

Management of Severe Atrophy with a Customised Subperiosteal Implant in the Posterior Mandible

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ABSTRACT

Clinical trials and follow-ups have provided ample documentation of the adaptability and predictability of endosseous implants (1). Patient general health state, bone availability and long osseointegration durations could have been limitations to the use of this implants. Subperiosteal implants with proper design can work effectively for many years and are a good substitute for endosseous implants, according to research findings (2). With the use of digital technology, clinicians can design the implant based on the patient's cone beam computed tomography (CBCT) scan well in advance of surgery, addressing the drawbacks of analogue subperiosteal implants, which included the possibility of implant misfit due to impression material contraction and more significant trauma to the patient requiring two surgical interventions rather than one.

This case study discusses the design characteristics of 3D printed superiosteal implants, the step-by-step procedure and their unique features based on recent research conducted in Romania with AB Dental International (3).

Keywords: implantology, customised implant, atrophy, resorption, oral surgery, 3D-printed.

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INTRODUCTION

In oral and maxillofacial surgery, the rehabilitation of an atrophic posterior mandible is a considerable challenge, particularly when substantial bone loss precludes the use of traditional implant procedures. For these situations, several restorative techniques are available, including nerve lateralisation, transposition operations, guided bone regeneration (GBR) and the insertion of short or ultra-short implants. However, each of the above-mentioned methods has a unique set of drawbacks and hazards.

To enhance bone volume and provide sufficient support for conventional implant placement, GBR and onlay bone grafting are frequently used. But these operations tend to be difficult and time-consuming approaches; also, they have varying success rates, especially in the posterior mandible, where the restricted vascularity and thick cortical structure of the bone might impede effective regeneration. Moreover, graft resorption and infection are potential postoperative problems associated with GBR that may jeopardise the long-term stability of implants (4, 5).

Nerve lateralisation, also known as transposition, is the process of relocating the inferior alveolar nerve (IAN) to allow for implant insertion. Although lengthier implants can be placed using these procedures in situations of severe atrophy, there is a considerable danger of nerve damage, which can result in sensory abnormalities, including paraesthesia, hypoesthesia, or even anaesthesia. Particularly in older patients or those with weakened health, these problems might adversely impact the patient's quality of life and restrict the viability of this technique (6, 7).

Short implants are an alternative, mainly when bone height is insufficient for regular implants. While there have been some successful examples of using short implants, the greater likelihood of implant failure can make the long-term prognosis less favourable. Because of their smaller surface area, short implants are less able to tolerate occlusal stresses, especially in the posterior jaw where masticatory loads are greater (8, 9).

However, when above-indicated methods might not be appropriate, subperiosteal implants are a good substitute. Subperiosteal implants are

specifically made to match the patient's mandibular anatomy; they do not require nerve realignment or bone augmentation. Instead, they are screw-anchored and rest on the surface of the bone. They are instrumental in situations of severe bone atrophy (10, 11). The accuracy and efficacy of subperiosteal implants have been significantly improved by digital technology and 3D printing developments, enabling less invasive implantation that avoids important anatomical features like the IAN. These implants are becoming a more and more popular choice for reconstructing severely atrophic posterior mandibles because they offer fast prosthetic rehabilitation with less surgical stress and a decreased risk of problems (12, 13). □

MATERIALS, METHODS AND RESULTS

A 76-year-old patient arrived at the clinic, claiming to be experiencing considerable discomfort and bleeding in the right mandibular area during mastication. In addition, the patient reports having bad taste in the region of interest and halitosis. The clinical examination indicated the presence of a fixed prosthesis with implant support in the area of teeth 43-48. It was cemented (not screwed) and had movement, notably at the distal implant. Prosthesis mobility may result from spontaneous disintegration, implant fracture, fracture of the screw holding the prosthetic abutment together, or movement of the device within the body.

Three categories of implant mobility exist: rotational, vertical and horizontal (14). While horizontal and vertical motion may signify bone loss and the existence of a soft tissue capsule, rotational motion may indicate inadequate bone/implant contact (15). The preliminary radiographic investigation orthopantomography (OPG), established a mixed bone defect surrounding the distal implant with coil exposure (Figure 1).



FIGURE 1. Initial orthopantomography

The first course of treatment was partial removal of the prosthetic work distal to implant 44 while maintaining an extension. The goal was to reduce patient's reported discomfort and soft tissue inflammation while preserving the masticatory and aesthetic functions. Following the ablation of the prosthetic work, the harmed implant was removed and the damaged region healed.

Removing dental implants with little to no bone-to-implant contact is possible using instruments like elevators and forceps, which are frequently used for tooth extraction. In the absence of resistance, rotational movements have no effect. Some other techniques and instruments for implant removal are an anticlockwise torque wrench, a laser, a piezotome and a trephine cutter. The optimum option for both the patient and dentist is rapid, least traumatic and economical (16).

The clinical status was reviewed three months after the distal implant explantation. The fastest rate of bone resorption occurs in the first three months following extraction, and after six months it starts to slow down considerably. Remodelling is frequently finished and stabilised within one year to two years (17). The mandible typically resorbs at a 0.2 mm/year rate, 3–4 times faster than the maxilla's rate (18). One of the bones in the human body most prone to atrophy is the mandible, which may lose up to 70% of its initial bone volume in the mandibular body area in extreme circumstances (19). No suppurative or inflammatory processes were seen in the healed intraoral tissues. From a radiological perspective, significant bone atrophy with a marked vertical loss is seen (Figure 2).



FIGURE 2. Orthopantomography illustrating the clinical situation three months after implant explantation

Clinicians face morphological, surgical and biological obstacles when treating edentulous posterior mandibular ridge atrophy in oral rehabilitation (20). Osseointegrated dental implants are often placed in the posterior mandibular region to support a fixed prosthesis. However, in many cases, the atrophied bone has made it impossible to place implants long enough to avoid harming the inferior alveolar nerve (INA). Short implants, ridge height augmentation by onlay bone grafting, and more intricate and comprehensive imaging investigations to enable implant placement close to the mandibular canal during the procedure are among the restorative options in such cases (21).

The patient was directed to conduct CBCT-type supplementary radiological imaging to accurately determine potential treatment options. We identified the route of the inferior alveolar nerve and quantified the separation between the mandibular canal and the crest of the edentulous ridge in two regions of interest on the CBCT images: the region containing the II premolar and the II molar (Figure 3). The measurements yielded a size of 4.5 mm and 5 mm, respectively.

Following a comprehensive assessment of the clinical condition and examination of alternative therapy choices, several potential approaches were considered. Everyone was examined in the case scenario, considering its efficacy, intricacy and likelihood of long-term success.

The edentulous posterior mandibular area with extensive bone atrophy, categorised as Class VI (22) by Cawood and Howell, presents several challenges in terms of restoration. These factors include the location of the mental nerve and the superficial NAI. The concave mandibular crest is

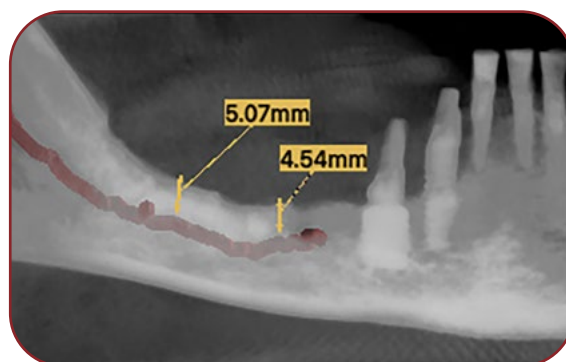


FIGURE 3. Cone beam computed tomography Dicom image showing the position of the alveolar nerve and the dimension of the residual crestal bone

typically found below the buccal vestibule and the level of the floor of the mouth, the severe basal bone resorption that results in a total mandibular height of less than 8 mm, and the height of the residual alveolar ridge above the NAI being reduced to 0 to 3 mm. Addressing these challenges, the surgical treatment plan might be adjusted depending on the circumstances (21).

After one to five years following insertion, the survival percentage for short implants (≤ 6 mm) is 86.7% to 100%, whereas the survival rate for longer implants (>6 mm) is 95% to 100%. In general, there was a 29% greater chance of failure for short implants compared to longer implants (>6 mm) according to the hazard ratio (RR) of 1.29 (95% CI 0.67 to 2.50, $p = 0.45$) for short implant failure (23). Because the crestal bone section of the implant experiences the most stress and the apical area experiences the minor stress distribution, the diameter of the implant has a more significant impact on stress dissipation than length (23, 25). Implant placement is not feasible in this case due to the magnitude of the remaining alveolar ridge, both in height (Figure 3) and thickness (Figure 4), as well as the proximity to the mandibular canal to accommodate the inferior alveolar nerve.

The inferior alveolar nerve is moved by the surgical procedures known as inferior alveolar nerve lateralisation (LNAI) and inferior alveolar nerve transposition (TNAI) (Figure 5), which enables implant implantation without requiring an increase in bone size. The buccal cortex around the mandibular is removed to move the IAN. The risk of neuropathy, encompassing paraesthesia, hypoesthesia and anaesthesia at the IAN



FIGURE 4. Cone beam computed tomography Dicom image showing the width of the residual alveolar crest

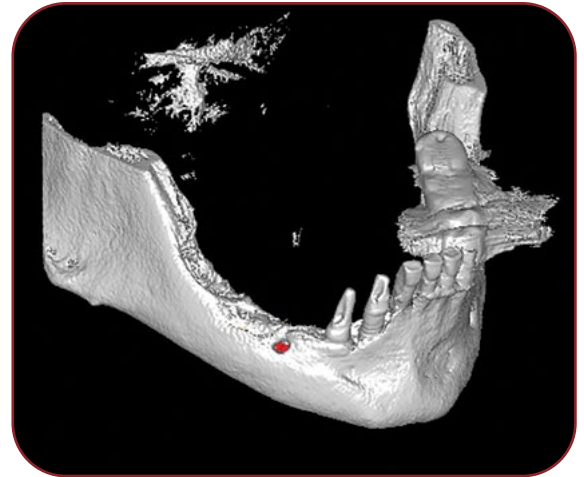


FIGURE 5. Cone beam computed tomography Dicom image showing the position of the mental foramen and the inferior alveolar nerve

level, is elevated by this procedure (26). During the implant placement, the NAI is deflected laterally using exposure and traction. Lateralisation and preservation of the inferior alveolar neurovascular bundle are defined as the lateral reflection of the NAI without incisive nerve tension. The NAI must then adjust its position about the fixtures (27).

A corticotomy is performed around the mental foramen, and the incisive nerve is tugged (the incisive neurovascular bundle is sacrificed) during the TNAI procedure to transposition both the mental foramen and the NAI so that the mental foramen is shifted more posteriorly (27).

Techniques for lateralisation or transposition of the NAI are frequently employed when choosing between short or ultra-short implants is not an option (in cases of atrophy severe bone loss when the remaining bone above the chin varies between 0.5 and 1.5 mm) or to lessen the risk of injury to the vascular-nerve bundle during the insertion of dental implants. While these methods offer an alternate course of treatment for cases of severe bone atrophy, their use is severely limited by contraindications, which include altered general health status, increased risk of bleeding or infection, thick bone cortex and weak vascular-nervous bundle (28).

Augmenting the atrophic posterior mandibular ridge in oral and maxillofacial surgery challenging regarding function and cosmetic restoration (29). For moderate (four to six mm) or substantial (more than seven mm) bone deficits,

guided bone regeneration (GBR) or onlay bone grafting (OBG) may be advised. However, this research contradicts the notion that bone augmentation techniques have a low success rate in the mandibular posterior region. This is because the mandibular bone has a microarchitecture different from the maxilla, which consists of thick cortical bone and dense trabecular bone. These characteristics hurt the vascularization sources and, indirectly, the area's capacity for regeneration (30).

To achieve functional rehabilitation of the edentulous area, a partially customised 3D printed subperiosteal implant with a novel design that avoids the surrounding anatomical elements was suggested, considering the limited therapeutic options and the contraindications and drawbacks of the previously mentioned methods. The obtained DICOM data was used for inverse planning. The surgeon and the manufacturing business were involved in the design of the personalised implants.

The EOSINT M 280 machine, specialising in producing high-quality metal components based on three-dimensional CAD information – entirely naturally, in hours, and without additional equipment – was used to construct the implant by directly laser sintering the metal (31). The implant was given by the manufacturing business in a complete package with all accessories required for treatment, ensuring an exceptionally smooth surgical stage and giving the doctors all instruments they needed, including: 1) a 3D printed polymer model that helps the physician determine how to contour the flap elevation, which needs to be 3–4 mm from the implant design; 2) the sterilised and 3D-printed implant; 3) screwdriver-assisted screw-fixing screws; 4) healing heads; 5) the temporary prosthetic work and prosthetic abutments; and 6) ready-to-use bone matrix.

Following a thorough preoperative examination by the anaesthesia and intensive care physician, the surgical operation was carried out under local anaesthesia and inhalation sedation with continuous monitoring of critical functions. Before the intervention, the patient was advised to take oral amoxicillin 875 mg plus clavulanic acid 125 mg every 12 hours for two days.

A full-thickness flap was raised to get a complete view of the surgical site (Figure 6), a crestal incision was created, with mesial and dis-



FIGURE 6. Intraoral image with the elevation of the mucosa



FIGURE 7. Postoperative orthopantomography postop image with the implant in position and the temporary prosthesis

tal unloading incisions dividing it. The polymer model of the implant was used to prepare the flap, verify whether the implant fits well intraoperatively and drill holes for the mini-screws that will secure the implant. The bespoke implant was removed from its sterile container and placed on the prepared site to ensure it lined up with the remaining bone and secured with osteosynthetic mini-screws (32).

After the procedure, periosteal release incisions were made and flap passivation was used to cover the whole area and promote per primam healing. To ensure the surgical and prosthetic clinical success of the implant, great care was given during the suturing procedure to avoid visible strain and retain the appropriate quantity of keratinised gingiva surrounding the developing abutments (32). Following the intervention, a control OPG was carried out following the placement of the temporary prosthetic work (Figure 7). □

DISCUSSIONS

In this instance, guided bone regeneration (GBR), nerve lateralisation, or short implants would have presented significant challenges. Instead, a custom 3D-printed subperiosteal implant provided a feasible alternative to conventional methods for restoring a severely atrophic posterior mandible. The observed success highlights this approach's potential, especially in complicated circumstances where alternative approaches might not be appropriate or as successful.

The results of the present case report align with current research supporting subperiosteal implants as a treatment option for severe bone atrophy. Stumpel (33) emphasised that subperiosteal implants offer a customised solution that considers the unique anatomical problems of each patient, especially when they are custom-designed utilising digital technology. This is particularly important when, as in this patient's case, the available bone volume is inadequate for the implantation of a traditional implant.

Despite widespread usage, GBR and onlay bone grafting frequently encounter difficulties in the posterior mandible because of the thick cortical bone and restricted vascularization that impede effective bone regeneration. While these methods can be successful in some situations, Simion *et al* (34) point out that they can be erratic in regions where bone quantity and quality are impaired. Comparatively, Misch *et al* (35) note that, although short implants can be helpful in cases of mild atrophy, they more frequently fail when the height of the bone is drastically decreased, as it was in this instance. Another alternative for implant placement in the posterior mandible is nerve lateralisation and transposition, as explained by Pogrel *et al* (36). However, the possibility of nerve damage and the ensuing sensory abnormalities, continues to be a serious worry.

A potentially effective treatment option for severe mandibular atrophy is customised, 3D-printed subperiosteal implants. Compared to more intrusive procedures, the ability to precisely customise the implant to the patient's anatomy minimises surgical trauma and lowers the chance of consequences, including nerve damage. This method shortens the duration of therapy and eliminates the need for several surgical proce-

dures, increasing implant placement precision and improving patient comfort and satisfaction.

According to Goiato *et al* (37), personalised treatment strategies frequently result in superior outcomes, underscoring the significance of customised treatments in complicated implantology. A significant advancement in dental implantology is 3D printing and modern imaging technology, which present new options for patients previously deemed inappropriate for implant insertion.

However, the conclusions of the present study are based on a single patient, limiting their generalisability. Moreover, even though 3D printing technology and materials are constantly advancing, they are still expensive and might only be available to some practitioners. Large-scale studies are needed to learn more about the long-term effects of these implants, particularly when compared to conventional techniques.

Further research should focus on long-term comparative studies comparing the endurance and efficacy of subperiosteal implants to more conventional methods such as nerve lateralisation, GBR and short implants should be the focus of future research. Furthermore, improvements in 3D printing technology may result in more generally available and reasonably priced solutions, increasing the application of customised implants in clinical settings. Research delving into patient-reported outcomes, such as satisfaction and quality of life, would also yield important information on the implants' overall effects on dental rehabilitation.

CONCLUSION

To summarise, customised 3D-printed subperiosteal implants represent a substantial development in treating severely atrophic mandibles, especially in situations where standard procedures are either unfeasible or associated with increased risks. This method offers a customised solution that not only satisfies the anatomical demands of difficult situations but also improves patient satisfaction and surgical trauma reduction, which improves patient outcomes. ■

Ethical statement: This case report complies with the ethical standards outlined in the Declaration of Helsinki. The patient gave written

informed consent to publish their case details, including any accompanying images. Every effort has been made to ensure the patient's confidentiality, and all identifying information has been removed or altered. Institutional policies have protected the patient's privacy.

Informed consent: The patient gave written informed consent to publish this case report and any accompanying images. The editor of this journal can review a copy of the written consent. Every effort has been made to ensure the patient's confidentiality, and all identifying information has been removed or altered.

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Authors' contribution: LN, as the primary author, conducted the clinical assessment,

collected patient data and drafted the case report; IS contributed to the clinical diagnosis, treatment plan, and ethical considerations; VDS checked for typographical errors, formatting issues and minor inconsistencies before the final submission of the manuscript; AMC played a key role in drafting the main body of the article; AR participated in case discussions, reviewed patient's history, and ensured compliance with ethical guidelines; VN assisted in data interpretation, reviewed relevant literature and provided critical feedback on the manuscript.

Data availability: Data supporting the findings of the present study are available from the corresponding author upon reasonable request.



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