Annals of Stomatology
ISSN 2975-1276

Case Report

REHABILITATION OF A SEVERELY ATROPHIC MAXILLA USING IMMEDIATELY LOADED ZYGOMATIC IMPLANTS PLACED WITH PIEZOELECTRIC PREPARATION OF THE IMPLANT TUNNEL

R. Pistilli[1], C. Barausse[2], L. Bonifazi[2], G. Pellegrino[2], S. Tayeb[2], C. Angelino[2] and P. Felice[2]

[1]Oral and Maxillofacial Unit, San Camillo Hospital, Rome, Italy;
[2]Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy

Correspondence to:
Pietro Felice MD, DDS, PhD
Department of Biomedical and Neuromotor Sciences,
Unit of Oral Surgery,
Alma Mater Studiorum,
University of Bologna,
Via San Vitale, 59
40120 Bologna - Italy
e-mail: pietro.felice@unibo.it

ABSTRACT

A surgical approach to implant site preparation in the rehabilitation of an atrophic maxilla with immediately loaded zygomatic implants is described. A 60-year-old systemically healthy female with severe maxillary atrophy was treated with immediately loaded zygomatic implants, placed after preparing the implant site with a piezoelectric device. Two different types of piezoelectric inserts were used to make the procedure safer. Wound healing was uneventful. There was no paraesthesia or neurological damage, and postoperative edema was minimal. Clinical and radiographic examinations showed the success of prosthetic rehabilitation from both the functional and esthetic points of view.

KEYWORDS: *maxillary atrophy, immediate loading, zygomatic implants, piezoelectric*

INTRODUCTION

The rehabilitation of patients with severely atrophied maxillae is challenging because of the complexity of the situation for implant placement. The problem is due to the lack of height and width of the alveolar ridge as a result of insufficient bone due to resorption, trauma, infection, and resective oncological surgery. These people have more problems in adapting to conventional dentures because of the lack of retention, so several surgical techniques have been developed to increase bone volume: guided bone regeneration (GBR) procedures (1), onlay (2-6), Le Fort I with interpositional grafting (7, 8), and sinus augmentation (9-11). However, the number of complications and failures with these augmentation procedures is still too high (well over 20%) to recommend their widespread use (5).

One solution may be to accept the lack of direct bone availability within the maxilla and instead use tilted implants in the parasinus region (12, 13), implants in the pterygoid apophysis (14), short implants (15, 16), and zygomatic

Received: 29 April 2024
Accepted: 04 June 2024

ISSN 2975-1276 [online]

implants. Zygomatic implants, introduced by Brånemark in 1988 (17), can be inserted using five surgical approaches, depending on the anatomical configuration:

1) the 'classical' approach (18, 19);
2) the sinus slot technique (20, 21);
3) the exteriorized approach (22);
4) the minimally invasive approach, using custom-made drill guides (23);
5) the computer-aided surgical navigation system approach (24, 25).

Prospective studies have shown that zygomatic implants can be used successfully for the rehabilitation of patients with extreme maxillary atrophy, also with immediate loading, with survival rates from 71 to 100% (19, 21).

However, the placement of zygomatic implants requires experienced surgeons; it is not risk-free because delicate anatomical structures, such as the orbit and brain, may be involved, especially during implant site preparation with drills (26). Ultrasonic osteotomy allows precise and effective bone cutting without damaging adjacent soft tissues. Thus, piezoelectric devices, used widely in traditional oral implantology (27, 28), may also be useful in zygomatic implant surgery to reduce surgical risks, complications, and morbidity.

In this case report, we describe a surgical approach to rehabilitation in a case of severe maxillary atrophy with four immediately loaded zygomatic implants placed using a piezoelectric device for implant site preparation.

CASE REPORT

A 60-year-old systemically healthy female was referred for a fixed prosthetic rehabilitation of a totally edentulous maxilla.

Surgical planning

On clinical examination, there was an important loss of the "Vertical Dimension of Occlusion" (VDO) extra-orally and an upper jaw with a bony crest that was very thin, vertically resorbed, and irregular intra-orally (Fig. 1).

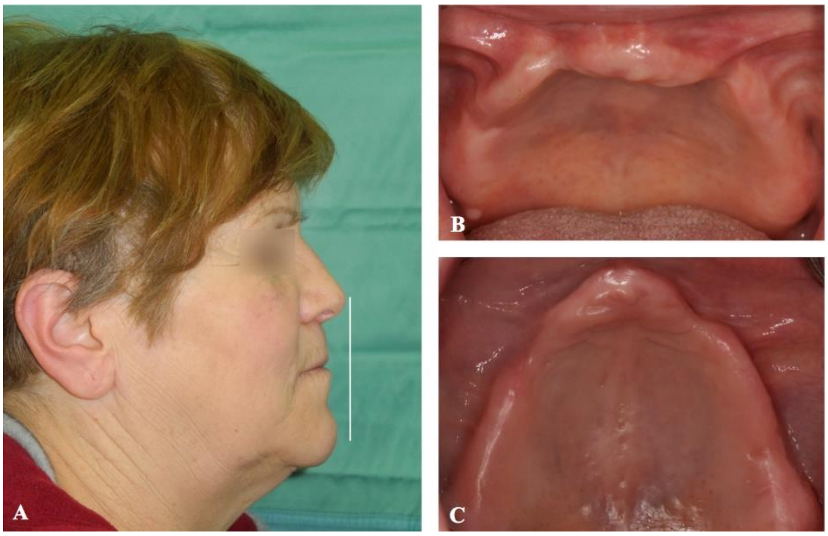

Fig. 1. ***(A)*** *Pre-operative extra-oral clinical situation revealing an important loss of the "vertical dimension of occlusion" (VDO; white line); pre-operative intra-oral clinical photographs showing the upper jaw bone resorption.* ***(B)*** *Vestibular aspect.* ***(C)*** *Occlusal aspect.*

A preliminary radiographic study [Orthopantomography (OPT) and Cone-Beam Computed Tomography (CBCT)] and a three-dimensional stereolithographic model revealed severe maxillary atrophy (class IV, according to Cawood and Howell (Fig. 2).

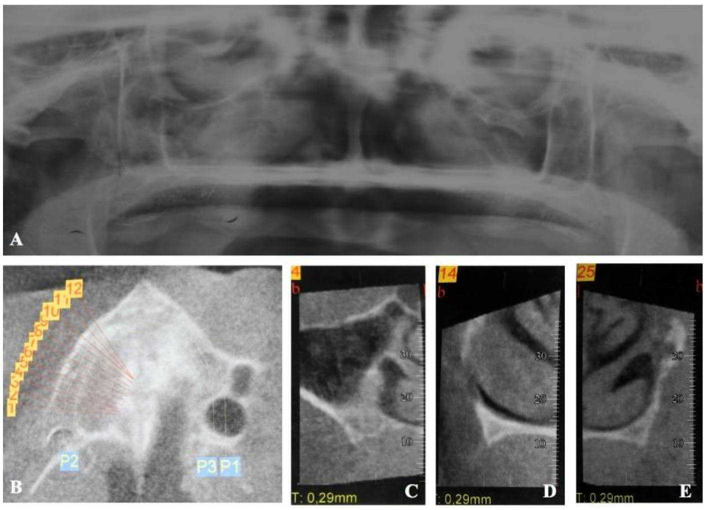

Fig. 2. P*re-operative Orthopantomography (OPG) (**A**) and CBCT series revealing bone atrophy (Cawood and Howell class IV). (**B**) axial section. (**C**) section 4 (right maxilla). (**D**) section 14 (**pre-maxilla**). (**E**) section 25 (**left maxilla**).*

CBTC sections showed a mean residual bone height of 7 mm and a mean residual bone width of 1.5 mm. This major and irregular atrophy, due to the early loss of teeth due to periodontal disease (the patient had been wearing a complete removable denture for 15 years), did not allow conventional implant placement and made successful reconstructive and regenerative surgery difficult. Consequently, since the patient requested prosthetic rehabilitation in the shortest possible time without extraoral donor sites, placing implants anchored in the zygomatic bone was suggested.

The requirements of the Declaration of Helsinki were observed. The patient gave written informed consent for all surgical procedures.

Zygomatic implant placement

One hour before the beginning of the surgery, the patient performed rinses for 60 s with 15 mL of a solution of chlorhexidine gluconate 0.12% and was given amoxicillin plus clavulanic acid (2.2 g, intravenously; Augmentin, GSK Pharma, Brentford, UK). Surgery planned using the stereolithographic model was performed under general anesthesia with rhino-tracheal intubation. An incision in the soft tissue along the entire maxillary crest, from the right tuber maxillae to the left, was first drawn with a dermographic marker and then made with a scalpel; three relieving incisions, one central and two distal, were also made. Then, the soft tissue was reflected entirely from the maxillary crest to the zygomatic buttress along the infrazygomatic crest, and the suborbital nerve was identified. The exposure was extended around the base of the piriform rim; the nasal mucosa was dissected to increase visibility and provide a detailed picture of the local anatomy. Anterior fibers of the masseter muscle were dissected for ~1 cm, and the Bichat's fat pad was exposed (Fig. 3A).

Sinus windows were drawn bilaterally with a sterile pencil in relation to the axis of implant placement. Then, the windows were opened using a round bur in the uppermost lateral aspect of the sinus wall. The Schneiderian membranes were then reflected. The windows provided direct visibility of the roof of the sinus and enabled localization of the optimal point for implant entrance (Fig. 3B). The proper implant axis, drawn on the bone with a sterile pencil, was a path that extended from the premolar region through the maxillary sinus, entering the midportion of the zygomatic body.

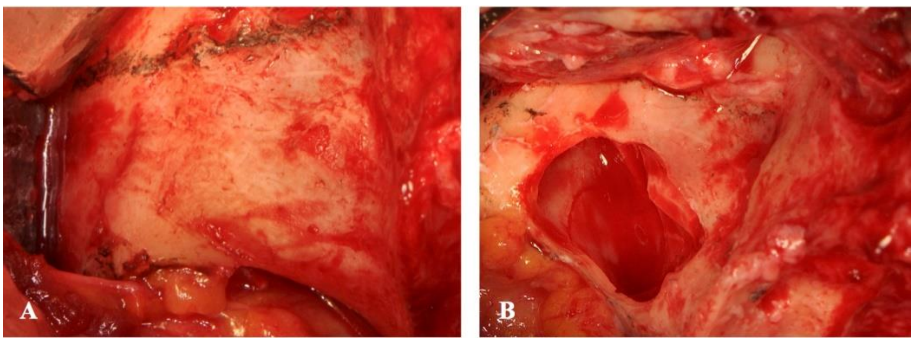

Fig. 3. *Exposure extension to the right zygomatic buttress (**A**); right maxillary sinus window, opened in the uppermost lateral aspect of the sinus wall. The Schneiderian membrane has been reflected (**B**).*

In this case, the implant tunnel was prepared with a piezoelectric device (Esacrom S.r.l., Imola, Bologna, Italy). It was used with two different piezoelectric inserts (Esacrom S.r.l.) with double internal irrigation, having a total length of 90 mm with a first angled part and a straight part (Fig. 4). The two inserts differ in terms of tip shape: conical (2.9-mm diameter) with micro-sharp blades (Fig. 4A) or diamond-shape (3.5-mm diameter) with blades (Fig. 4B). These zygomatic inserts were manufactured from medical stainless steel with T-black finishing, obtained with a double-coated nanostructure surface treatment that allows heating tissue reduction and has greater resistance to wear and corrosion.

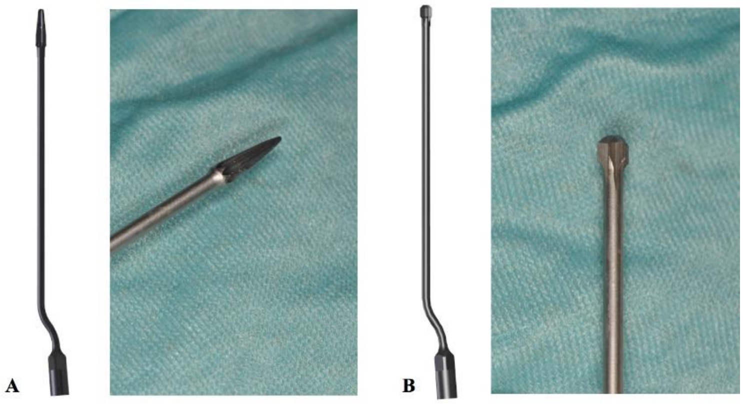

Fig. 4. *Piezoelectric inserts, 90 mm long, manufactured from medical stainless steel with T-black finishing. (**A**) conical tip shape (2.9-mm diameter). (**B**) diamond tip shape (3.5-mm diameter).*

The conical-shaped tip insert was used to prepare the implant tunnel. It was inserted in the residual alveolar bone and was then taken out at the base of the sinus window; in this way, the implant had an endosseous path also at the level of the atrophic crest, providing better primary stability (Fig. 5A). Subsequently, the tip of this insert, due to its length, passing through the maxillary sinus, entered the midportion of the zygomatic body and came out from the zygomatic malar face (Fig. 5B). During this critical phase, the piezoelectric device can be particularly useful in minimizing the risk of damage to the edge of the orbit, reducing the rate of periorbital hematomas and orbital injuries.

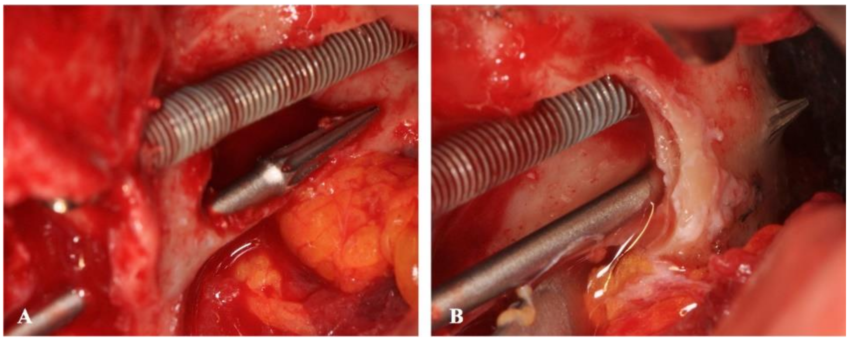

Fig. 5. *Conical-shaped tip insertion in the left residual alveolar bone to improve implant stability (**A**), and the tip of the conical-shaped insert coming out from the left zygomatic malar face (**B**).*

The diamond-shaped tip insert was then used to widen the tunnel to the desired size (3.5 mm) in relation to the implant diameter (4 mm) (Fig. 6). A depth indicator was then inserted into the site to determine the correct length of the zygoma fixture.

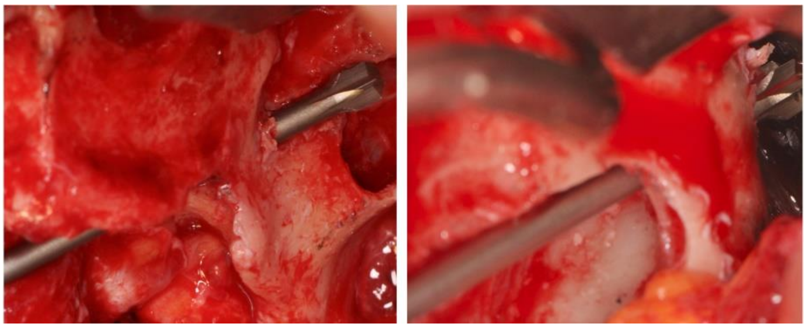

Fig. 6. *Diamond-shaped tip insert used to widen the tunnel preparation.*

Four zygomatic implants (Zygoma TiUnite Implant Brånemark System, Nobel Biocare AB, Goteborg, Sweden) with a 45° angulated head were used. Posteriorly, two implants (42.5 × 4 mm and 45 × 4 mm) were placed, one on each side, and two more implants (40 × 4 mm) were placed anteriorly, one on each side (Fig. 7).

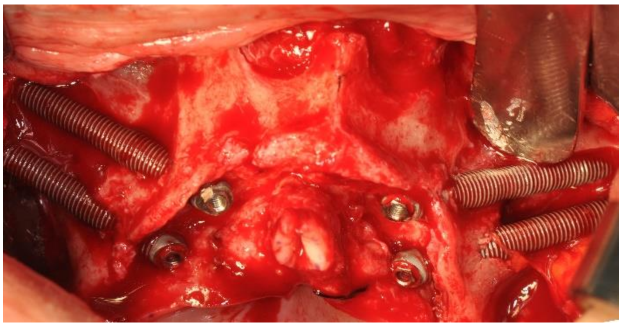

Fig. 7. *Four zygomatic implants were placed. Posteriorly, two implants (42.5 × 4 mm and 45 × 4 mm) were placed, one on each side, and two more implants (40 × 4 mm) were placed anteriorly, one on each side.*

Implants were inserted slowly until their apical portion was anchored in the alveolar crest and then manually inserted to an adequate depth; the insertion torque was 40 Ncm at 20 rpm. The apical portion of the implant was embedded in ~8-10 mm of the zygomatic bone; if necessary, some threads had emerged from the bone body for better stability. The zygomatic implants were positioned in the premolar and molar zones.

Prosthetic phases

We connected the 17° angled multi-unit abutments, 3 mm high (Zygoma 17° Multi-unit Abutment Brånemark System) to the implants. Because the implant insertion torque was greater than 35 Ncm, an immediate-loading protocol was initiated, and pick-up transfers were positioned. Bichat's fat pads, rich in pluripotent cells, were gently shifted medially to cover the exposed implant threads to ensure better healing. Tissues were then sutured with simple interrupted 4-0 resorbable sutures (Vicryl, Ethicon FS-2, Johnson & Johnson, New Brunswick, NJ) and self-curing acrylic resin (Pattern Resin, GC, Alsip, IL, USA), positioned on a brass wire, was used to secure abutment transfers in position (Fig. 8A). A pick-up impression was then completed using a polyester material (Impregum, 3M ESPE, Pioltello, Milan, Italy); the previous prosthesis, with a hole in the resin palate, was used as the tray and healing caps were then positioned (Fig. 8B). The postoperative pharmacological therapy was then established: 2.2 g of amoxicillin plus clavulanic acid (Augmentin) and 500 mg of metronidazole, twice per day for 5 days, intravenously, omeprazole once per day in the evening for 5 days, Bentelan (Biofutura Pharma S.p.A., Rome, Italy) 4 mg on the evening after surgery, 3 mg the day after, 2 mg 2 days after, and 1 mg 3 days after surgery. The patient was also recommended to perform gentle rinses for 60 s with 15 mL of chlorhexidine gluconate 0.12% twice daily.

The provisional prosthesis, prepared in acrylic resin and reinforced with a titanium structure, was delivered 24 h after the surgery (Fig. 8C).

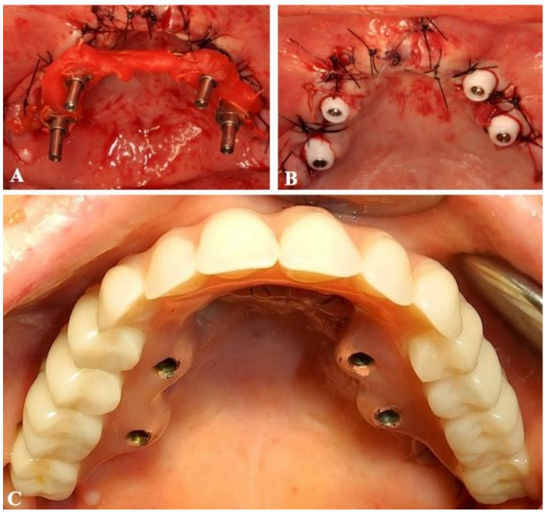

Fig. 8. *Self-curing acrylic resin, positioned on a brass wire, used to secure the abutment transfer position for the pick-up impression (**A**) and healing cap positioning after the pick-up impression (**B**). Provisional prosthesis delivered 24 h after the surgery (**C**).*

The patient was monitored clinically at 6, 12, 21, and 28 days after surgery and then up to 4 months. The radiographic control was performed 48 h after surgery (Fig. 9).

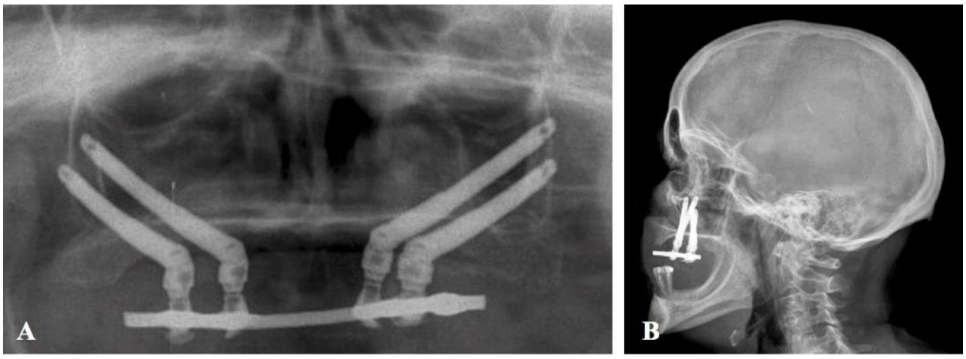

Fig. 9. *Post-operative OPG (**A**) and latero-lateral teleradiography (**B**).*

Sutures were removed after 12 days. The postoperative course and wound healing were uneventful. There was no paraesthesia or neurological damage, and postoperative edema was minimal (Fig. 10).

Fig. 10. *Extra-oral clinical situation 24 h after surgery. Note minimal postoperative edema (**arrow**).*

Clinical and radiographic controls showed the success of the prosthetic rehabilitation from both functional and esthetic perspectives.

DISCUSSION

The evolution of osseointegrated implant concepts has been enhanced significantly with implant support from osseous sites in remote locations, such as zygomatic bone (29). Zygomatic implants offer an interesting alternative solution to heavy bone grafting and to other surgical techniques in the severely resorbed maxilla (1-11). Their advantages include interventions for bone harvesting and placing grafts, which have high rates of complications and failures (19, 21), which are avoided. Moreover, patients are treated with a fixed denture much sooner. Zygomatic implants have been used for more than 10 years, with survival rates from 71 to 100% (19, 21), and give predictable outcomes in the rehabilitation of totally edentulous patients (30). In the literature, 12 studies have evaluated the use of these implants with immediate-function protocols (26). The high survival rates reported in these studies (95.8-100%) indicate that they can be used this way with initial implant stability. With immediate occlusal loading, the morbidity and treatment time can be decreased substantially, and patient acceptance can be increased (31).

However, some problems related to zygomatic implants have been reported, including infections in the maxillary sinus, intraoral soft tissue problems, oroantral fistula formation, periorbital hematoma, orbital injury, temporary sensory nerve deficits, moderate nasal bleeding for 1-3 days, and inadvertent intracranial penetration. Many of these problems occur during or as a consequence of using drills to prepare the implant tunnel. Drills are very aggressive and sometimes difficult to control in cutting, leading to complications and a more disabling postoperative period. For these reasons, we considered using a piezoelectric device with dedicated inserts.

Ultrasonic osteotomy allows precise and effective bone cutting without damaging adjacent soft tissues. This approach is based on micro-vibrations (25-30 kHz) created by the piezoelectric effect (32). Histological and histomorphometric analyses of wound healing and bone formation have shown that hard tissue responses to ultrasound cutting are more favorable than conventional drills (33). The beneficial effect of a piezoelectric device on bone healing is well-established and has been used in maxillofacial and oral surgery (32).

Recently, ultrasound has been used in oral surgery for implant site preparation with excellent results in terms of complications and implant survival rate (97.7%, with follow-up of 1-3 years) (34). Based on these data, we used specific piezoelectric inserts to prepare the implant tunnel sites for placing zygomatic implants. This approach could have several advantages in relation to traditional surgery:

1) more precise and secure tunnel preparation;

2) better osseointegration (35) because of the micro-vibrations that increase the release of free bone morphogenetic proteins (BMP) and cause cell stimulation (36);

3) a lower risk of surgical complications, such as neurological damage, periorbital hematoma, orbital injury, and intracranial penetration:

4) better intraoperative visibility (micro-vibrations generate cavitation of liquids, increasing detergent action);

5) better control of the tool;

6) less pain and swelling after the surgery. In any case, the placement of zygomatic implants requires highly experienced surgeons. A potential disadvantage of this new method is the lengthening of the operative time, which we noted.

CONCLUSIONS

In conclusion, this approach could be safer and more accurate within the limits of a case report. However, further research is needed to confirm its potentially advantageous properties compared to the traditional method.

REFERENCES

1. Simion M, Jovanovic SA, Tinti C, Benfenati SP. Long-term evaluation of osseointegrated implants inserted at the time or after vertical ridge augmentation. A retrospective study on 123 implants with 1-5 year follow-up. *Clinical Oral Implants Research*. 2001;12(1):35-45. doi:https://doi.org/10.1034/j.1600-0501.2001.012001035.x
2. Chiapasco M, Zaniboni M, Rimondini L. Autogenous onlay bone grafts vs. alveolar distraction osteogenesis for the correction of vertically deficient edentulous ridges: a 2?4-year prospective study on humans. *Clinical Oral Implants Research*. 2007;18(4):432-440. doi:https://doi.org/10.1111/j.1600-0501.2007.01351.x
3. Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. *The International Journal of Oral & Maxillofacial Implants*. 2009;24 Suppl:237-259.
4. Donos N, Mardas N, Chadha V. Clinical outcomes of implants following lateral bone augmentation: systematic assessment of available options (barrier membranes, bone grafts, split osteotomy). *Journal of Clinical Periodontology*. 2008;35:173-202. doi:https://doi.org/10.1111/j.1600-051x.2008.01269.x
5. Esposito M, Grusovin MG, Felice P, Karatzopoulos G, Worthington HV, Coulthard P. Interventions for replacing missing teeth: horizontal and vertical bone augmentation techniques for dental implant treatment. *Cochrane Database of Systematic Reviews*. 2009;7. doi:https://doi.org/10.1002/14651858.cd003607.pub4
6. Jacotti M, Barausse C, Felice P. Posterior Atrophic Mandible Rehabilitation With Onlay Allograft Created With CAD-CAM Procedure. *Implant Dentistry*. 2014;23(1):22-28. doi:https://doi.org/10.1097/id.0000000000000023
7. Chiapasco M, Brusati R, Ronchi P. Le Fort I osteotomy with interpositional bone grafts and delayed oral implants for the rehabilitation of extremely atrophied maxillae: a 1?9-year clinical follow-up study on humans. *Clinical Oral Implants Research*. 2007;18(1):74-85. doi:https://doi.org/10.1111/j.1600-0501.2006.01287.x
8. Marchetti C, Felice P, Lizio G, Rossi F. Le Fort I Osteotomy With Interpositional Graft and Immediate Loading of Delayed Modified SLActive Surface Dental Implants for Rehabilitation of Extremely Atrophied Maxilla: A Case Report. *Journal of Oral and Maxillofacial Surgery*. 2009;67(7):1486-1494. doi:https://doi.org/10.1016/j.joms.2009.03.020
9. Stern A, Green J. Sinus lift procedures: an overview of current techniques. *Dental Clinics of North America*. 2012;56(1):219-233, x. doi:https://doi.org/10.1016/j.cden.2011.09.003
10. Esposito M, Maria Gabriella Grusovin, Rees J, et al. Effectiveness of sinus lift procedures for dental implant rehabilitation: a Cochrane systematic review. *European Journal of Oral Implantology*. 2010;3(1):7-26.
11. Esposito M, Felice P, Worthington HV. Interventions for replacing missing teeth: augmentation procedures of the maxillary sinus. *Cochrane Database of Systematic Reviews*. 2014;17.

doi:https://doi.org/10.1002/14651858.cd008397.pub2
12. Calandriello R, Tomatis M. Simplified Treatment of the Atrophic Posterior Maxilla via Immediate/Early Function and Tilted Implants: A Prospective 1-Year Clinical Study. *Clinical Implant Dentistry and Related Research*. 2005;7(s1):s1-s12. doi:https://doi.org/10.1111/j.1708-8208.2005.tb00069.x
13. Maló P, Nobre, Lopes A. Immediate Loading of "All-on-4" Maxillary Prostheses Using Trans-Sinus Tilted Implants Without Sinus Bone Grafting: A Retrospective Study Reporting the 3-year Outcome. *Eur J Oral Implantol*. 2013;6(3):273-283.
14. Balshi TJ, Wolfinger GJ, S F Balshi nd. Analysis of 356 pterygomaxillary implants in edentulous arches for fixed prosthesis anchorage. *The International journal of oral & maxillofacial implants*. 1999;14(3):398-406.
15. Pistilli R, Felice P, Maurizio Piattelli, et al. Posterior atrophic jaws rehabilitated with prostheses supported by 5 x 5 mm implants with a novel nanostructured calcium-incorporated titanium surface or by longer implants in augmented bone. One-year results from a randomised controlled trial. *Eur J Oral Implantol*. 2013;6(4):343-357.
16. Pistilli R, Felice P, Cannizzaro G, et al. Posterior atrophic jaws rehabilitated with prostheses supported by 6 mm long 4 mm wide implants or by longer implants in augmented bone. One-year post-loading results from a pilot randomised controlled trial. *European Journal of Oral Implantology*. 2013;6(4):359-372.
17. Smalley WM, Shapiro PA, Hohl TH, Kokich VG, Brånemark PI. Osseointegrated titanium implants for maxillofacial protraction in monkeys. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1988;94(4):285-295. doi:https://doi.org/10.1016/0889-5406(88)90053-4
18. Brånemark PI. *Surgery and Fixture Installation: Zygomaticus Fixture Clinical Procedures.* PART 1. Nobel Biocare AB; 1998.
19. Malevez C, Abarca M, Durdu F, Daelemans P. Clinical outcome of 103 consecutive zygomatic implants: a 6-48 months follow-up study. *Clinical Oral Implants Research*. 2004;15(1):18-22. doi:https://doi.org/10.1046/j.1600-0501.2003.00985.x
20. John Paul Stella, Warner MR. Sinus slot technique for simplification and improved orientation of zygomaticus dental implants: a technical note. *The International journal of oral & maxillofacial implants*. 2001;15(6):889-893.
21. Davo R, Malevez C, Rojas J, Rodríguez J, Regolf J. Clinical outcome of 42 patients treated with 81 immediately loaded zygomatic implants: a 12- to 42-month retrospective study. *Eur J Oral Implantol*. 2008;1(2):141-150.
22. Shihab Romeed, Malik R, Dunne S. Zygomatic Implants: The Impact of Zygoma Bone Support on Biomechanics. *Journal of Oral Implantology*. 2014;40(3):231-237. doi:https://doi.org/10.1563/aaid-joi-d-11-00245
23. Van Steenberghe D, Malevez C, Van Cleynenbreugel J, et al. Accuracy of drilling guides for transfer from three-dimensional CT-based planning to placement of zygoma implants in human cadavers. *Clinical Oral Implants Research*. 2003;14(1):131-136. doi:https://doi.org/10.1034/j.1600-0501.2003.140118.x
24. Ewers R, Schicho K, Undt G, et al. Basic research and 12 years of clinical experience in computer-assisted navigation technology: a review. *International Journal of Oral and Maxillofacial Surgery*. 2005;34(1):1-8. doi:https://doi.org/10.1016/j.ijom.2004.03.018
25. Pellegrino G, Relics D, Tarsitano A, Basile F, Grande F, Marchetti C. Computer-assisted surgery in the rehabilitation of the upper jaw with zygomatic implants - a cohort study comparing atrophic and oncologic patients. Preliminary results at 4 years follow-up. *Clinical Oral Implants Research*. 2018;29:437-437. doi:https://doi.org/10.1111/clr.322_13358
26. Chrcanovic BR, Abreu MHNG. Survival and complications of zygomatic implants: a systematic review. *Oral and Maxillofacial Surgery*. 2012;17(2):81-93. doi:https://doi.org/10.1007/s10006-012-0331-z
27. Vercellotti T, Stacchi C, Russo C, et al. Ultrasonic Implant Site Preparation Using Piezosurgery: A Multicenter Case Series Study Analyzing 3,579 Implants with a 1- to 3-Year Follow-Up. *The International Journal of Periodontics & Restorative Dentistry*. 2014;34(1):11-18. doi:https://doi.org/10.11607/prd.1860
28. Vercellotti T, De Paoli S, Nevins M. The piezoelectric bony window osteotomy and sinus membrane elevation: introduction of a new technique for simplification of the sinus augmentation procedure. *PubMed*. 2001;21(6):561-567.
29. Parel SM, Brånemark PI, Ohrnell LO, Svensson B. Remote implant anchorage for the rehabilitation of maxillary defects. *The Journal of Prosthetic Dentistry*. 2001;86(4):377-381. doi:https://doi.org/10.1067/mpr.2001.118874
30. Malevez C, Daelemans P, Adriaenssens P, Durdu F. Use of zygomatic implants to deal with resorbed posterior maxillae. *Periodontology 2000*. 2003;33(1):82-89. doi:https://doi.org/10.1046/j.0906-6713.2002.03307.x
31. Davo R, Malevez C, Rojas J. Immediate function in the atrophic maxilla using zygoma implants: A preliminary study. *The Journal of Prosthetic Dentistry*. 2007;97(6):S44-S51. doi:https://doi.org/10.1016/s0022-3913(07)60007-9
32. Eggers G, Klein J, Blank J, Hassfeld S. Piezosurgery®: an ultrasound device for cutting bone and its use and limitations in maxillofacial surgery. *British Journal of Oral and Maxillofacial Surgery*. 2004;42(5):451-453. doi:https://doi.org/10.1016/j.bjoms.2004.04.006
33. Vercellotti T, Nevins ML, Kim DM, et al. Osseous response following resective therapy with piezosurgery. *Int J Periodontics Restorative Dent*. 2005;25(6):543-549.
34. Stacchi C, Vercellotti T, Torelli L, Furlan F, Di Lenarda R. Changes in Implant Stability Using Different Site Preparation Techniques: Twist Drills versus Piezosurgery. A Single-Blinded, Randomized, Controlled Clinical Trial. *Clinical Implant Dentistry and Related Research*. 2011;15(2):188-197. doi:https://doi.org/10.1111/j.1708-8208.2011.00341.x

35. Preti G, Martinasso G, Peirone B, et al. Cytokines and growth factors involved in the osseointegration of oral titanium implants positioned using piezoelectric bone surgery versus a drill technique: a pilot study in minipigs. *Journal of Periodontology*. 2007;78(4):716-722. doi:https://doi.org/10.1902/jop.2007.060285
36. Di Alberti L, Donnini F, Di Alberti C, Camerino M. A comparative study of bone densitometry during osseointegration: Piezoelectric surgery versus rotary protocols. *Quintessence International*. 2010;41(8):639-644.