

Zygomatic implantology: synergy between piezosurgery and traditional technique for the rehabilitation of atrophic jaws. A case report

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Abstract

AIM: Zygomatic implantology offers an effective solution for the rehabilitation of patients suffering from severe maxillary atrophy, allowing for the placement of dental implants anchored to the zygomatic bone. The preparation of the implant site in this procedure, traditionally performed with rotating burs, can now also be performed with piezosurgery.

Materials and methods: A 76-year-old male patient presented for evaluation by the authors for rehabilitation of an atrophic maxilla.

Results: The patient was successfully treated, and good clinical conditions were observed at the 2-year follow-up.

Conclusions: A combined approach, integrating both techniques, may represent the ideal solution to optimize the procedure and ensure maximum safety and predictability. This case report explores the characteristics, advantages, and disadvantages of traditional burs and piezosurgery in zygomatic implantology, analyzing the clinical applications of a combined approach.

Keywords: Zygoma implants, Atrophic maxillae, Conventional drills, Piezoelectric Surgery

Introduction

The phenomenon of edentulism, mainly associated with advanced dental caries and periodontal disease, can be psychologically traumatic, socially damaging, and functionally limiting (1, 2). The average global prevalence of edentulism reaches about 7% in individuals aged 20 years or older and 23% in those aged 60 years or older (2). Implant rehabilitation of edentulous patients represents a valid method in daily clinical practice with well-standardized procedures and excellent predictability, overcoming the poor retention and instability typical of removable complete dentures (3, 4). Unfavorable anatomical characteristics represent the main limitation of these forms of implant-prosthetic rehabilitation due to the presence of severe atrophy of the maxillary bones (3, 5). Bone augmentation techniques and the use of bone grafts have therefore been introduced to enable implant placement in anatomically compromised sites, maxillary sinus lifts, and the transposition of the inferior alveolar nerve (3, 6). It is also important to remember the relevance of introducing morphological implant types aimed at resolving different types of atrophy and compromise of the maxillary bones, such as short implants (6 mm), ultra-short implants (4 mm), pterygoid implants, and zygomatic implants (7, 10). Another rehabilitation technique is represented by juxta-osseous grids (10).



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How to Cite

Alberto Gasbarri, Giulia Caporro, Sofia Rastelli, Giulia Ciciarelli, Mauro Arcangeli, Antonio Capogreco, Maurizio D'Amario.

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Annali Di Stomatologia, 17(1), 179-188. <https://doi.org/10.59987/ads/2026.1.179-188>

Developed by Brånemark and first proposed by Aparicio, zygomatic implants have revolutionized treatment in cases of severe maxillary atrophy (6). Zygomatic implants are long, self-tapping implants that, when anchored in the zygomatic bone, allow immediate loading interventions to be performed, avoiding the need for complex regenerative procedures (1, 6). The favorable success rate of zygomatic implants compared with that of conventional implants across various clinical conditions makes them a valid and effective option for the rehabilitation of the severely atrophic maxilla (11, 12).

An implant-prosthetic rehabilitation using zygomatic implants must consider the type of restoration planned, the anatomy of the residual ridge and the zygomatico-maxillary region, the patient's general health and expectations, as well as the experience of the surgical team. To date, the literature does not define a minimum amount of bone required for the insertion of short implants or for simultaneous placement and grafting procedures as a valid alternative to zygomatic implants. The main indication for the use of zygomatic implants is therefore considered "extreme maxillary bone atrophy", typical of: (a) patients who do not have adequate alveolar bone for whom regenerative treatment would be indicated, but which would not be desirable due to medical contraindications to the grafting procedure; (b) patients with a previous history of failed oral implantology and/or regenerative surgery; (c) patients undergoing maxillary resection secondary to pathology or trauma; (d) patients with congenital deformities that have led to the absence of maxillary bone, such as cleft palate (1, 6, 11).

Surgical techniques for the insertion of zygomatic implants are divided into intra- or extra-sinus, depending on whether or not the inserted implant passes through the maxillary sinus (12).

Despite the evolution of surgical techniques, zygomatic implantology interventions are highly complex, mainly due to the presence of contiguous noble anatomical structures such as the maxillary sinus, the infraorbital nerve, the orbit, and the infratemporal fossa. The most frequent complication following zygomatic implant insertion is sinusitis; further postoperative complications include paresthesia of the infraorbital or zygomaticofacial nerves and the formation of oroantral fistulas (12, 13).

The preparation of the implant site for zygomatic implant insertion can be performed using the traditional technique with rotating burs or with piezoelectric devices and dedicated inserts.

Conventional rotating burs mounted on an implant motor, although a valid operative method, are associated with a greater risk of tissue damage, heat generation, and reduced visibility of the operative site (14). Piezoelectric devices in the fields of oral surgery, periodontology, and implantology represent a valid alternative to conventional instruments for the execution of personalized, minimally invasive osteotomies through the use of high-frequency ultrasonic vibrations (16, 17). The piezoelectric crystals contained in the piezoelectric handpiece expand and contract when an electric current is applied, generating

microvibrations that are transmitted to the cutting insert (17, 18). These vibrations have a frequency of 25-29 kHz and an amplitude of 60-200 μm , allowing the operator to perform an atraumatic bone cut and minimize damage to soft tissues (17, 18). This amplitude allows only the mineralized tissue to be cut; in fact, soft tissues require frequencies above 50 kHz (19, 20). During the execution of the osteotomy, part of the mechanical energy produced is converted into thermal energy, which, partially dissipated by the refrigeration system of the piezoelectric unit and the outflow of physiological solution at a flow rate of 0-60 ml/min, helps prevent overheating (18, 21). The physiological solution in contact with the insert, vibrating at an ultrasonic frequency, generates cavitation due to mechanical micromovements at about 25-30 kHz (19). This phenomenon is responsible for reducing bleeding, favoring hemostasis, optimal intraoperative visibility, cleaning of the osteotomy sulcus, tissue oxygenation, a good postoperative course, and, in the field of implantology, preventing the escape of bone fragments from the surgical site (18, 20).

The potential advantages of piezoelectric surgery favor its use in preparing the surgical site for the insertion of zygomatic implants. The precise, selective cutting capacity of these inserts favors their use near noble anatomical structures, reducing the risk of complications such as sinus membrane perforation, bleeding, or damage to the infraorbital nerve. Furthermore, the cavitation effect induced by ultrasonic vibrations enhances intraoperative visibility, thereby enabling more accurate and safer implant placement (12, 15).

The validity of both techniques for preparing implant sites is highlighted in the following case report, which shows how patients suffering from severe maxillary atrophy can, when the anatomy of the specific case allows, be rehabilitated by inserting zygomatic and paranasal implants. The implant preparation of zygomatic implants is therefore performed using an extra-sinus approach, combining piezosurgery and the traditional technique, depending on the intraoperative phase and bone density. The introduction of ultrasonic instrumentation into zygomatic implantology interventions allows for the exploitation of the advantages this method offers over traditional rotating instrumentation alone, thereby reducing the invasiveness of the surgical procedure.

Case description

A 76-year-old male patient presented to the authors with an upper skeletal prosthesis and masticatory difficulties.

The patient's medical history revealed that he was being treated with Ramipril 10 mg tablets for hypertension. The patient underwent both clinical and radiological evaluations.

Intraoral examination and panoramic radiographic assessment (Figures 1 and 2) indicated the need for implant-prosthetic rehabilitation treatment.

After analyzing the second-level radiographic examination, specifically the CBCT scan, and in agreement with the patient, it was decided to fulfill his specific request to perform a fixed prosthetic rehabilitation with implant support.

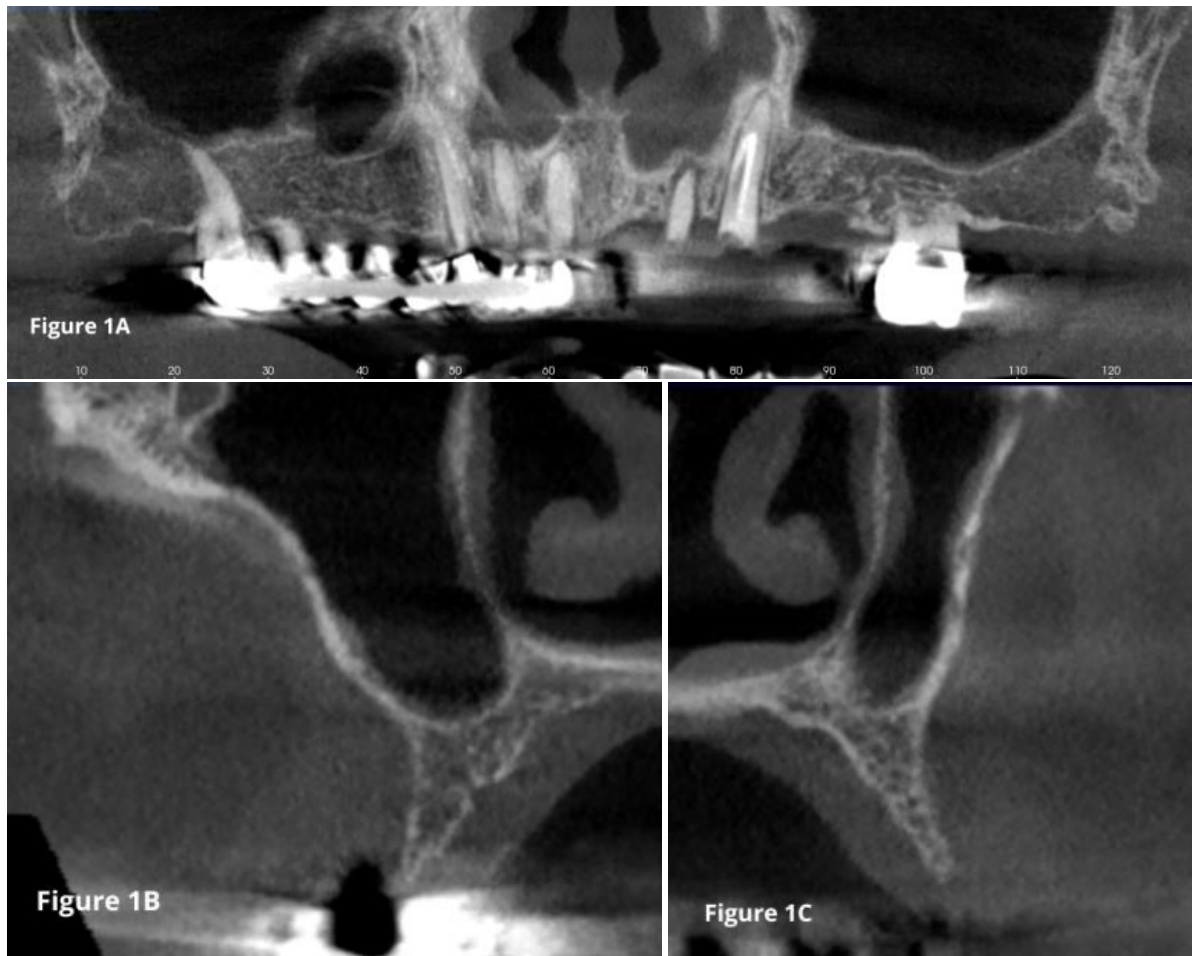


Figure 1. 1A: Pre-operative panoramic radiograph; 1B: Right coronal section; 1C: Left coronal section.



Figure 2. Intraoral clinical examination.

To achieve optimal implant-prosthetic rehabilitation given the severe maxillary atrophy, it was decided to perform a Hybrid Zygoma intervention with the insertion of two zygomatic implants, two paranasal implants in regions 1.2 and 2.2, and a pterygoid implant in the second quadrant.

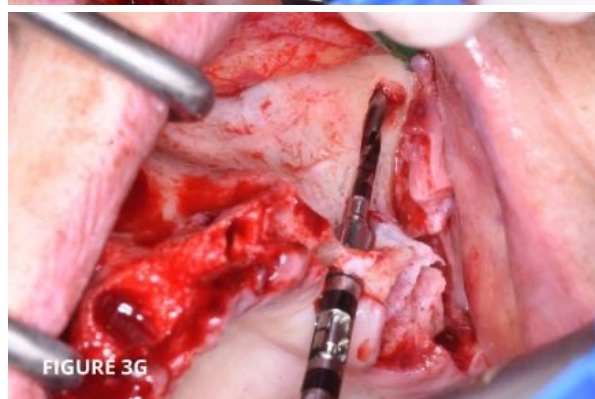
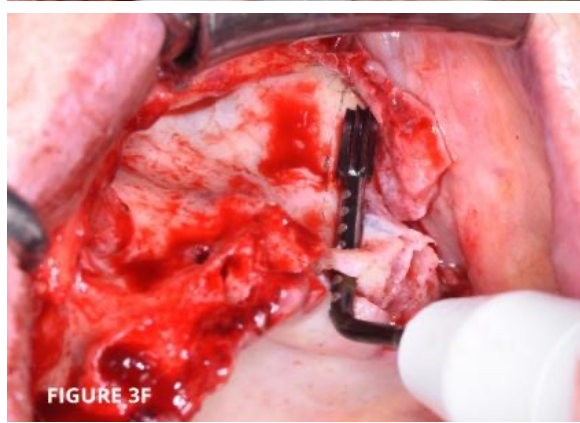
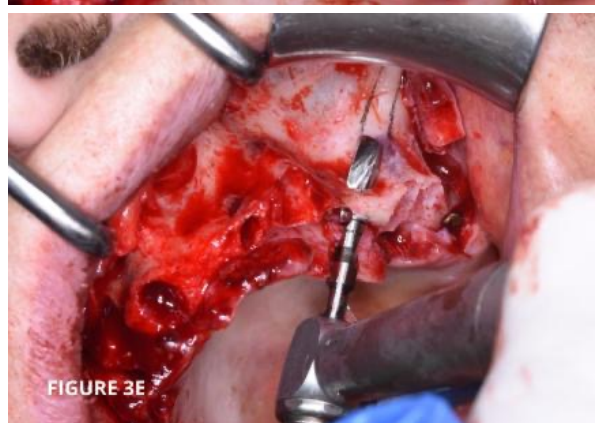
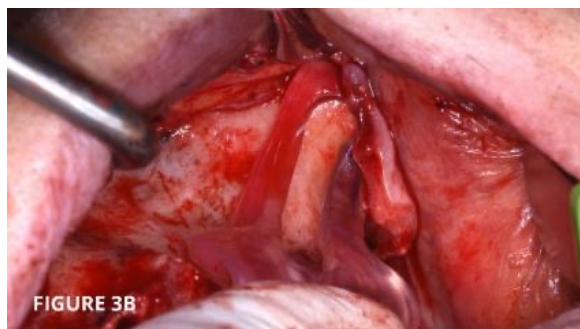
The surgical procedure was then carried out (Figure 3). The intervention was performed under general anesthesia, following an anesthesiological consultation and preoperative examinations.

From a dental perspective, the procedure was performed

using a block anesthesia of the infraorbital, greater palatine, and nasopalatine nerves with Mepivacaine 3% and plexus anesthesia with Mepivacaine 2% with adrenaline 1:100,000.

Following the extraction of the residual dental elements, a full-thickness mucoperiosteal flap was raised, paramarginal in the palatal direction, from the midline to the area ideally occupied in the arch by the second molar, with a vertical posterior releasing incision at the level of the retromolar trigone.

The flap was carefully dissected both at the vestibular level and at the level of the palatal fibromucosa for its entire length. The flap was released buccally to allow skeletonization of the maxillary bone. The exposure of the anterolateral face of the maxillary bone allowed the identification of the nasal fossae, skeletonizing the piriform aperture to mobilize the flap, and the infraorbital foramen with the emergence of the homonymous nerve. In the buccal dissection phase, the zygomatic process of the maxillary bone was then reached, highlighting the body of the zygomatic bone and exposing its temporal portion. The zygomatic arch was skeletonized in the coronal, caudal, and posterior directions to highlight the zygomatic knob, and the anterior zygomatic insertion of the masseter muscle was identified and sectioned, allowing control of the entire zygomatic body. The emergence of the infraorbital nerve was highlighted with



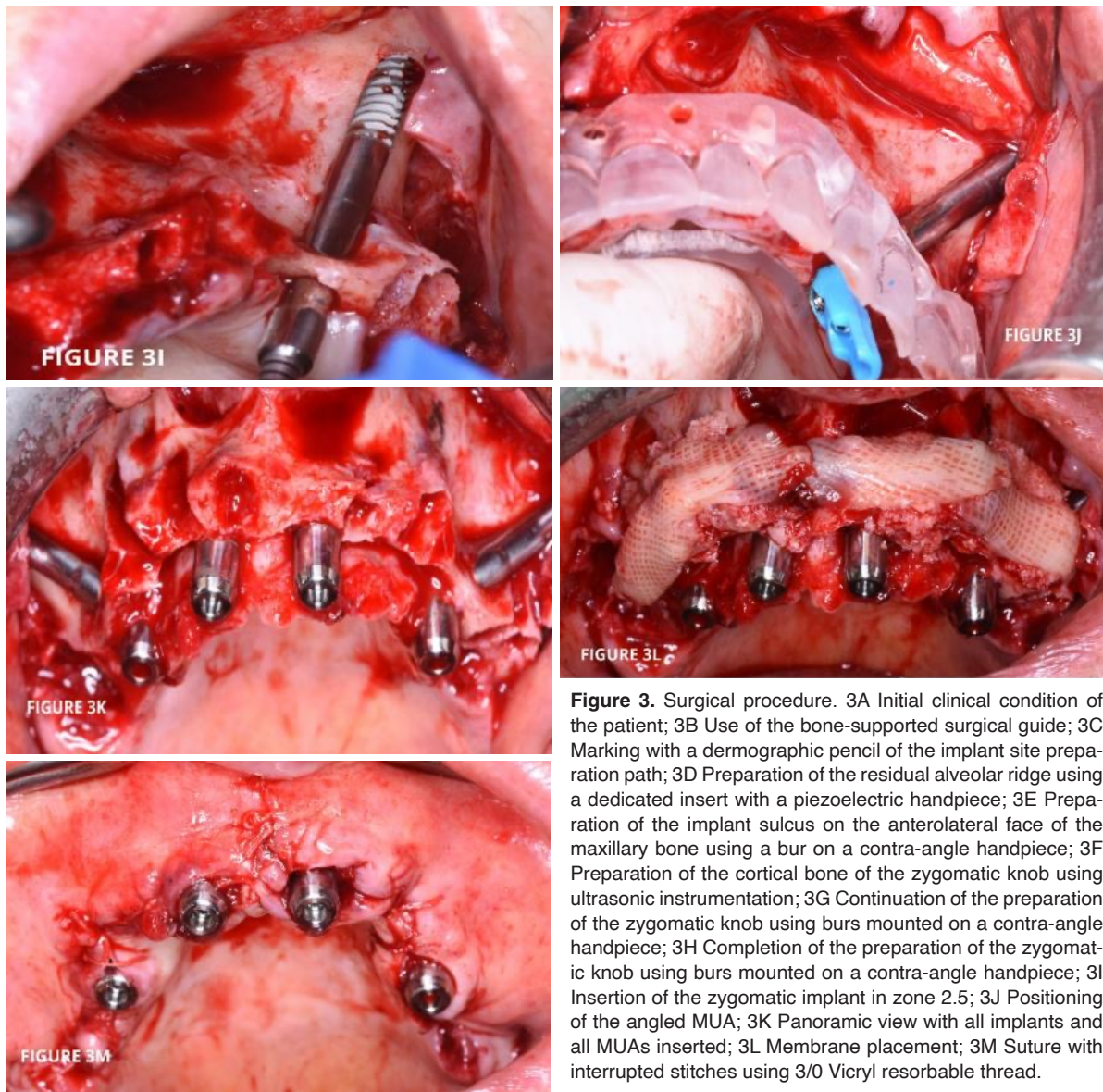


Figure 3. Surgical procedure. 3A Initial clinical condition of the patient; 3B Use of the bone-supported surgical guide; 3C Marking with a dermographic pencil of the implant site preparation path; 3D Preparation of the residual alveolar ridge using a dedicated insert with a piezoelectric handpiece; 3E Preparation of the implant sulcus on the anterolateral face of the maxillary bone using a bur on a contra-angle handpiece; 3F Preparation of the cortical bone of the zygomatic knob using ultrasonic instrumentation; 3G Continuation of the preparation of the zygomatic knob using burs mounted on a contra-angle handpiece; 3H Completion of the preparation of the zygomatic knob using burs mounted on a contra-angle handpiece; 3I Insertion of the zygomatic implant in zone 2.5; 3J Positioning of the angled MUA; 3K Panoramic view with all implants and all MUAs inserted; 3L Membrane placement; 3M Suture with interrupted stitches using 3/0 Vicryl resorbable thread.

a dermographic pencil, drawing a horizontal line above the homonymous foramen, which was then directed towards the zygomatic knob. This delineated the safety area within which the surgeon could operate, avoiding complications secondary to orbital involvement.

Subsequently, a preliminary phase of surgical site preparation was performed using a bur or bone rongeur to level the residual alveolar bone and obtain a bone plateau.

The use of a bone-supported surgical guide, constructed from the stereolithographic model, allowed the preparation to be oriented by tracing the implant preparation trajectory with a dermographic pencil.

The preparation of the surgical site began with the execution of the osteotomy on the anterolateral wall of the maxillary bone, on the plane that ideally connects the buccal region of the residual bone crest to the zygomatic knob. Using a traditional bur on an implant motor, a groove was then prepared on the

anterolateral wall of the maxilla, delineating the extra-sinus preparation path, in which the body of the implant would be placed without invading the maxillary sinus, ensuring that the Schneiderian membrane remained intact.

The preparation of the residual alveolar ridge was then continued using the piezoelectric motor, maintaining the bone bridge at the crest level.

Finally, following the previously created groove, the cortical bone of the zygomatic knob was prepared, maintaining the angulation provided by the previous preparatory phases. At this point, the zygomatic bone was prepared using appropriate ultrasonic inserts combined with traditional burs on an implant motor, with the bur in the previously prepared site, and then proceeding with spiral rotating burs.

The implant length was confirmed by measuring the preparation depth with a millimeter probe.

The next phase involved inserting the implant using

an implant motor with a minimum torque of 35 Ncm, ensuring favorable crestal emergence for access to the prosthetic abutment. The implant tightening torque of at least 35 Ncm allowed the insertion of the MUAs at 60°, which were then tightened and protected by a healing cap for immediate loading.

In each hemiarch, a zygomatic implant measuring 3.5 mm in diameter and 42.5 mm in length was inserted, along with a paranasal implant measuring 3.3 mm in diameter and 13 mm in length.

After completing the right hemiarch, the procedure continued on the left hemiarch, performing the same surgical procedures.

Following implant placement, a regenerative procedure with CGF was performed.

The procedure ended with suturing the flap with interrupted sutures using 3/0 Vicryl resorbable thread, and attention to the initial incision ensured an adequate band of attached gingiva around the abutments.

After the surgical phase and hemostasis control, an impression was taken.

After hemostasis was achieved, the patient was discharged with prescriptions for antibiotics and

analgesics and postoperative instructions regarding home hygiene and dietary guidelines.

The pharmacological treatment consisted of:

- Amoxicillin and Clavulanic Acid 1 g (CPR), twice a day for 6 days, starting three days before surgery;
- Metronidazole (AUROBINDO) 250 mg (CPR), twice a day for 10 days, starting three days before surgery;
- Pantoprazole 40 mg (CPR), once a day for 6 days, starting the day before surgery;
- Sodium dexamethasone phosphate 0.2% (oral drops), from the day after surgery according to the following protocol:
- Naproxen sodium 550 mg (CPR), 1 tablet every 12 hours as needed for a maximum of 3 days;
- 0.5% chlorhexidine digluconate gel for plaque control, twice daily after home oral hygiene, starting 24 hours after surgery for 15 days.

The prosthetic work was delivered 4 hours after surgery, and an occlusal increase of the lower arch was performed at the same time (Figure 4). A panoramic radiograph was then taken at the end of the prosthetic work delivery (Figure 5).



Figure 4. Delivery of the prosthetic work 4 hours after surgery.

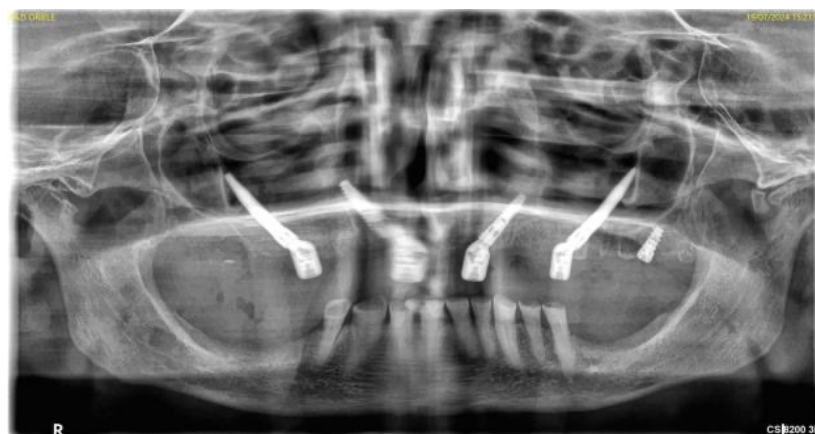


Figure 5. Post-operative panoramic radiograph.

A follow-up CBCT scan was performed two years after surgery. The Schneiderian membrane showed physiological ventilation with no signs of inflammation (Figure 6).

Discussion

The use of autologous bone grafting raises concerns due to morbidity at the donor site and increased treatment times, often proving incompatible with the needs of individual patients who experience problems that affect them on a functional and social level. Therefore, alternative techniques have been developed and introduced for the treatment of severely atrophic edentulous patients.

Zygomatic implants were introduced for the oral rehabilitation of patients with severe and extensive maxillary defects caused by post-oncological resections, trauma, congenital malformations, or edentulism. Today, zygomatic implants represent a valid therapeutic option with high success rates (15, 23). Factors influencing long-term implant success, and consequently the achievement of osseointegration, include the presence of vital bone in close contact with the implant, primary stability, bone density, and surgical site preparation (29).

The execution of careful, atraumatic, and correct preparation of the implant site, therefore, allows osseointegration (25, 30).

As evidenced in the literature, the preparation of the implant site in zygomatic implantology can be performed either with a conventional preparation technique using rotating burs or with dedicated inserts mounted on a piezoelectric motor (24, 25). Both methods have peculiarities that make them suitable and advantageous for the execution of specific operative phases; the surgeon's skill therefore lies in knowing how to integrate them, exploiting the advantages that

each technique brings by adapting the surgical strategy to the needs of the individual patient (24).

From Li's studies, the comparison between osteotomies performed with the conventional preparation protocol and with piezoelectric inserts concluded that the method used, regardless of the equipment, may not influence implant survival rate (31). However, Bassi argues that piezoelectric surgery can surpass the traditional method for implant osteotomy by promoting implant secondary stability at 1, 2, and 3 months after placement (32).

Rotating burs are widely used because they are easy to handle, reduce intraoperative times, and are not excessively expensive (22). However, the heat they generate during preparation can cause tissue damage, necrosis of surrounding structures, difficulty in providing correct three-dimensional positioning, and the risk of invading noble anatomical structures such as the infraorbital nerve, the lower edge of the orbit, and the Schneiderian membrane (27-28).

In the literature, the importance of piezoelectric surgery is mainly associated with the execution of a micrometric cut and the preservation of soft tissues. Several studies also highlight that piezoelectric bone surgery promotes healing by inducing early increases in BMP-4 and TGF- β 2 levels, reducing inflammation, and accelerating bone remodeling (33). Furthermore, compared with osteotomy performed with traditional burs, piezoelectric surgery results in less osteoclastic activity and more favorable bone healing at the surgical site, with lower RANKL levels (34).

All these advantages allow for a precise and safe crestal osteotomy, as the pivoting piezoelectric handpiece's shape eliminates the wobbling phenomena commonly observed with rotary handpieces. Therefore, piezoelectric surgery makes the initial crestal osteotomy more accurate and, through cavitation, facilitates rapid migration of osteoprogenitor cells and the elimination



Figure 6. 2-year follow-up coronal section.

of bone fragments and intraoperative tissue debris, promoting early healing (35).

Piezosurgery is therefore particularly useful in the initial stages of surgery; incision and tissue detachment are less traumatic, reducing bleeding and promoting healing by reducing possible postoperative edema. Furthermore, the precision of the ultrasonic cut makes this method ideal for performing the osteotomy near critical anatomical structures, such as the infraorbital nerve, minimizing the risk of injury. In patients with particularly dense bone, piezosurgery may also be preferred for preparing the implant site, avoiding overheating of the bone and consequent necrosis, which could compromise osseointegration of the implants (15, 16, 18).

On the other hand, the traditional technique with rotating burs remains valid, especially in phases that require greater power and speed of execution. In the presence of bone that is not excessively dense and in the absence of critical structures, rotating burs allow the osteotomy to be performed effectively and quickly, reducing the overall surgical time (28 – 30).

A careful preoperative evaluation of bone density using second-level examinations, such as CBCT, is essential in this type of intervention, as it allows the surgeon to identify the best sites for implant placement and the specific surgical procedure to be used. Bone density, in fact, significantly influences the primary stability of the implants, tissue healing, and the long-term success of implant rehabilitation (29).

In general, piezoelectric surgery may be preferred for low-density bone (D3-D4), where precision of the cut and reduced trauma are crucial for implant success. Rotating burs, on the other hand, can be used with caution in dense bone (D1-D2), with care to avoid overheating and damage to soft tissues (39). In recent years, there has been a growing interest in minimally invasive techniques in zygomatic implantology. The “Zygomatic Minimally Invasive Technique” is an example of this approach, which aims to reduce surgical trauma and improve patient comfort (40). Piezoelectric surgery, with its precision and ability to preserve soft tissues, fits perfectly into this trend (40).

Aspects of fundamental importance in surgical planning are therefore represented by the influence of milling protocols and bone density on subsequent implant stability, particularly on the Implant Stability Quotient (ISQ). A careful assessment of bone quality must guide the choice of milling protocol and instruments to maximize the primary and secondary stability of the implant.

As highlighted by Stacchi, following implant placement, an initial decrease in primary stability may be encountered, followed by a significant increase during the healing period (37). The primary and secondary stability of the implant, measured following osteotomy using traditional or piezoelectric instrumentation, is not statistically significant. However, at 4 months after implant placement, the second method appears to be more favorable (29, 37).

Although there is no significant difference in the detection of implant stability as a function of the surgical method used for the osteotomy, the use of

piezoelectric surgery can still positively influence the osseointegration of the implant thanks to its advantages at the biological level that reduces the activity of pro-inflammatory cytokines and promotes the synthesis of osteoprogenitors, as shown in several studies (31, 34). The combined approach, which integrates piezosurgery and traditional techniques, therefore represents an ideal solution to personalize the intervention and maximize results. For example, in a patient with dense bone and complex anatomy, the surgeon could use piezosurgery for the most delicate phases, such as incision, detachment, and osteotomy near the infraorbital nerve, and then move on to traditional burs to complete the osteotomy and insert the implants.

The choice of the most appropriate surgical strategy rests with the surgeon, who must carefully evaluate several factors, including their own experience with both techniques, the patient's bone density, the presence of complex anatomies, and the preferences of the patient himself, who must be involved in the decision-making process and informed about the benefits and risks of each approach. Careful preoperative planning, based on a three-dimensional radiographic analysis (CBCT) and a complete clinical evaluation, is essential to define the most effective and personalized surgical strategy.

The ultimate goal is always to ensure maximum safety and the best clinical outcome for the patient, promoting rapid and predictable healing and optimal osseointegration of the implants. The combined approach, which integrates piezosurgery and traditional techniques, therefore represents the ideal solution to personalize the intervention and maximize results while ensuring maximum patient safety.

Conclusions

Currently, there are no specific protocols that define the combined use of piezoelectric surgery and rotating burs based on bone density. However, it is essential to adapt the surgical technique to the patient's individual characteristics, taking into account bone density, anatomy, and specific needs. The combined use of piezoelectric surgery and the traditional technique in the operative phase, supported by a solid knowledge of anatomy, careful preoperative planning, and a careful assessment of the patient's needs, represents an evolved and promising approach in zygomatic implantology, which contributes to improving the safety, predictability, and effectiveness of the procedure, reducing the risk of complications and promoting healing, opening new perspectives in oral rehabilitation in patients with severe maxillary atrophy.

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