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IMPLANT-BASED REHABILITATION STRATEGIES FOR THE SEVERELY ATROPHIC MAXILLA

Corina Roxana Cîmpean[1,†], Alina Ormenișan[2,†], Alexandru Burcea[3*], Claudia Florina Bogdan-Andreescu[3,*], Andreea Mariana Bănățeanu[3], Cristian-Viorel Poalelungi[4], Laura Nan[5], Ionuț Vlad Şerbanică[6]

[1]"Regina Maria" Dental Clinics, Bucharest, Romania,
[2]"George Emil Palade" University of Medicine, Pharmacy, Science and Technology, Tg. Mureș, Romania, Faculty of Dental Medicine, Department 2,
[3]"Titu Maiorescu" University, Bucharest, Romania, Faculty of Dental Medicine, Department of Speciality Disciplines,
[4]"Carol Davila" University of Medicine and Pharmacy Bucharest, Romania, Faculty of Medicine, Department 13,
[5]Caraiman Multifunctional Medical Complex, Bucharest, Romania, Department of Dentistry,
[6]"Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania, Doctoral School

Corresponding authors; Alexandru Burcea - e-mail: alexandru.burcea@prof.utm.ro,
Claudia Florina Bogdan-Andreescu – e-mail: claudia.andreescu@prof.utm.ro

†These authors contributed equally to this work.

ABSTRACT

The posterior atrophic maxilla remains one of the most challenging regions in implant dentistry, primarily due to limited residual bone height, compromised bone quality, and maxillary sinus pneumatization. Available treatment options are sinus augmentation procedures, short and ultra-short implants, tilted implants, zygomatic and pterygoid implants, and various bone augmentation techniques. Each approach offers distinct advantages and limitations, and the optimal treatment plan often involves a combination of these methods adapted to the patient's specific anatomical conditions and clinical needs. A wide range of implant solutions is now available to address the complexities of the severely atrophic maxilla. The appropriate implant type and surgical technique selection should consider individual anatomical variations, systemic health status, and prosthetic requirements. This paper presents a case series illustrating different surgical approaches to the severely atrophic maxilla. Additionally, we provide an overview of current implant solutions, with particular attention to their clinical indications, expected outcomes, and inherent limitations.

Key words: atrophic maxilla; conventional dental implant; pterygoid implant, zygomatic implants, fixed oral rehabilitation

INTRODUCTION

Dental implant therapy has become a widely accepted and predictable modality for replacing missing teeth, offering improved function and aesthetics for partially and fully edentulous patients [1-4]. However, the severely atrophic posterior maxilla presents unique anatomical and technical challenges that complicate implant placement and long-term success. Key limiting factors include reduced vertical bone height due to alveolar bone resorption, poor bone density (typically Type III or IV), and the anatomical proximity of the maxillary sinus [5,6]. Moreover, the posterior maxilla often presents with restricted access, limited intraoral visibility, and reduced interarch space, especially in the molar region, further complicating surgical and prosthetic procedures [7].

Various advanced surgical and prosthetic approaches have been developed to address

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these challenges over the past two decades. These include traditional bone augmentation procedures, sinus elevation techniques, and the introduction of graftless solutions such as subperiosteal and extra-maxillary implants, notably zygomatic and pterygoid implants [8-12]. In addition, tilted, short, and ultra-short implants have gained popularity, supported by evolving implant designs and biomechanically optimized prosthetic concepts [13-16].

Together, these innovations have significantly expanded the therapeutic options available for rehabilitating the severely atrophic posterior maxilla. However, careful case selection, comprehensive preoperative planning, and a thorough understanding of anatomical variations remain critical for ensuring long-term success.

This study aims to provide an overview of current implant treatment strategies for managing the severely atrophic posterior maxilla, particularly emphasizing one-stage surgical approaches and protocols that enable rapid prosthetic rehabilitation. Here, three patients with severe atrophic maxilla are reported, and clinical outcomes are discussed. Furthermore, we review the advantages and limitations of each method, delineating their clinical indications, procedural considerations, and potential outcomes.

MATERIAL AND METHODS

Between May and December 2024, three patients with severe maxillary atrophy were treated at the “Regina Maria” Dental Clinics in Bucharest, Romania. The batch consisted of one female and two male patients, with a median age of 53.67 years (range 45–65 years). All patients had a history of periodontitis, contributing to their edentulous state and maxillary bone loss. Two patients were in good general health, while one presented with cardiac insufficiency and type II diabetes mellitus, both of which were medically managed and stable at the time of surgery.

A trial orthopantomogram (OPG) was initially performed, followed by cone-beam computed tomography (CBCT) to confirm the presence of severe maxillary atrophy. Routine blood tests were conducted to evaluate the patient's general health status. All patients included had no history of systemic conditions that would contraindicate surgical intervention.

Before surgery, full-arch impressions of the maxilla and mandible, along with a bite registration, were taken to record the maxillomandibular relationship.

The procedure was performed under local anesthesia (Articaine 1:200,000 with vasoconstrictor) combined with intravenous conscious sedation using Midazolam. Antibiotic prophylaxis was administered with amoxicillin–clavulanic acid (2 g orally) two hours prior to surgery.

In cases of bimaxillary implantation, the surgical sequence commenced with the placement of mandibular implants, followed by the maxillary implants. This approach facilitated improved intraoperative control, occlusal alignment, and prosthetic planning.

A slightly palatal incision was made along the maxillary crest, extended by bilateral vertical posterior releasing incisions. A mucoperiosteal flap was elevated to fully expose the alveolar crest, piriform aperture, the central and posterior zygomatic complex, infraorbital nerve, and the lateral wall of the maxillary sinus.

A retractor was carefully positioned to retract the cheek, provide osteotomy guidance, and safeguard adjacent soft tissues during drilling. Implant site preparation was performed freehand, guided by preoperative

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CBCT measurements, allowing for the correct placement of zygomatic, pterygoid, and conventional implants.

A corticotomy of the anterolateral wall of the maxillary sinus was performed, followed by an antrostomy using a progressive-diameter diamond bur, carefully preserving and slightly elevating the Schneiderian membrane. Implant site preparation started with the drilling of conventional implants sites, guided by the established mandibular occlusion. Subsequently, the preparation of zygomatic and pterygoid implant sites was performed under direct visual control using progressively sized drills. This technique ensured precise angulation along the extraoral trajectory toward the alveolar crest and zygomatic arch, optimizing implant stability and prosthetic alignment.

Hemostasis was achieved through careful suturing of the surgical field.

A full-arch impression was taken for the fabrication of a temporary prosthesis, enabling immediate functional and aesthetic rehabilitation. The temporary prosthesis was screw-retained using preformed abutments and delivered the day after surgery.

The post-operative medication protocol included amoxicillin–clavulanic acid (1 g twice daily for five days), etoricoxib 60 mg twice daily for three days, and adjunctive probiotics to support gastrointestinal health.

All patients consented to adhere to a strict oral hygiene protocol and regular recall visits. The postoperative period was uneventful, with no evidence of soft tissue down growth that could interfere with osseointegration or bone healing.

Prosthetic rehabilitation was completed on all implants with fixed screw prosthesis, and no adverse events were reported by patients throughout the follow-up period.

Approval consent forms for the treatment plan and the surgical procedure were signed by the patients. This study was conducted in accordance with the Declaration of Helsinki. Ethical approval for this study was not required according to the rules of the Bioethics Committee of the “Regina Maria” Dental Clinics, because this study was not a medical experiment, only a comprehensible summary of the different treatment options already existing and scientifically proven.

RESULTS AND DISCUSSION

Case No. 1. A 51-year-old female patient with a history of smoking and periodontitis presented in overall good general health. She expressed dissatisfaction with her removable partial dentures and strongly preferred a fixed oral rehabilitation solution, ideally with immediate restoration (Figure 1). A CBCT scan revealed severe maxillary bone atrophy accompanied by odontogenic maxillary sinusitis (Figure 2).

Figure 1. Preoperative view of the patient’s smile.

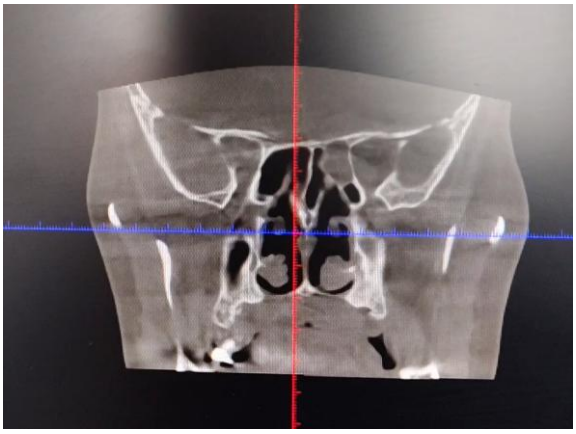

Figure 2. CBCT image showing severe maxillary bone atrophy.

A graft-less implant-based surgical

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approach was planned to meet the patient's expectations while avoiding toothlessness. To reduce the risk of postoperative sinus complications, the treatment began with sinus drainage via meatal access, performed by an ENT (ear, nose, and throat) specialist and patient agree to reduce smoking.

A single-stage surgical protocol was employed: mandibular rehabilitation with placement of four conventional implants in an All-on-4 configuration and maxillary rehabilitation with placement of two conventional anterior implants, combined with two zygomatic implants and two pterygoid implants in the posterior region, to achieve full-arch support (Figure 3 and 4).

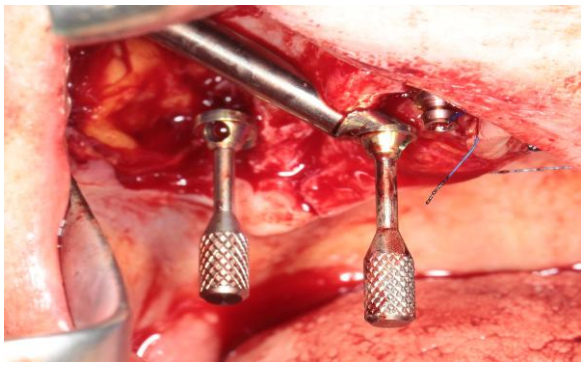

Figure 3. Intraoperative view of left pterygoid and zygomatic implants.

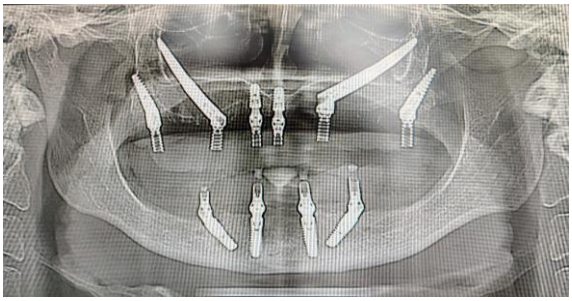

Figure 4. Postoperative OPG after surgery.

The following day, the patient received a temporary fixed prosthesis, ensuring functional and aesthetic rehabilitation. Four months postoperatively, after successful osseointegration and soft tissue healing, a definitive long-term prosthesis was delivered (Figures 5 and 6).

Figure 5. Fixed screw dentures.

Figure 6. Radiological aspect of loaded implant, six months after surgery.

Case No. 2. A 45-year-old edentulous male patient, wearing complete dentures for the past five years, presented with complaints of denture instability and expressed a strong desire for fixed prosthetic rehabilitation (Figure 7).

Figure 7. Preoperative aspect.

Preoperative imaging, including OPG and CBCT, revealed significant bone resorption

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in both the maxilla and mandible due to periodontitis history and wearing of removable dentures (Figures 8 and 9).

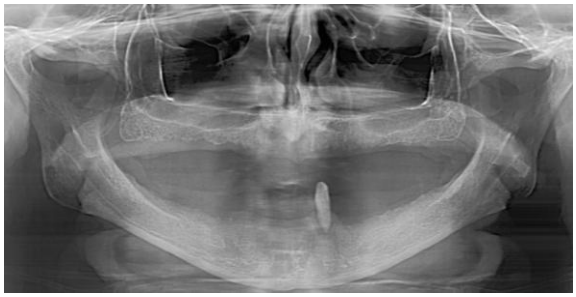

Figure 8. Preoperative OPG.

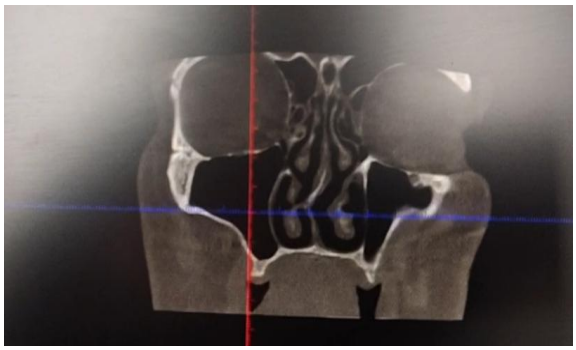

Figure 9. CBCT image showing severe maxillary bone atrophy.

A single-stage surgical protocol was adopted to address the anatomical limitations and patient expectations. The maxillary rehabilitation involved the placement of five conventionally implants placed strategically to ensure optimal support for the occlusal load. On the left side, a lateral sinus lift was performed to augment vertical bone height. On the right side, due to severe posterior atrophy and the infeasibility of sinus augmentation, a zygomatic implant was placed (Figures 10 and 11).

Following maxillary implantation, mandibular rehabilitation was carried out using an All-on-6 approach, with six conventional implants placed to support a full-arch fixed restoration. A fixed temporary prosthesis was delivered the day after surgery, providing immediate function and aesthetics. After a four-month healing period, during which successful osseointegration was confirmed, long-term prostheses were placed on both arches (Figures 12 and 13).

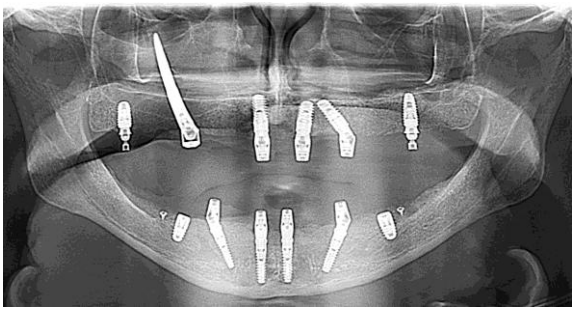

Figure 10. Postoperative OPG after surgery.

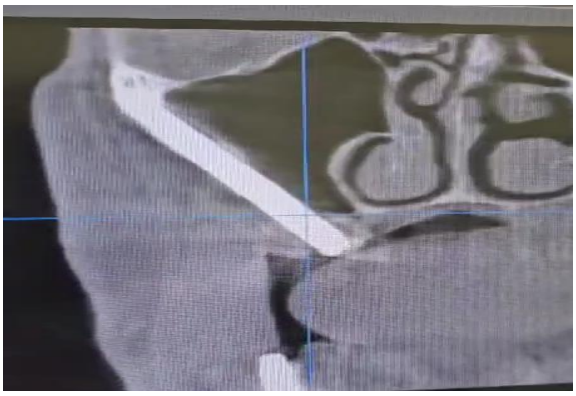

Figure 11. Zygomatic implant on CBCT.

Figure 12. Fixed screw dentures in place.

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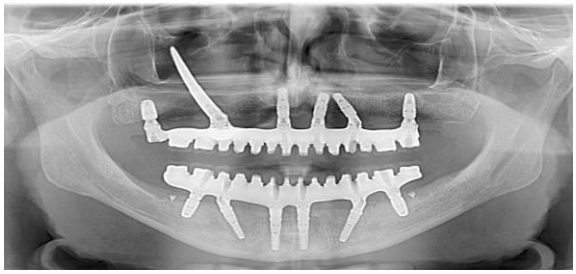

Figure 13. Radiological aspect of loaded implant, five months after surgery.

Case No. 3. A 65-year-old patient with a medical history of chronic cardiac insufficiency and type II diabetes mellitus presented dissatisfaction with a previous implant-supported prosthetic rehabilitation completed five years prior, as well as with the mobility of the remaining teeth (Figure 14). Given the patient's desire for a staged treatment approach, rehabilitation began with the maxillary arch.

The first phase involved the placement of four implants following the All-on-4 protocol, supplemented by two pterygoid implants. This strategy was chosen to avoid involvement of the maxillary sinuses, minimize postoperative complications, and facilitate recovery (Figure 15). A temporary restoration was delivered the next day, and the final one four months later (Figure 16).

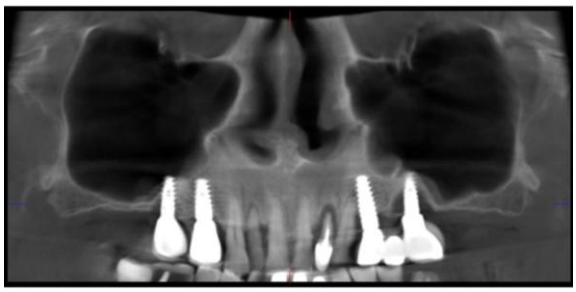

Figure 14. Preoperative view on CBCT.

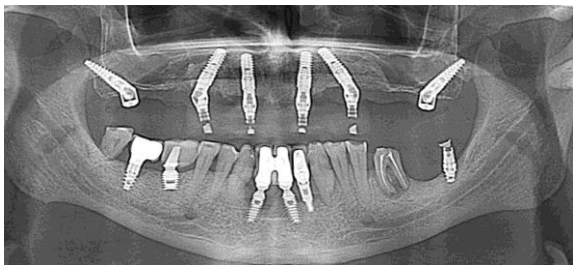

Figure 15. Postoperative OPG.

Figure 16. Final fixed prosthesis.

Given the current socio-economic climate, there is a growing trend in clinical practice toward treatment strategies that balance efficacy with affordability and minimal disruption to daily life. Patients increasingly seek therapies that offer favorable clinical outcomes while reducing overall costs, healing time, and periods of work incapacity, particularly in contrast to extensive reconstructive procedures involving extraoral graft harvesting.

In this context, the use of special implants, such as zygomatic and pterygoid implants, has gained importance over the past decade. These solutions have proven to be reliable and effective alternatives for patients with severe maxillary atrophy, providing predictable long-term outcomes and enabling rapid delivery of fixed prosthetic rehabilitation without the need for complex grafting procedures. In all cases, postoperative healing was uneventful, including in the patient with multiple chronic conditions and on polymedication as is reported by different authors [17,18].

Moreover, these types of implants can be successfully combined with conventional implants and/or sinus lift procedures, thereby broadening their clinical applicability and offering greater flexibility in treatment planning, particularly for patients presenting with maxillary atrophy who are seeking a rapid and fixed restorative solution.

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In all cases, special implants, such as zygomatic and pterygoid implants, were used in conjunction with conventional endosseous implants to optimize biomechanical stability and ensure uniform distribution of occlusal forces.

Since the fact that occlusal overload is the main cause of failure of implant-borne prosthesis, this combined approach provided a stable foundation for fixed prosthetic restoration, particularly in patients with severe maxillary atrophy where conventional implants alone may not offer sufficient support [19,20].

By strategically placing implants in areas with better bone quality, such as the zygomatic and pterygoid regions, the treatment avoided the need for extensive bone grafting procedures [12]. It allowed for immediate or early loading in most cases. This hybrid implant protocol also facilitated improved prosthetic design and reduced cantilever effects, contributing to long-term functional and esthetic success.

High-density polymers present a valuable opportunity for fabricating adjustable and well-performing prosthetic solutions, particularly suited for use as interim restorations during the healing or transitional phases of treatment [21-24].

The management of the atrophic maxilla necessitates a range of advanced surgical techniques tailored to the patient's specific anatomical and clinical presentation. Commonly employed treatment modalities include sinus floor elevation (via both lateral and transcrestal approaches), short and ultrashort implants, tilted implants, zygomatic and pterygoid implants, subperiosteal implants, as well as various bone grafting and augmentation strategies.

Sinus floor elevation remains one of the most established techniques for enabling implant placement in the posterior maxilla, particularly when vertical bone height is compromised due to sinus pneumatization [25-28]. The choice of technique is typically based on the residual bone height:

- **Lateral Window Technique**: This approach is indicated when the residual bone height is less than 5 mm [29,30]. It facilitates either simultaneous or staged implant placement alongside grafting procedures. While offering high predictability and long-term success, the technique is more invasive, requires extended healing time, and carries a risk of sinus membrane perforation [31,32].
- **Transcrestal (Osteotome) Technique**: Recommended when residual bone height is 5 mm or greater [33], this minimally invasive procedure is associated with reduced morbidity and shorter healing periods [34]. However, it provides limited augmentation volume and is technique-sensitive, particularly in patients with compromised bone quality [35].

Despite favorable implant survival rates reported in the literature, both techniques have limitations that may reduce their suitability for certain patients. These include increased surgical morbidity, dependence on bone grafting, and higher overall treatment costs and duration [36].

Additionally, traditional approaches often do not support immediate loading or functional restoration, especially in fully edentulous patients, which can negatively impact patient satisfaction and delay complete oral rehabilitation [37].

Short and ultra-short implants, generally defined as implants with a length of ≤8 mm—have gained clinical acceptance as a viable alternative to bone grafting in cases of limited vertical bone height in the posterior maxilla [38]. These implants offer notable advantages, including reduced

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surgical morbidity, decreased treatment costs, and shorter overall treatment duration, as they circumvent the need for augmentation procedures. Despite these benefits, their reduced length may lead to increased biomechanical stress, particularly in areas with poor bone density or under significant occlusal forces [39]. Consequently, meticulous prosthetic planning and optimized load distribution are critical to ensuring long-term success [40]. Recent clinical studies have demonstrated survival rates exceeding 90% for short implants when placed in appropriately selected patients under controlled prosthetic conditions [41,42].

Tilted implants, also referred to as angulated or non-axial implants—are strategically positioned at an angle to capitalize on available anterior bone, thereby avoiding the maxillary sinus and obviating the need for sinus augmentation [43,44]. This approach is integral to full-arch rehabilitation protocols such as the All-on-4 concept [45]. Tilted implants offer distinct advantages, including the feasibility of immediate loading and the elimination of complex grafting procedures [46]. However, their use demands precise surgical execution and comprehensive prosthetic planning to minimize biomechanical risks, including cantilever-induced stress and peri-implant overload [47].

Zygomatic implants are extra-long fixtures anchored in the zygomatic bone. They are primarily indicated in cases of advanced maxillary atrophy—particularly when the residual alveolar bone height is less than 3 mm or when previous augmentation attempts have failed [48]. Their principal advantage is offering a graftless, immediate-load solution that enables prompt functional and aesthetic rehabilitation, often within 24–72 hours post-surgery [49,50]. This technique is especially valuable for edentulous patients or those with significant posterior maxillary bone loss who seek fixed prosthetic solutions without the extended treatment timelines of graft-based protocols. However, zygomatic implant placement is a technique-sensitive procedure requiring advanced surgical training and careful anatomical consideration. Potential complications include sinusitis, soft tissue dehiscence, paresthesia, and, more rarely, infraorbital or orbital injury due to the proximity of critical anatomical structures [51.52].

Pterygoid implants, on the other hand, are placed through the maxillary tuberosity and anchored in the pterygoid process of the sphenoid bone, thereby avoiding the maxillary sinus altogether [53]. They serve as a posterior anchor in full-arch maxillary prostheses and are particularly useful when the posterior bone volume is inadequate for conventional implants. This approach extends the prosthetic support zone, enabling immediate function without the need for sinus grafting. Nonetheless, the technique presents notable surgical challenges due to limited intraoral access, complex anatomical landmarks, and reduced intraoperative visibility [54]. Although long-term data are still emerging, the current literature indicates that the survival rates of pterygoid implants are comparable to those of other posterior maxillary implant solutions when placed by experienced clinicians [37].

Subperiosteal implants offer a graftless alternative for the rehabilitation of the severely atrophic maxilla, particularly in cases where the residual bone volume is insufficient to accommodate conventional endosseous implants [55]. Unlike traditional implants that are embedded within the alveolar bone, subperiosteal implants consist of a custom-designed framework that rests

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on the bony surface beneath the periosteum [56]. These frameworks are typically secured using fixation screws and serve as a stable base for a fixed or removable prosthesis without necessitating extensive bone grafting or sinus elevation procedures [57].

The fabrication and placement of subperiosteal implants require advanced imaging, such as CBCT, and digital or conventional impressions to achieve a precise fit to the patient's unique maxillary anatomy. Although modern techniques, including 3D printing and computer-aided design and manufacturing (CAD/CAM), have improved accuracy and reduced operative time, the procedure remains surgically demanding [58]. Furthermore, the subperiosteal placement of a large framework beneath the soft tissue envelope increases the risk for complications such as mucosal irritation, wound dehiscence, and postoperative infection [59]. Therefore, case selection and meticulous surgical technique are critical to the long-term success of subperiosteal implants in complex maxillary reconstructions.

Bone grafting and augmentation remain essential strategies in the rehabilitation of the severely atrophic maxilla, particularly when anatomical limitations preclude the placement of conventional endosseous implants. These procedures aim to restore bone volume and architecture, facilitating predictable implant osseointegration and long-term prosthetic success. Two principal grafting approaches are commonly employed:

Autogenous Block Grafts: remain the gold standard in grafting due to its osteogenic, osteoinductive, and osteoconductive properties [60]. Typically harvested from intraoral sites, such as the mandibular symphysis or ramus, or extraoral sites, such as the iliac crest, autogenous block grafts offer high-quality, vital bone that supports optimal implant integration [61]. However, these procedures are associated with increased surgical morbidity, necessitate a second operative site, and are accompanied by longer healing times [62]. Furthermore, variable and sometimes significant resorption rates have been reported, potentially compromising the stability and volume of the regenerated bone [63].

Alloplastic and Xenografts with Membranes: Synthetic (alloplastic) and animal-derived (xenograft) materials are widely used in Guided Bone Regeneration (GBR) protocols. These materials are typically combined with resorbable or non-resorbable membranes to maintain space and facilitate new bone growth [64]. The main advantages of these materials include reduced invasiveness, elimination of donor site morbidity, and favorable handling characteristics. Nonetheless, their osteoconductive properties are generally inferior to autogenous grafts, and they may demonstrate slower integration and less predictable volumetric stability over time [65].

Despite the documented efficacy of both approaches, bone grafting procedures are often associated with extended treatment timelines, increased patient discomfort, and potential complications such as graft failure, infection, or resorption [66]. As a result, there is a growing clinical preference for less invasive alternatives, such as zygomatic and pterygoid implants or short implants, particularly in patients with comorbidities or those seeking faster rehabilitation.

Treatment planning and decision-making in case of severe atrophic maxilla needs a comprehensive approach that should integrate:

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-CBCT imaging for 3D anatomical evaluation.
-Digital planning tools to simulate implant position.
-Patient-specific factors such as age, comorbidities, and preferences.
-Prosthetic considerations, including available interarch space and occlusal scheme.

Implant rehabilitation in the severely atrophic maxilla is associated with several potential complications, particularly due to anatomical limitations and the complexity of advanced surgical techniques. Common complications include sinus membrane perforation, implant failure due to insufficient primary stability, soft tissue dehiscence, peri-implantitis, and sinusitis associated with zygomatic implants [12].

Minimizing these risks requires meticulous preoperative planning, incorporating CBCT to accurately assess anatomical structures and bone volume, as well as the use of digital planning software. While the use of digital planning software and guided surgical techniques can enhance the precision of implant placement and reduce intraoperative errors, all implants in this case series were placed freehand. This decision was primarily driven by the high cost of surgical guides, which is a limiting factor. Despite the absence of computer-guided assistance, careful preoperative analysis using CBCT, combined with surgical experience and tactile feedback, enabled accurate implant positioning.

Additionally, adherence to a strict surgical protocol, maintenance of aseptic conditions, and appropriate case selection are critical. Advanced procedures, such as zygomatic or pterygoid implant placement, should be performed exclusively by surgeons with specialized training and experience to ensure optimal outcomes and minimize complication rates.

CONCLUSIONS

Rehabilitating the severely atrophic maxilla remains one of the most demanding challenges in implant dentistry due to anatomical constraints such as reduced bone volume, poor bone quality, and maxillary sinus expansion. As demonstrated in this case series, a combination of special and conventional implants can overcome these limitations, offering the benefits of fast and fixed restoration. These approaches require careful planning, clinical experience, and, in some instances, a multidisciplinary approach to minimize complications and enhance outcomes.

This study highlights the effectiveness of combining implants and techniques to achieve predictable, functional, and aesthetic outcomes in the treatment of severely atrophic maxillae.

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