The patient opted for the placement of four zygomatic implants anchored to the zygomatic bone. The surgery was uneventful, though she reported significant postoperative discomfort.

Initially, she was rehabilitated with bilateral zygomatic implants due to severe maxillary bone atrophy. However, chronic inflammation and recurrent infections occurred, leading to implant instability (Fig. 1). Given the failure to control peri-implantitis and associated complications, the patient was advised to undergo implant removal (Fig. 2). Initially, she was apprehensive and resistant to the proposed treatment. After further consultations, the removal of the zygomatic implants and the placement of custom subperiosteal implants were suggested. The possibility of completing the rehabilitation in the same surgical session reassured the patient. In alignment with her expectations, it was decided to remove the zygomatic implants and place a custom subperiosteal implant, designed based on her CT scans and manufactured through additive titanium fabrication. Preoperative imaging and surgical risk assessments were conducted.

A computed tomography (CT) scan was sent for virtual planning and simulation for implant sintering according to fabrication orientation (1mm slice thickness, 250 mm FOV) without radiological guide. CAD/CAM planning was performed using 3-matic® software (Materialise, Leuven, Belgium) (Fig. 3). The implants used were from the Customlife® brand (CPMH, Brasília, Brazil). Once the surgery was scheduled, the implant and prosthetic bar were sintered in titanium grade 4 ($TiAl_6V_4$). Mini-pillar prosthetic connections were crafted. A single implant was chosen for fabrication, despite the increased surgical difficulty, due to the potential for greater long-term stability. In addition to the implants and total prosthesis, the manufacturer provided an osteotomy and drilling guide to ensure precise implant placement.

2.2. Surgical protocol

The surgery was performed under general anesthesia due to dental anxiety and psychological trauma from multiple previous procedures. A vestibular intraoral approach was used, starting from the left to the right first molars. Soft tissue detachment was challenging due to multiple previous procedures. The zygomatic implants were carefully removed to minimize trauma to the adjacent tissues. At the time of removal, the implants were already exposed, with no remaining bone coverage (Fig. 4). The manual key for implant removal was kindly provided by the surgeon who originally placed them, significantly facilitating this surgical step.

Fig. 2. Intraoral exposure of zygomatic implants in semi-profile, highlighting the level of peri-implantitis, despite all hygiene measures being strictly followed.

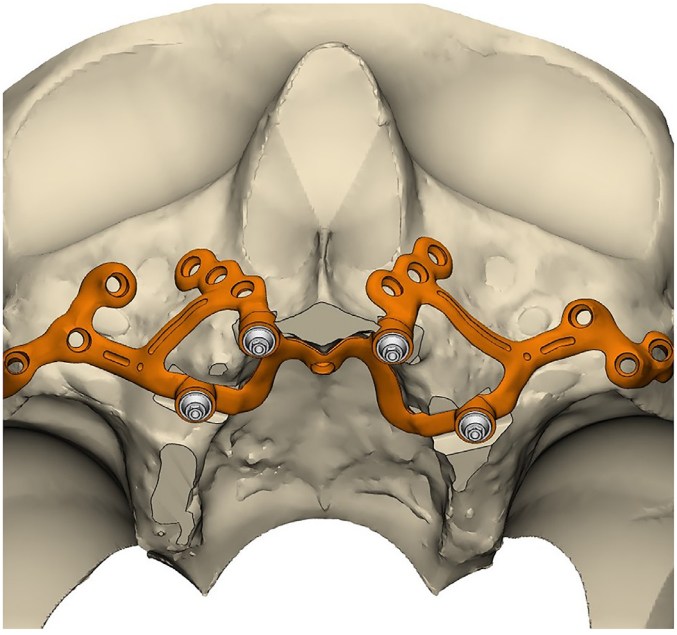

Fig. 3. Virtual planning of the Customlife in an inferior-superior view, where the prosthetic pillars (light gray) can be observed.

Immediately after the removal, the bone ridge was regularized using piezosurgery to eliminate irregularities (Fig. 5). The osteotomy for flattening and creating the support gaps for the implants was performed as planned virtually. Osteotomy, cutting, and positioning guides were utilized to ensure maximum accuracy in implant placement. The custom subperiosteal implant was then placed and fixed directly to the maxillary bone surface with titanium screws, ensuring stability and a precise fit, as determined through virtual planning (Fig. 6). Bone graft was used in specific areas where zygomatic implants removal was more difficult.

2.3. Complications and management

Approximately two weeks after the initial procedure, the patient experienced partial exposure of the subperiosteal implant in a specific area of the maxilla, resulting in a difficult-to-manage complication. To address this issue, a secondary surgical intervention was performed to cover the exposed implant. Under local anesthesia, an intraoral approach was utilized over the exposed area with posterior extension. Careful detachment was carried out, with the primary goal of accessing Bichat's fat pad. The fat was delicately detached from its position without complete removal. Once sufficient elasticity was achieved to cover the entire exposed area, it was stabilized using absorbable sutures (polyglactin) and non-absorbable sutures (nylon). During this procedure, Bichat's fat pad, along with a connective tissue graft, was used to cover the exposed area and promote soft tissue healing (Fig. 7). Fifteen days after total healing, prosthetic rehabilitation was performed.

2.4. Follow-up

Postoperative follow-up included regular consultations to monitor tissue healing and implant integrity. The patient was advised to maintain strict oral hygiene (Fig. 8). After 18 months of follow-up, there were no signs of recurrent implant exposure or other complications. The patient reported a significant improvement in both functionality and quality of life (Fig. 9).

3. Discussion

This paper aims to describe the successful rehabilitation of a patient who underwent several unsuccessful procedures prior to receiving custom subperiosteal implants made through additive manufacturing. The positive results and the patient's experience underscore the significance of this technology as an effective alternative for complex rehabilitation cases.

The data gathered from the literature review indicate a gradual increase in the number of publications on custom subperiosteal

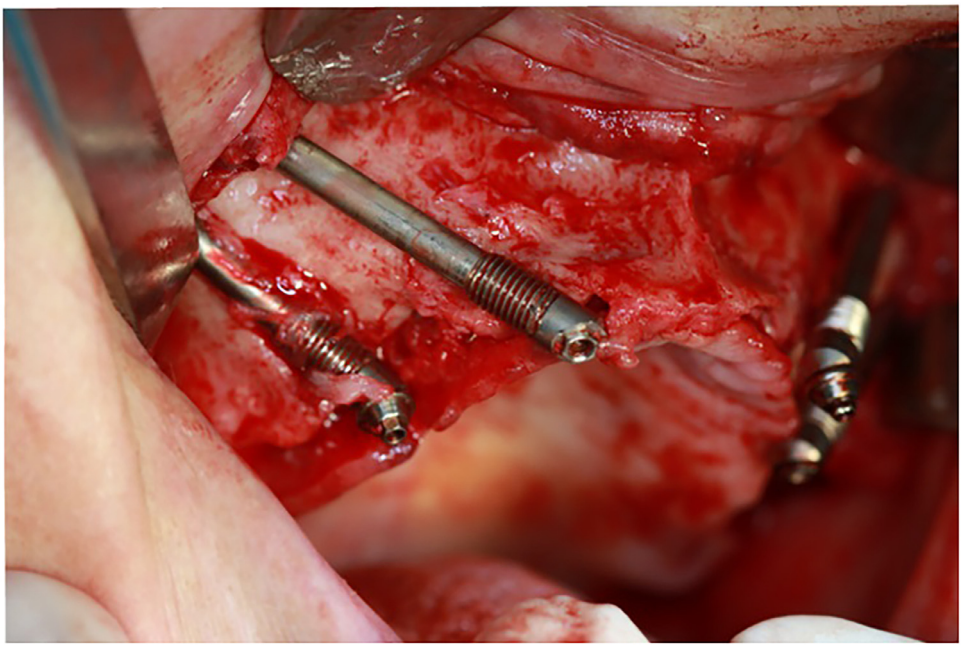

Fig. 4. Surgical view of anterior zygomatic implants and bone resorption.

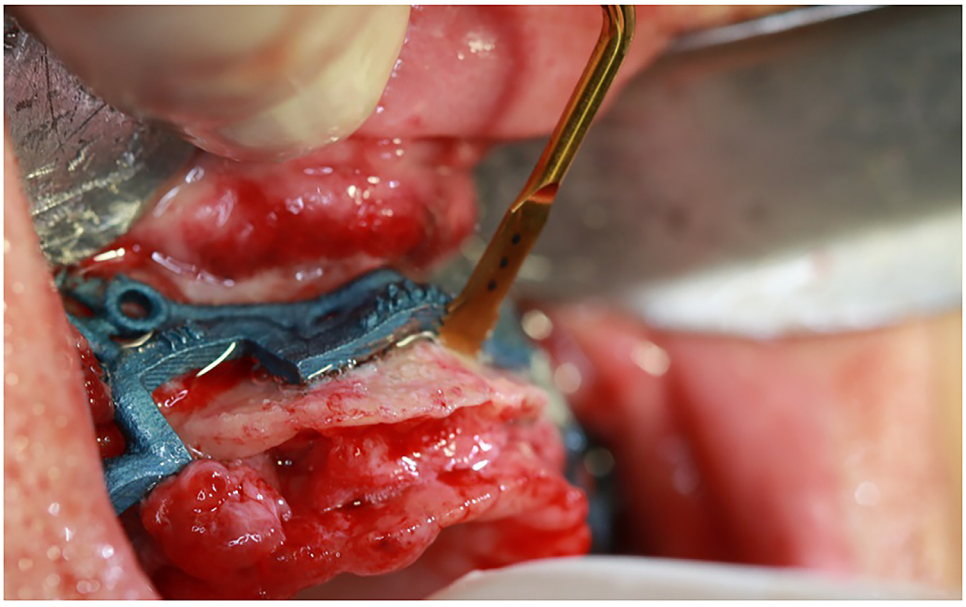

Fig. 5. Bone regularization with piezosurgery.

implants in recent years, highlighting growing interest in the field, particularly from 2020 onward. This increase is accompanied by a steady rise in the average impact factor, suggesting that more recent publications have been featured in journals of greater scientific relevance. However, the literature still reveals a significant gap in the volume of available studies, especially when compared to other areas of implant dentistry. For many years, this gap limited the development and adoption of techniques such as custom subperiosteal implants. However, the introduction of new technologies, such as virtual surgical planning and additive manufacturing, has progressively addressed this gap [12–17]. These innovations have not only increased predictability in clinical outcomes but also opened new therapeutic approaches for complex cases, contributing to the growth of scientific knowledge in this area [10].

Zygomatic implants are currently the most commonly used technique for managing severe maxillary atrophy; however, they are associated with several potential complications, including chronic inflammation, recurrent infections, and implant instability. As these challenges arise, there is an increasing demand for alternative solutions that can provide effective rehabilitation without the drawbacks associated with zygomatic implants.

The new-generation subperiosteal implants represent a significant advancement in implant dentistry, offering numerous benefits such as improved customization, reduced invasiveness, and enhanced aesthetic outcomes. Custom subperiosteal implants have proven to be a crucial tool in the rehabilitation of severely atrophic maxillae, where conventional implants are often not viable due to insufficient bone volume [15,18,19]. These personalized solutions allow for precise adaptation to the patient's anatomy, offering a viable and effective alternative for treating complex cases that previously required invasive procedures, such as bone grafts or maxillary sinus lift techniques. The customization of these implants facilitates an individualized approach, increasing the chances of long-term success and promoting better aesthetic and functional outcomes [16,20].

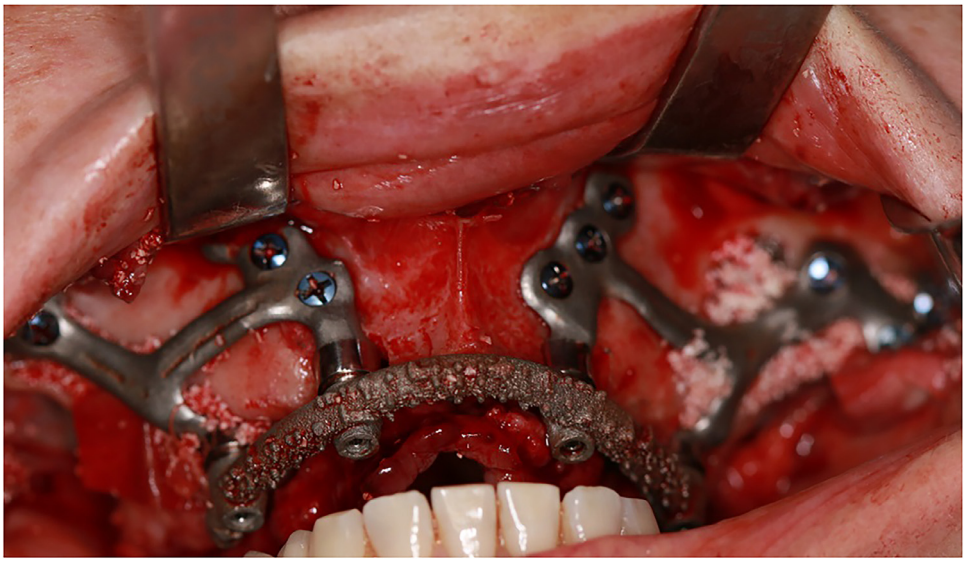

Fig. 6. Custom subperiosteal implant installed and fixed to the bone surface. The use of particulate graft was necessary to reconstruct the bone walls, which exhibited extreme resorption in the anterior maxillary region.

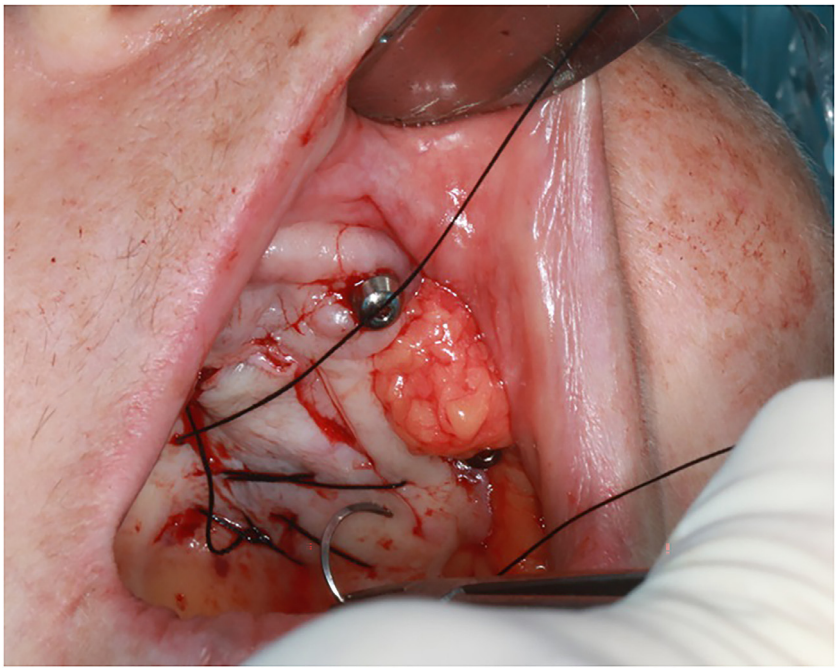

Fig. 7. Final intraoral view after the second surgery, showing the fat graft.

Rehabilitation of patients with comorbidities and conditions resulting from sequelae such as tumors, major infections, and trauma is also a promising alternative [10,14,21,22].

The presence of zygomatic implants can lead to potential interference with the surrounding bone surfaces, posing a risk of complications such as bone resorption or implant failure. To minimize this risk during implant design, careful consideration of the implant geometry is essential [23]. The design should incorporate arms that extend over the maxillary support pillars, providing enhanced stability and distribution of occlusal forces across the implant structure. This extension allows for a more even load transfer, reducing stress concentrations that could adversely affect the surrounding bone. Rigid fixation on these support pillars is crucial, as it ensures that the implant remains firmly anchored, which helps maintain osseointegration and enhances the overall longevity of the implant. In this case report, the implant design was established through virtual planning, utilizing advanced imaging techniques and finite element analysis as a validation method to create a custom solution tailored to the patient's unique anatomy, thereby optimizing the positioning and stability of the subperiosteal implants [24].

Virtual surgical planning and three-dimensional simulation, now essential in this field, bring an unprecedented level of precision and accuracy to the placement of subperiosteal implants [3,13,21]. The ability to accurately map the patient's anatomical structure before surgery minimizes the risk of complications and allows for predictability in implant positioning [13,22]. This approach reduces surgical time and improves clinical outcomes, as the implants are designed to perfectly fit the needs of each case, avoiding intraoperative improvisation and increasing the safety of procedures [3,12].

Additionally, additive manufacturing, which enables the creation of complex geometries using biocompatible materials, has brought significant advancements to implant dentistry [19,22]. The ability to fabricate subperiosteal implants with millimeter precision using techniques such as laser metal sintering allows for the creation of robust, personalized structures that were previously impossible to achieve with traditional methods [3,14]. This not only reduces

Fig. 8. Intraoral view after complete repair from both surgical stages in a frontal view.

Fig. 9. Final case outcome, where the aesthetic result of the smile can be observed.

production time but also improves implant fit and enhances osseointegration with the remaining bone, contributing to the longevity and functionality of the rehabilitation [12,17,22].

Implant exposure is a common complication in implant dentistry that frequently requires further surgical intervention. The literature emphasizes the importance of meticulous surgical planning and techniques for effective management [25,26]. One effective approach utilizes Bichat's fat pad, providing a beneficial layer of cushioning, effectively thickening the tissues above the implant. This technique not only enhances soft tissue healing but also reduces the likelihood of future exposure, thereby improving the overall success rates of implant rehabilitation. Other techniques include local prophylaxis, antibiotic therapy, substitution of cover screw to healing abutment and guided regeneration [27,28]. As in the present case, smokers present an augmented risk of early dental implant exposure [29].

Custom subperiosteal implants have also significantly improved patients' quality of life [8,16,23]. By avoiding the need for additional invasive procedures, such as bone grafts, these implants enable a faster and less traumatic functional recovery, effectively restoring chewing, speech, and facial aesthetics [12,15,19]. The positive feedback from patients undergoing this type of rehabilitation, both in terms of comfort and functional outcomes, reinforces the importance of this approach in challenging cases of maxillary atrophy [18].

Finally, although the use of custom subperiosteal implants has shown promising results, there is an urgent need for more scientific publications on the subject [20,22]. Retrospective, multicenter studies with larger patient samples are essential to establish this technique as a standard in the treatment of severe atrophy. The literature remains scarce, and greater production of robust clinical data could improve understanding of best practices and expand the use of this innovative solution in implant dentistry.

This case report illustrates the successful rehabilitation of a patient with complex maxillary atrophy through the use of custom subperiosteal implants fabricated via additive manufacturing. The advancements in technology, including virtual surgical planning and 3D printing, have enabled precise and individualized solutions, significantly improving clinical outcomes. The ability to tailor implants to each patient's unique anatomy offers a viable alternative to traditional approaches, reducing the need for more invasive procedures and enhancing patients' quality of life. Moreover, this type of surgery can be considered a rescue option for addressing sequelae resulting from previous dental implant failures.

Declaration of competing interest

We declare that there are no conflict of interests of any author in this paper.

CRediT authorship contribution statement

Frederico Rodger Gomes Rodrigues Cardoso: Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ricardo Grillo:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Formal analysis, Data curation.

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