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PERSPECTIVES ON ZYGOMATIC IMPLANTS

CONSULTING EDITOR
RUI P. FERNANDES

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ANASTASIYA QUIMBY
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Perspectives on Zygomatic Implants

Editors
ANASTASIYA QUIMBY
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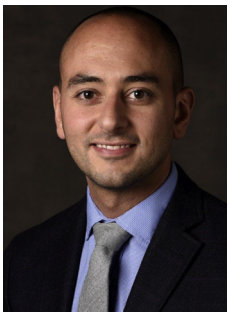
Preface

Perspectives on Zygomatic Implants: Overview, Controversies, and Future Directions



Anastasiya Quimby, MD, DDS Salam Salman, MD, DDS, FACS

Editors

The aging population of the United States is expected to continue to increase and reach the milestone of outnumbering children in 2035 as projected by the US census data. This generation of older adults is leading an active lifestyle, and quality of life is an important consideration. Although the dental field has been making a transition to a more preventative approach and maintenance of natural dentition, a significant proportion of this population has been managed in a less conservative fashion. Moreover, with age, the likelihood of developing a pathologic lesion requiring surgical resection also increases. While complete dentures and maxillary obturators were accepted as a gold standard prior to dental implant development, with the advent of implant-supported prostheses, few patients are content with the conventional dentures or ill-fitting obturators. In order to satisfy what undoubtedly is going to be an increasing demand for fixed prostheses, oral and maxillofacial surgeons should be well equipped with skills to offer comprehensive oral rehabilitation.

Management of patients with severely atrophic maxilla has long been a treatment challenge for our specialty. The advent of zygomatic implants in 1988 by Branemark led to an alternative treatment modality for patients with maxillary defects and those with severely resorbed alveolar ridges. Over the past two decades, several implant and treatment advances have been made to improve treatment planning, placement, and restoration of the severely atrophic maxilla, making zygomatic implants a first-line treatment option in these situations.

In the process of creating this issue of the *Atlas of the Oral and Maxillofacial Surgery Clinics of North America*, it became evident that there are parallel and opposing concepts and philosophies with respect to zygomatic implants. The objective of this issue evolved from simply providing the reader with the set of technical instructions on how to place zygomatic implants to allowing the reader to explore the various ideologies and adopt those that resonate most. Our world-renown authors and leaders in their field shared their expertise and experience in this collection of the articles. They illustrate the fascinating development of different schools of thought on techniques, utilization of computer-assisted surgical planning, and 3D and navigation technologies.

We hope that through this text the reader is able to appreciate and obtain an understanding of different perspectives on zygomatic implant indications, placement, restoration, and recent technological advances.

We would like to sincerely thank all the contributing authors for their time and effort spent on providing excellent articles for this issue of the *Atlas of the Oral and Maxillofacial Surgery Clinics of North America* "Perspectives on Zygomatic Implants."

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Zygomatic Implants

A Review of a Treatment Alternative for the Severely Atrophic Maxilla

Amanda Andre, DDS*, Harry Dym, DDS

KEYWORDS

• Zygoma • Atrophic maxilla • Immediate load • Zygomatic implant

KEY POINTS

- When indicated, Zygomatic implants can offer a graftless approach to patients with severely atrophic maxilla.
- The time from surgical intervention to final prosthetic restoration can be shortened with the use of zygomatic implants.
- New guidelines are being developed for the evaluation of the success of zygomatic implants since the parameters for stability and restorability differ from traditional implants.

Introduction

Paired with the promise of "teeth-in-a-day," zygomatic implants have increased in popularity as a graftless treatment option that can reduce the timeline between the surgical procedure and prosthetic reconstruction, while offering a highly predictable outcome for patients with a severely resorbed maxilla.[1,2] However, the placement of these implants requires ample knowledge of the local anatomy and surgical technique in order to optimize treatment outcomes and avoid major complications. Careful planning and open communication between the surgeon, restorative dentist, laboratory technicians, and patient can assist in optimizing the final results.

Recent surgical approaches pay close attention to individual anatomic, physiologic, and prosthetic needs in order to create safer surgical protocols, increase predictability, and consequently, achieve satisfactory long-term results.[3,4] Zygomatic implants may offer an answer to the complicated question of how to rehabilitate completely edentulous patients with a severely deficient maxilla. Implant-supported prosthetics can enhance the quality of life of edentulous individuals by improving their function and esthetics and positively affecting the patient's social life.

Other treatment options for the rehabilitation of the atrophic maxilla with an implant-supported prosthesis include bone augmentation with delayed or immediate placement of endosseous implants, as well as pterygoid plate, "all-on-four," and short implants. Bone grafting techniques used to satisfy the horizontal and vertical requirements for successful implant placement include sinus augmentation,[5] guided bone regeneration, onlay grafting, interpositional bone grafts, ridge splitting, and distraction osteogenesis. Autogenous bone remains the gold standard for alveolar bone augmentation because of its unique combination of osteoinductive, osteoconductive, and osteogenic properties.[6]

In the severely atrophic maxilla, the use of extensive autogenous bone augmentation may be required in order to allow for a successful treatment outcome. One of the disadvantages of harvesting large amounts of autogenous bone is the addition of distal surgical sites, which can lead to increased operating time and potentially increased surgical morbidity. In addition, the time between bone grafting in severely atrophic sites with autogenous bone grafts and implant placement can range from 4 to 6 months.[6]

Zygomatic implant placement, a graftless technique, provides another modality for patients who have had bone graft failures in the past[7] or for those who are medically complex and cannot tolerate extensive surgical procedures.[8] A position statement by the American College of Prosthodontists[9] stated that "the use of the zygomatic implant in various clinical scenarios with multiple configurations enables the dental team to restore quality of life and gives patients an expedited and predictable option." The reduction in surgical sites, fewer number of surgical procedures, and the shortening of the timeframe between surgery and final prosthesis delivery are some of the advantages that may lead the surgeon and patient to choose this treatment option. In this article, the authors aim to provide an overview of the indications for zygomatic implants and the local anatomy involved and describe the various techniques used for the placement of these implants.

Background

Brånemark and colleagues[10,11] introduced zygomatic implants in 1988 with the initial objective of providing implant-supported prosthetic solutions for patients with severe maxillary

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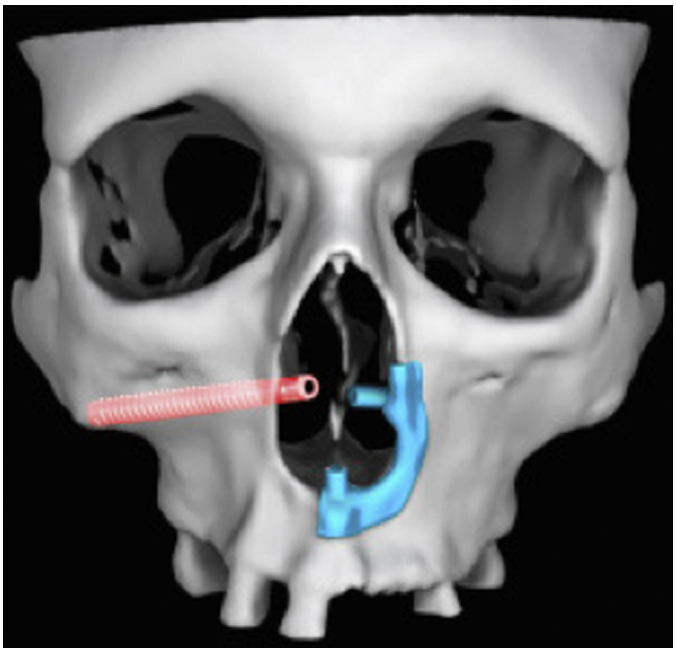

Fig. 1 The use of zygomatic implants for the retention of nasal prosthesis following rhinectomy: the Morriston experience. (*From* Scott N, Kittur MA, Evans PL, Dovgalski L, Hodder SC. The use of zygomatic implants for the retention of nasal prosthesis following rhinectomy: the Morriston experience. Int J Oral Maxillofac Surg. 2016 Aug;45(8):1044-8; with permission.)

atrophy and maxillary defects resulting from trauma or resections. After a decade of clinical studies, zygoma implants were made available to the dental profession (Fig. 1).[9] Changes to the initially proposed surgical approach have rapidly taken place as individual considerations and prosthetic needs have become evident. Currently, various companies offer different variations of zygomatic implants, including Nobel Biocare, Neodent, Noris Medical, Southern Implants, and Implant Swiss. Nobel Biocare Zygomatic implants are available in lengths from 30 to 52.5 mm. Brånemark System Zygoma Implants have a 45° abutment head[4] and can have a TiUnite surface or machined surface. TiUnite is a roughened thickened titanium oxide layer that is highly porous. The machine surface layer implants have an opening in the head, allowing for the use of the regular platform Brånemark System components.[4]

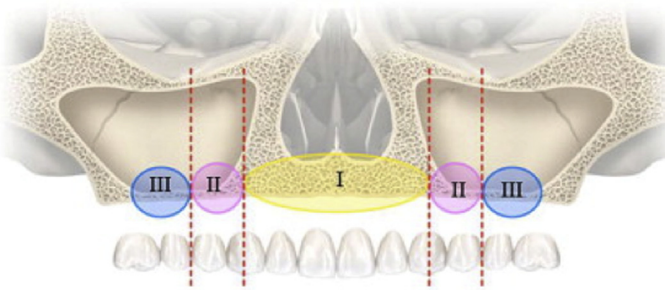

Fig. 2 Zones of the maxilla. (*From* Bedrossian E. Rescue implant concept: the expanded use of the zygoma implant in the graftless solutions. Oral Maxillofac Surg Clin North Am. 2011 May;23(2):257-76, vi; with permission.)

Indications and contraindications

Zygomatic implant placement is indicated for the implant-supported rehabilitation of completely edentulous patients with significant sinus pneumatization and severe posterior alveolar ridge resorption.[12] There is little clinical research demonstrating the success of these implants in partially edentulous patients. Bedrossian[13] described a systematic pretreatment approach for the classification and treatment of the atrophic maxilla. The maxilla is divided into the following 3 zones: zone I (premaxilla), zone II (premolar area), and zone III (molar area) (Fig. 2). The availability of bone in each zone should be assessed by the clinician, typically through the evaluation of a preoperative cone-beam computed tomography (CBCT). Table 1 describes the recommended surgical approaches. These recommendations can assist the surgeon in formulating the surgical treatment plan. Bedrossian and colleagues[11] recommended the placement of zygoma implants when there is less than 2 to 3 mm in zone 2 and zone 3. In the case of an edentulous patient with inadequate bone in all 3 zones, the placement of 4 zygoma implants, also known as Quad Zygomatic Implants, has shown promising results in the literature (Boxes 1 and 2).[14,15]

Biomechanics

The stability and success of zygomatic implants have been attributed to the "quad-anchoring" of the implant to the maxilla and zygoma bones. When following Professor Brånemark's technique, the stability of zygomatic implants originates from its engagement at the alveolar crest by the lingual cortex of the alveolus and the cortical floor of the maxillary sinus (Fig. 4). Stabilization at the apex of the implant is provided by the zygomatic bone itself.[18] In a study by Nkenke and colleagues,[19] the bone mineral density, trabecular bone volume, and trabecular bone patterns were assessed in 30 human zygomatic bone specimens. Interestingly, the quantitative computed tomography and histomorphometry analysis

Table 1 Bedrossian zones and suggested surgical approaches

Areas of Adequate Bone for Implant Placement	Bedrossian Zones	Surgical Approach
Premaxilla, premolar, and molar area	Zones 1, 2, and 3	Traditional endosseous implants
Premaxilla and premolar area	Zones 1 and 2	All-on-four
Premaxilla only	Zone 1	Zygomatic implants plus 2—4 traditional implants
Insufficient bone		Four zygomatic implants "quad-zygomas"

Adapted from Bedrossian E. Rehabilitation of the edentulous maxilla with the zygoma concept: a 7-year prospective study. Int J Oral Maxillofac Implants 2010;25(6):1213-21; with permission.

Box 1. Indications

- Prosthetic rehabilitation of patients with extensive defects of the maxilla owing to trauma, congenital defects, or neoplastic disease
- Completely edentulous patients with severe atrophy in zone II and zone III of the maxilla who require implant placement for prosthesis support (Fig. 3):
  - Significant sinus pneumatization
  - Severe atrophy of the maxillary alveolar ridge
- Patients with history of bone graft failure in the maxilla[7]
- Patients unable to undergo bone grafting procedures because of compromised vasculature or other comorbidities[8]

Data from Refs.[8,11,16]

revealed the zygomatic bone has an unfavorable microarchitecture for implant placement. However, despite that fact, the study concluded that zygoma implants may achieve long-lasting success, as proven by the literature, when multicortex stabilization is achieved. It was determined that the engagement of the zygomatic implant to cortical bone plays a more significant role in the stability of the implant than contact with larger amounts of trabecular bone.

Various studies have focused on the precise location of stress of these implants during function. When occlusal forces are applied, most of the support comes from the zygoma bone.[4,20] More specifically, Freedman and colleagues[21] described the lateral cortex of the zygoma as the main load-bearing area. Ujigawa and colleagues[20] conducted a finite elemental analysis that concluded that the stresses during occlusal load transfer differ in zygomatic implants with or without connected standard implants supporting the superstructure. In Fig. 5, connected zygoma implants to standard implants, referred to as the combination model, show better stress distribution. In contrast, stress load of implants not combined with standard implants, or the single model, is seen to be partially concentrated at the joint of the fixture abutment. It can also be appreciated that in both models, the midportion of the implant shows higher stresses during bending movements. Bending forces could have adverse effects in the stability and longevity of the implant.[12] The role of the maxillary alveolar support in reducing the maximum stress distribution of zygomatic implants was further studied by Freedman and colleagues.[21] When the 2 zygomatic implants,

Box 2. Contraindications

- Absolute contraindications
  - Acute sinus infection
  - Maxillary or zygoma pathologic condition
  - Underlying uncontrolled or malignant systemic disease
- Relative contraindications
  - Chronic infectious sinusitis
  - Bisphosphonate use
  - Smoking more than 20 cigarettes a day

Data from Refs.[11,12,17]

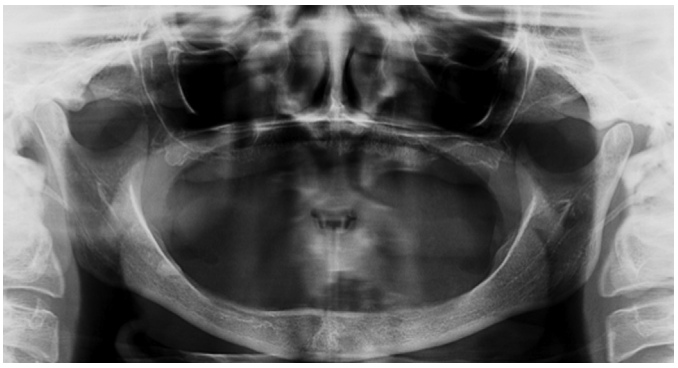

Fig. 3 Panoramic radiograph of severely atrophic maxilla pneumatized sinuses and severe deficient bone in zones II to III of the maxilla.

anchored in the zygomatic bone and maxillary alveolar bone, are connected by a fixed bridge, the occlusal and lateral stresses are reduced compared with models with no alveolar bone support.

These studies prove that with the current techniques, the distribution of forces is better managed by cross-arch stabilization of the zygoma implants with a rigid superstructure to standard implants in the premaxilla. Final prosthesis considerations should include minimizing distal cantilevers, achieving a balanced occlusion, and decreasing the cuspal inclination of prosthetic teeth.[4]

Workflow: anatomically versus prosthetically driven

Multiple approaches have been developed by oral surgeons with the intention to decrease surgical time, decrease patient morbidity, and increase the success of zygomatic implants. The

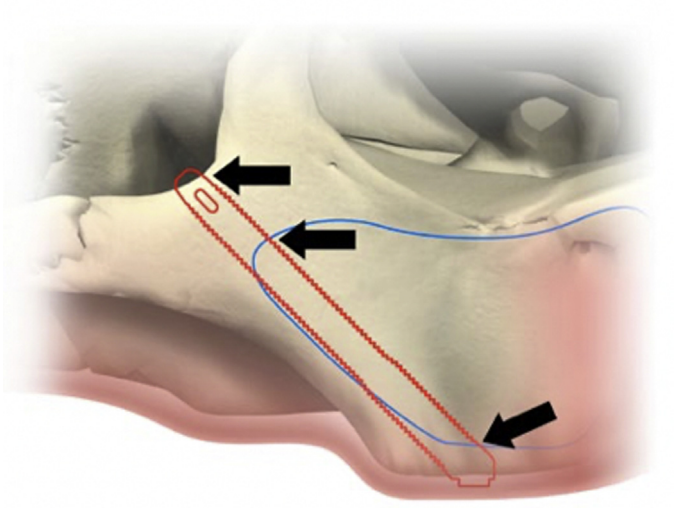

Fig. 4 The red outline indicates the planned intrasinus position for a zygomatic implant, showing the stability to the 4 cortices in the maxilla and zygoma bone. The blue outline delineates the maxillary sinus The black arrows point at the proposed trajectory for a zygomatic implant, delineated in red. This image illustrates the intra-sinus approach. (*From* NobelBiocare. Brånemark System Zygoma Procedures Manual 2013.1. 2013: 25; with permission.)

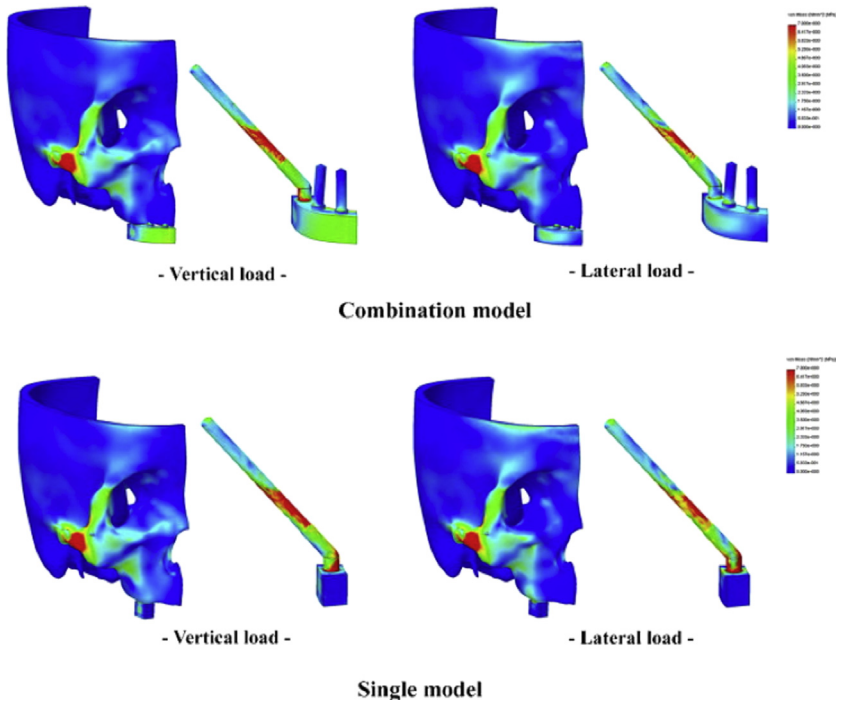

Fig. 5 Three-dimensional finite elemental analysis of zygomatic implants in craniofacial structures. (*From* Ujigawa K, Kato Y, Kizu Y, Tonogi M, Yamane GY. Three-dimensional finite elemental analysis of zygomatic implants in craniofacial structures. Int J Oral Maxillofac Surg. 2007 Jul;36(7):620-5; with permission.)

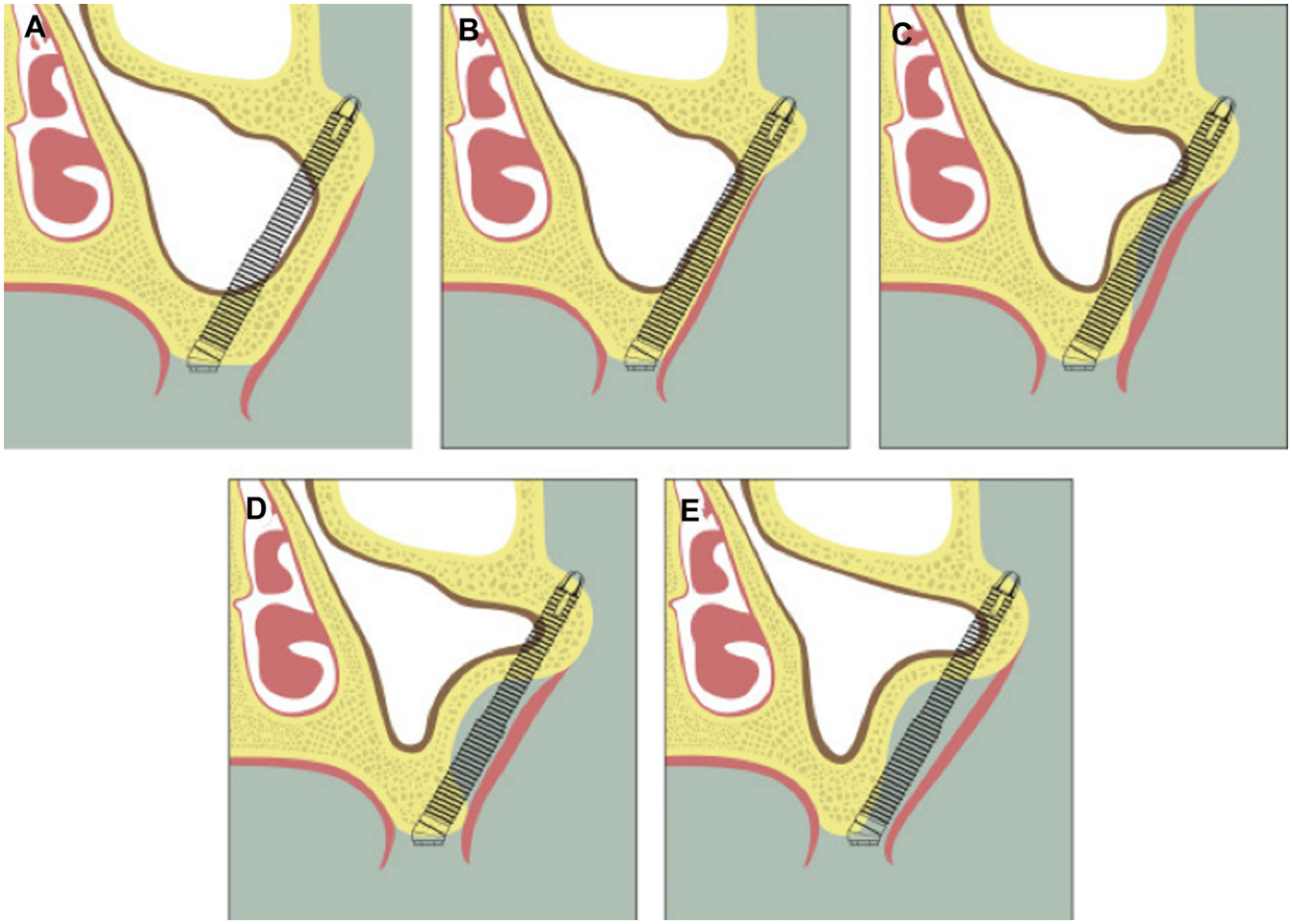

Fig. 6 Zygoma anatomic guided approach. (*A*) ZAGA 0; (*B*) ZAGA 1; (*C*) ZAGA 2; (*D*) ZAGA 3; (*E*) ZAGA 4. (*From* Davó R, David L. Quad Zygoma: Technique and Realities. Oral Maxillofac Surg Clin North Am. 2019 May;31(2):285-29; with permission.)

Table 2 Zygomatic anatomy-guided approach system

ZAGA Type	Anterior Maxilla	Implant Head Location	Implant Body Path	Implant Contact with Bone	% Out of 100 Patients
ZAGA 0	Very flat	Alveolar crest	Intrasinus	Alveolar crest Zygomatic bone Lateral sinus wall (partially)	15
ZAGA 1	Slightly concave	Alveolar crest	Intrasinus	Alveolar crest Zygomatic bone Lateral sinus wall	49
ZAGA 2	Concave	Alveolar crest	Mostly extrasinus	Alveolar crest Zygomatic bone Lateral sinus wall	20.5
ZAGA 3	Very concave	Alveolar crest	Mostly extrasinus	Alveolar crest Zygomatic bone	9
ZAGA 4	Extremely vertical and horizontal atrophy	Buccal to alveolar crest	Extrasinus, extramaxillary	Zygomatic bone Lateral sinus wall (partially)	6.5

Adapted from Aparicio, C. (2011). A proposed classification for zygomatic implant patient based on the zygoma anatomy guided approach (ZAGA): a cross-sectional survey. Eur J Oral Implantol, 4(3), 269-275; with permission.

ultimate decision on which approach to use lies at the hands of the operator after a throughout review of the patient's local and systemic factors. Evaluation of the potential implant site and trajectory of the zygomatic implant via computed tomography is crucial in the planning phase. Special attention is placed on the availability of bone in the zygomatic arch and the residual alveolar crest. The relationship of the proposed zygomatic implant path to the lateral wall of the maxillary sinus and proximity to the orbital rim should be considered. There are 2 proposed surgical approaches: anatomically driven and prosthetically driven.[12,16,22] The placement of the zygoma implants can be extramaxillary, extrasinus, or intramaxillary.

The zygomatic anatomy-guided approach (ZAGA) was originally proposed by Dr Carlos Aparicio[23] in 2010 (Fig. 6). The investigator studied 200 zygomatic implant sites in 100 patients with a focus on skeletal forms of the zygomatic buttress-alveolar crest complex and developed 5 typical anatomic and implant pathway situations. The proposed classification is outlined in Table 2. The ZAGA system highlights the anatomic differences among patients and within the same patient bilaterally and can be used during surgical planning.

A recent publication by Ponnusamy and Miloro[3] proposed a restoratively aimed zygomatic implant routine (RAZIR) workup. The preoperative workup consists of CBCT, intraoral scans, diagnostic impressions, record bases, and occlusal rims. This protocol is based on (1) determining the position of the teeth in

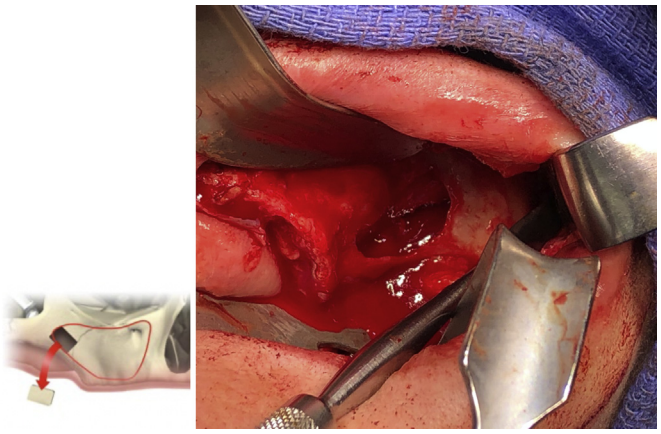

Fig. 7 Maxillary sinus lateral window for increased visualization of the trajectory of the zygomatic implant. (*From* NobelBiocare. Brånemark System Zygoma Procedures Manual 2013.1 2013: 24; with permission.)

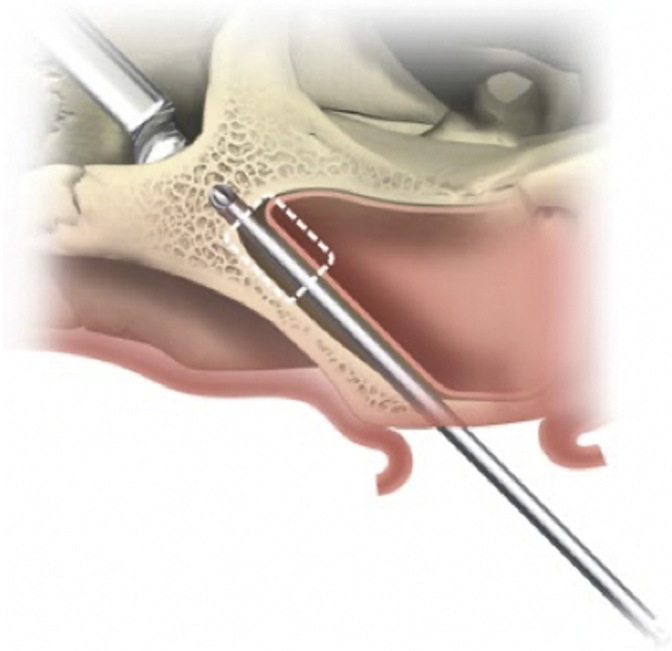

Fig. 8 Use of a round bur to mark the implant entrance and trajectory of the zygomatic implant. (*From* NobelBiocare. Brånemark System Zygoma Procedures Manual 2013.1. 2013:28; with permission.)

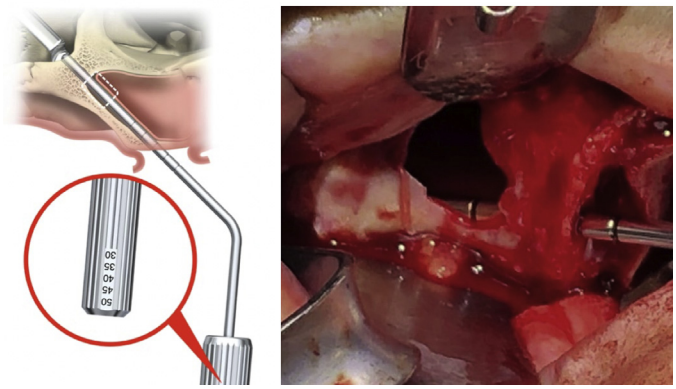

Fig. 9 The use of the depth indicator in order to confirm or determine the zygoma implant length. (*From* NobelBiocare. Brånemark System Zygoma Procedures Manual 2013.1. 2013:30 and Rosenstein J, Dym H. Zygomatic Implants: A Solution for the Atrophic Maxilla. Dent Clin North Am. 2020 Apr;64(2):401-40; with permission.)

Esthetic and functional considerations are meticulously considered to support esthetics, phonetics, lip position, lip support, and function and to allow the patient to easily maintain oral hygiene. For example, the buccopalatal placement of the teeth and an analysis of the relationship between the proposed implant emergence sites and alveolar ridge. The required thickness of the final restoration is analyzed, and the appropriate final prosthesis is selected. RAZIR requires the merging of the final tooth positions (digital or analog) with the intraoral scan and diagnostic CBCT scan. This step allows the surgeon to virtually place the zygomatic implants and determine the appropriate surgical technique (intrasinus, extrasinus, or extramaxillary).

Prosthetic reconstruction of the edentulous maxilla with zygomatic implants can be achieved in a 2-stage protocol[24] or immediate-loading protocol.[25] In the 2-step protocol, the zygomatic implants are uncovered after a period of osseointegration for 6 months, and cross-stabilization is established with the Cal technique or similar passive bar insertion. During stage II surgery, osseointegration is confirmed by the lack of mobility, resistance to a reverse torque of 10 Ncm, absence of pain on percussion, and absence of signs of peri-implantitis. Immediately loaded zygomatic implants are also splinted with the use of a fixed provisional prosthesis, oftentimes the patient's preexisting denture. Cross-arch stabilization is key, and occlusal loading of zygomatic implants without cross-arch stabilization is not recommended.[4,13,26]

Fig. 10 Insertion of zygomatic implant with the zygoma handpiece versus manually with the Z-handle. (*From* NobelBiocare. Brånemark System Zygoma Procedures Manual 2013.1. 2013:33; with permission.)

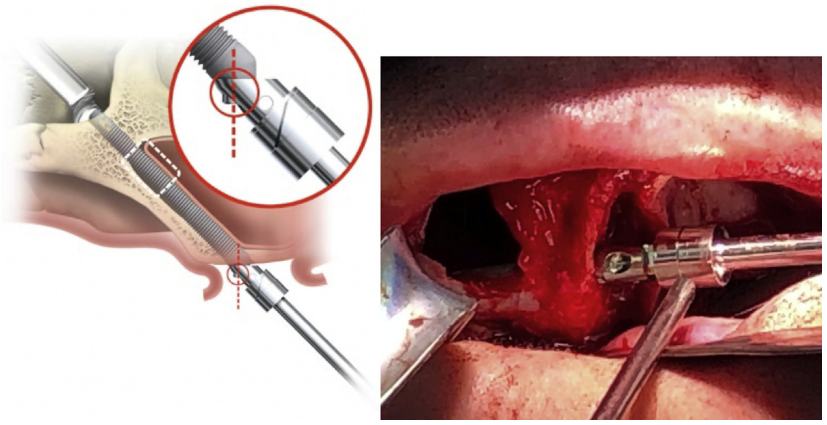

Fig. 11 Perpendicular positioning of the abutment screw. (*From* NobelBiocare. Brånemark System Zygoma Procedures Manual 2013.1. 2013:33; with permission.)

the final restoration via a diagnostic tooth setup, (2) virtually determining the zygoma implant position by directing the implant platform at the central fossa of the second premolar or at the cingulum of the lateral incisor for anterior zygomatic implants, and (3) the selection of the appropriate surgical approach based on the required trajectory.

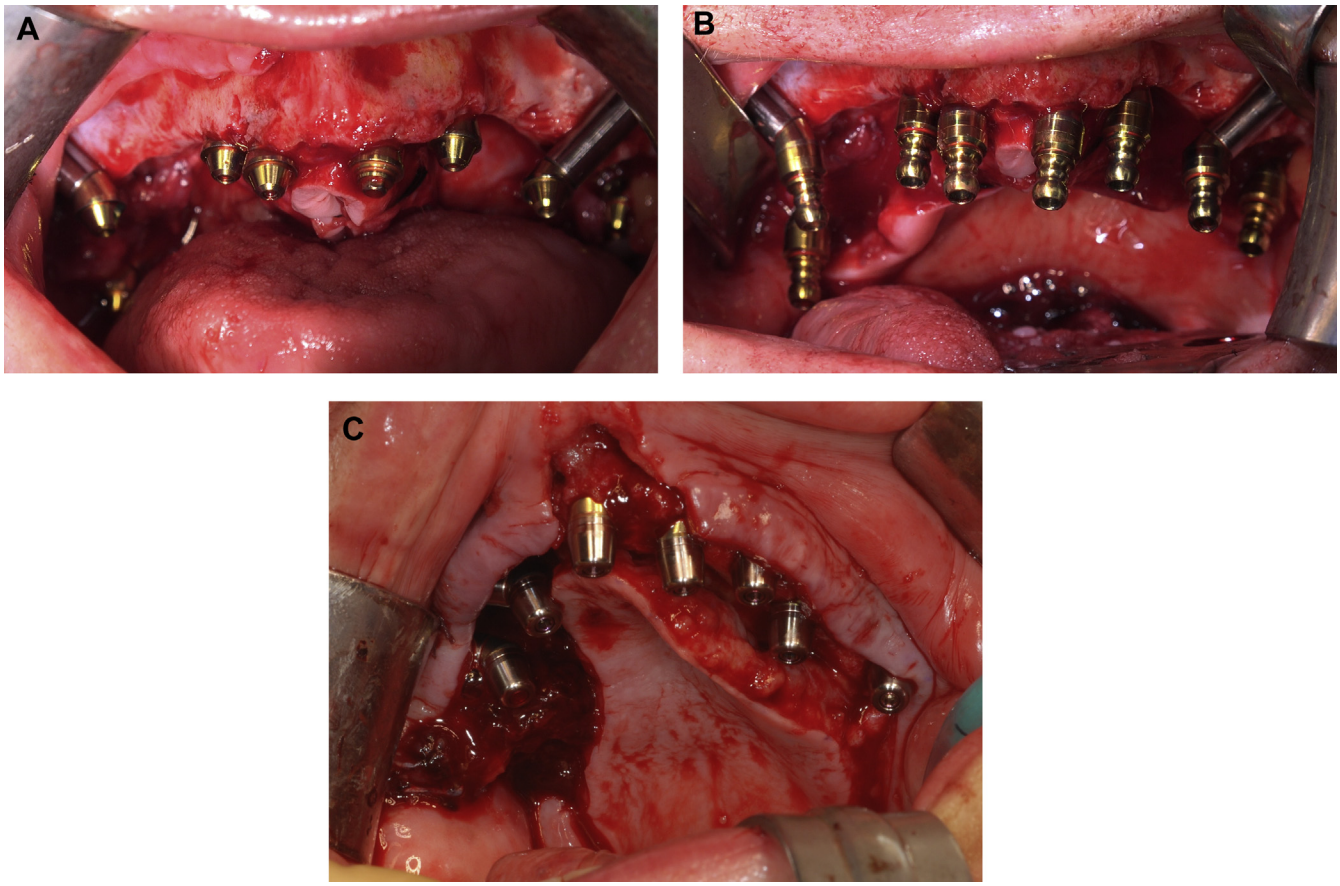

Fig. 22 Installation of prosthetic abutments. (*A*) A variety of angulated abutments between 0° and 60° may be used for a uniform prosthetic path of insertion. (*B*) Transfers for immediate impressions. (*C*) Angulated abutments covered with cover-screws.

torque should be between 35 and 45 Ncm to ensure primary stability and to avoid damage to the zygomatic bone.

After the connection of the angulated abutments (Fig. 22A), prosthetic transfers may be connected for immediate impressions (see Fig. 22B). Alternatively, the abutments may be covered with cover-screws for delayed impressions (see Fig. 22C). Before suturing the soft tissues, it is the authors' advice to cover the extramaxillary implants with buccal fat pads (Fig. 23). This is used for soft tissue augmentation around the implants and provides additional protection against peri-implantitis. If any augmentation procedure is needed, this should be performed at the final surgical stage before soft tissue suturing (Fig. 24). The soft tissue should be meticulously sutured with the aid of mattress sutures for suture stability.

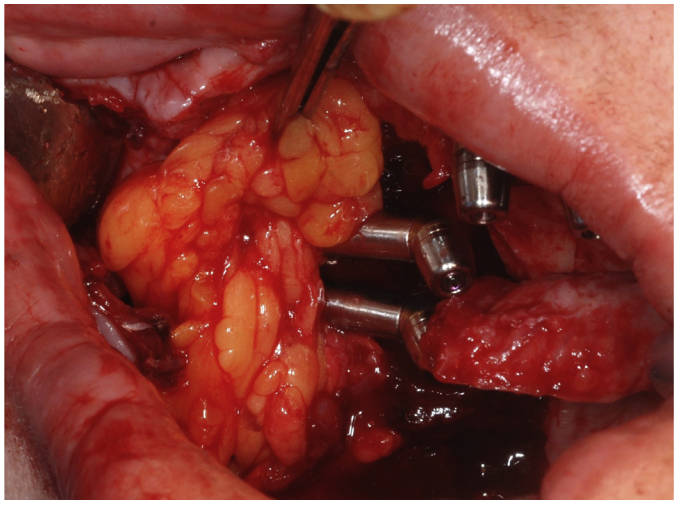

Fig. 23 Covering of the zygomatic implants using buccal fat of pad.

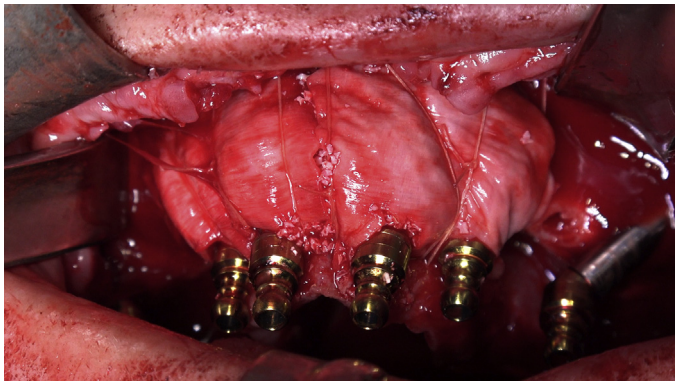

Fig. 24 Guided bone reaeration around the axial implants in the premaxilla.

Fig. 19 Case 1: final prostheses and soft tissues 1 year postsurgery. Prostheses placed by Drs Peter and Madalina Simon, ZAGA Center Stuttgart, Germany.

Fig. 20 Case 1: patient satisfaction 1 year postsurgery. Prostheses placed by Drs Peter and Madalina Simon, ZAGA Center Stuttgart, Germany.

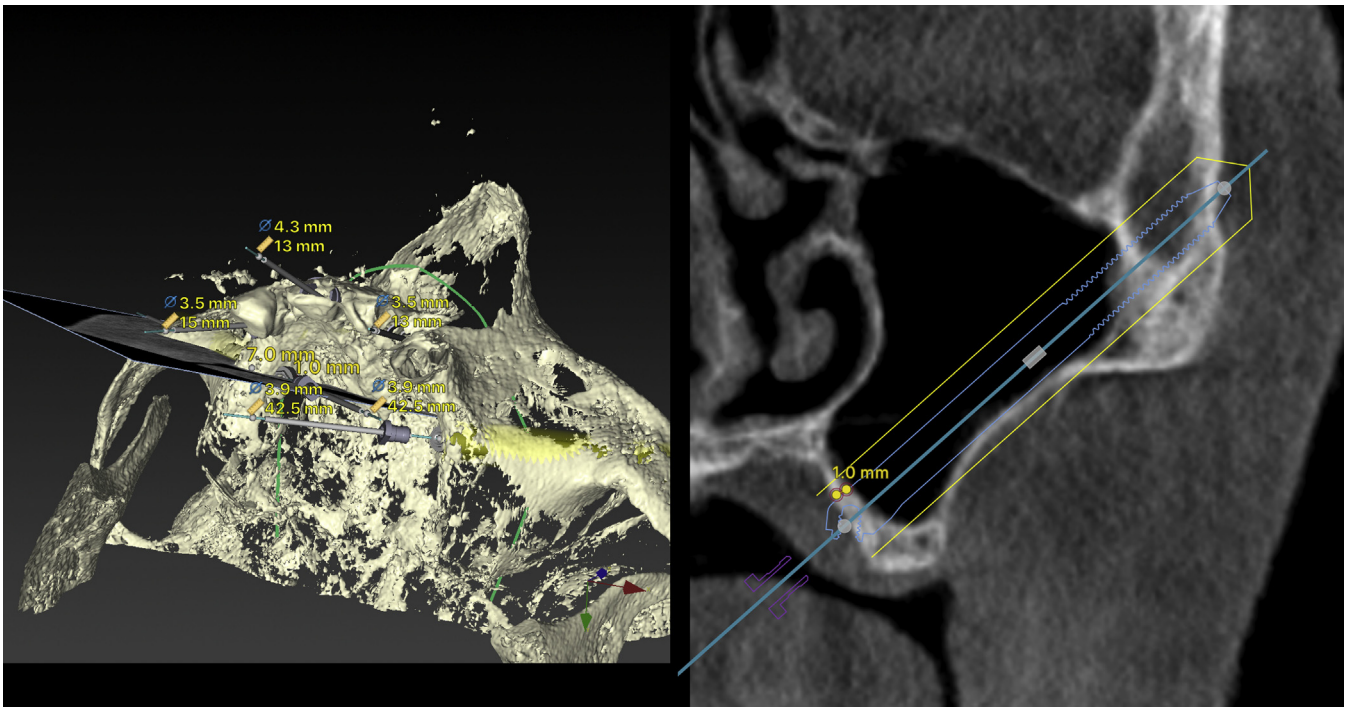

Fig. 21 Case 2: right side 3D and 2D images representing the anatomic features of an eventual ZI trajectory. The planning software simulating an intrasinus classic path. An eventual circular tunnel osteotomy would reach the sinus through scarcely 1 mm to 2 mm of alveolar bone thickness. The ZAGA concept recommends visualizing the possibility for bone loss around the implant neck and subsequent development of an oral-antral fistula.

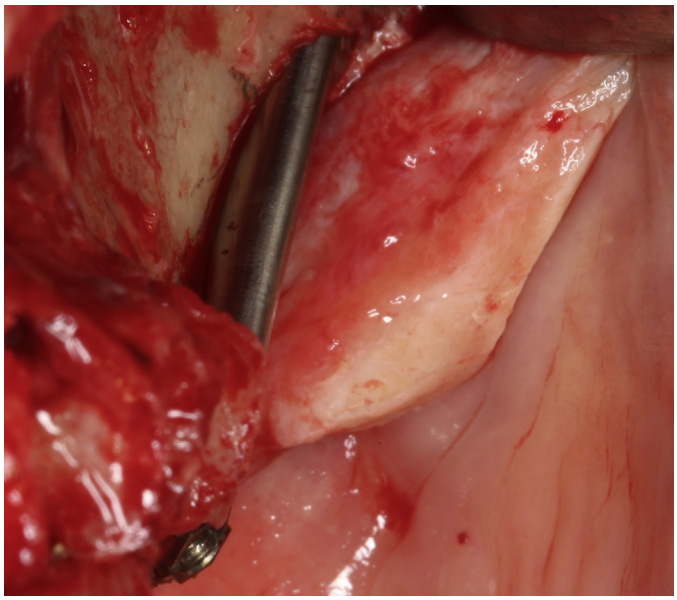

Fig. 39 Case 2: the Straumann ZAGA Flat implant from a lateral view. Its flat profile is not protruding from the remaining alveolar bone.

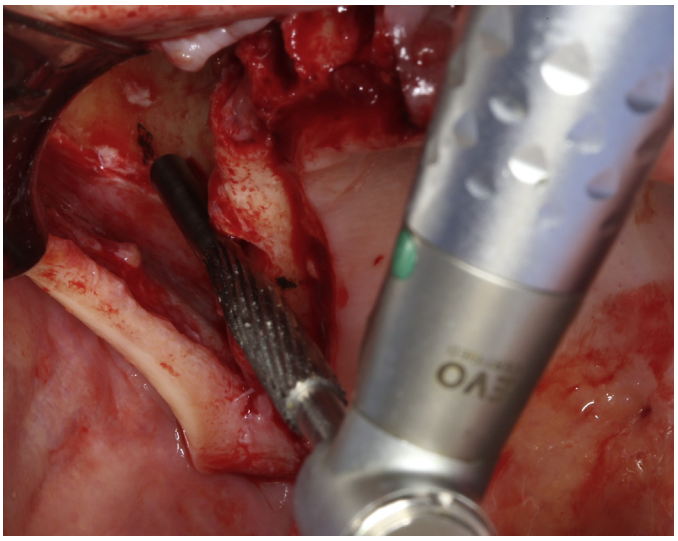

Fig. 40 Case 2: the Straumann AG lateral cutting bur is starting a channel osteotomy on the right posterior area.

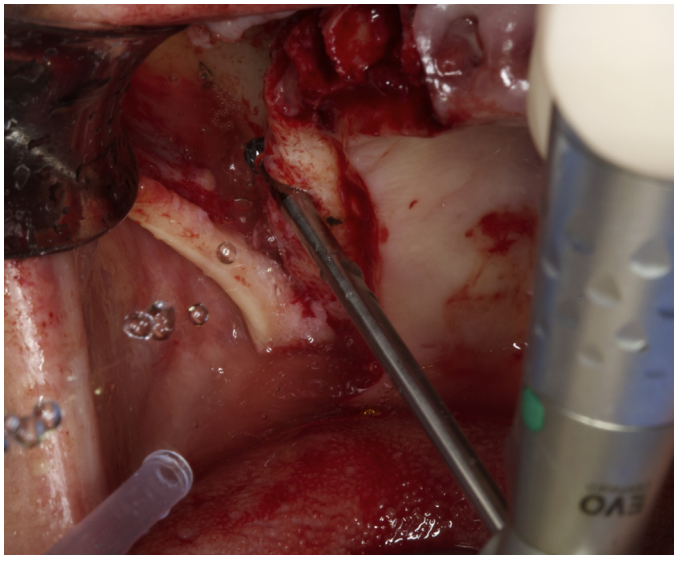

Fig. 41 Case 2: the initial alveolar channel is used for a smooth back and forward sliding movement of the round bur tail.

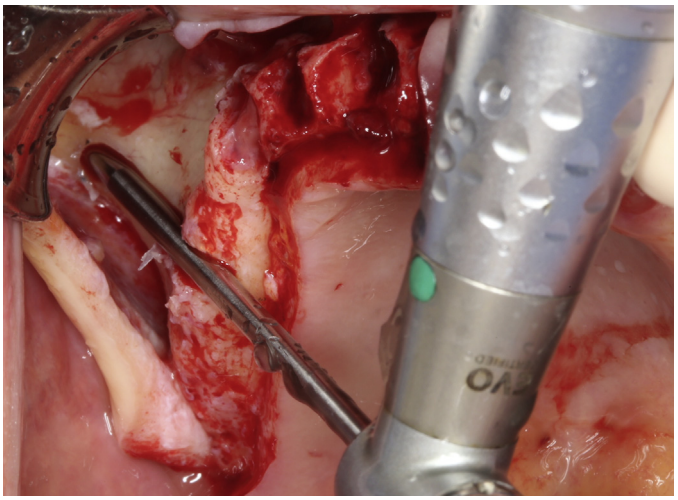

Fig. 42 Case 2: once the desired depth has been achieved, the round bur is perforating the maxillary buttress (antrostomy zone), with no care about sinus lining integrity.

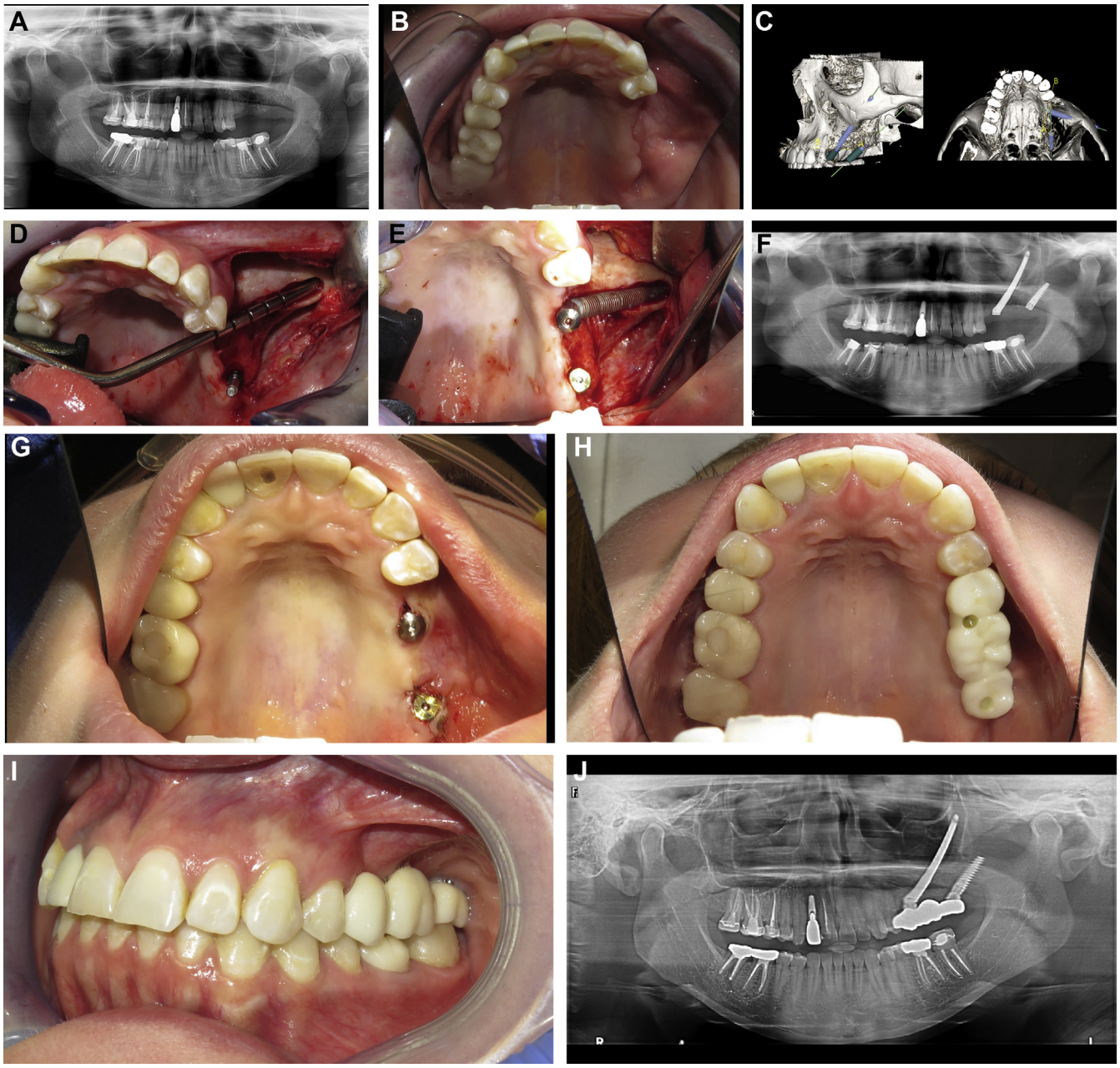

Fig. 6 Partially edentulous patients. A 30-year-old woman referred to the authors' department after 2 previously failed sinus lifts to replace teeth 13, 14, and 15. After clinical and radiographical examination, it was determined that the patient would benefit from the placement of 1 left pterygoid implant and 1 zygoma implant around tooth numbers 13 to 1. (*A*) Preoperative panoramic radiograph showing missing teeth numbers 13, 14, and 15. (*B*) Occlusal view demonstrating a left posterior alveolar ridge defect. (*C*) Prosthetically driven virtual treatment plan. The pterygoid implant was planned with a custom-made drill guide, and the zygoma was planned to be placed freehand. (*D*) Intraoperative view. The pterygoid implant is already placed, and the osteotomy for the zygoma implant is being performed. (*E*) Occlusal view demonstrating the placement of the zygoma and pterygoid implant. Note the placement of both implants within the crest of the alveolar ridge. (*F*) Postoperative panoramic radiograph. (*G*) Occlusal view at the time of implant uncovering. (*H*) Occlusal view of the final 3-unit bridge. (*I*) Final occlusion. (*J*) Final panoramic radiograph.

bone, the biomechanical requirements of the final prosthesis, necessary hygiene considerations, finances as well as surgeon and restorative dentist preferences and experience.

Surgical technique (pearls and pitfalls)

The surgical technique for the placement of zygoma implants has been already discussed in previous articles, and very few modifications are necessary for the combination with regular implants. The following are some pearls and pitfalls of these modifications:

Intravenous sedation versus general anesthesia

- If the case calls for the placement of traditional implants in combination with only 1 zygoma implant bilaterally, the procedure can be accomplished in the office setting under IV) sedation with very good acceptance from the patient.

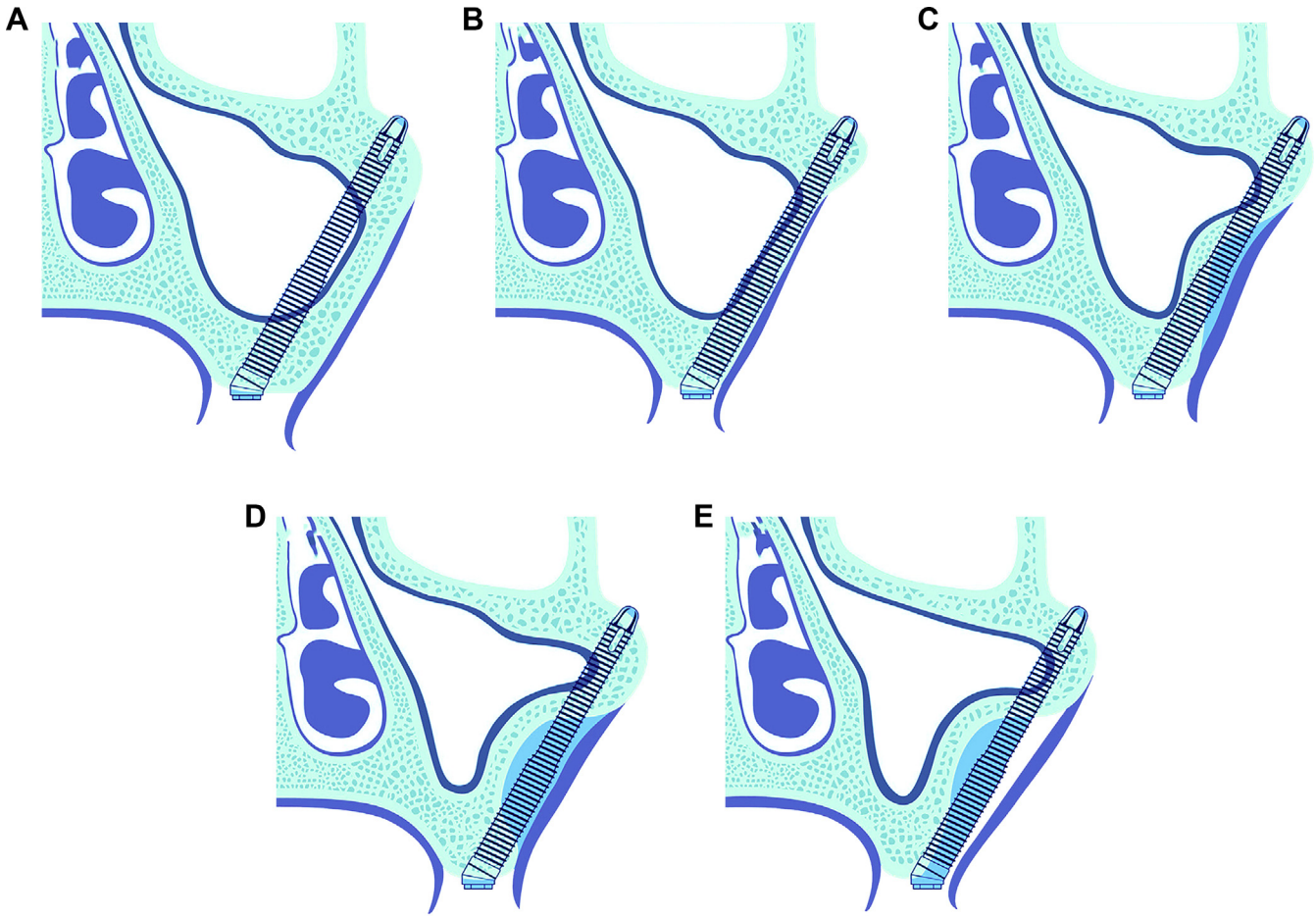

Fig. 9 Zygoma anatomic-guided approach. (*A*) ZAGA 0, (*B*) ZAGA 1, (*C*) ZAGA 2, (*D*) ZAGA 3, (*E*) ZAGA 4.

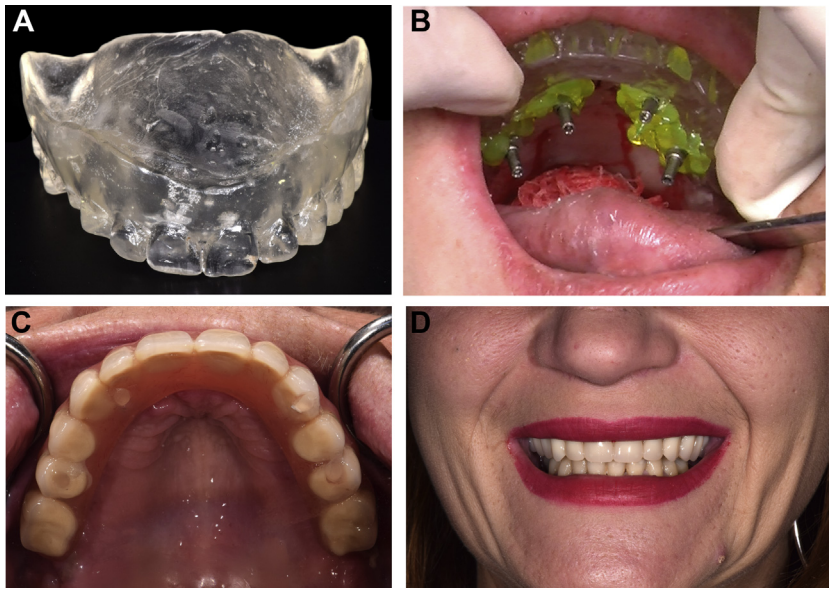

Fig. 10 Prosthetic phase. (*A*) Surgical guide. (*B*) Taking impressions by using the surgical guide. (*C* and *D*) Provisional prosthesis.

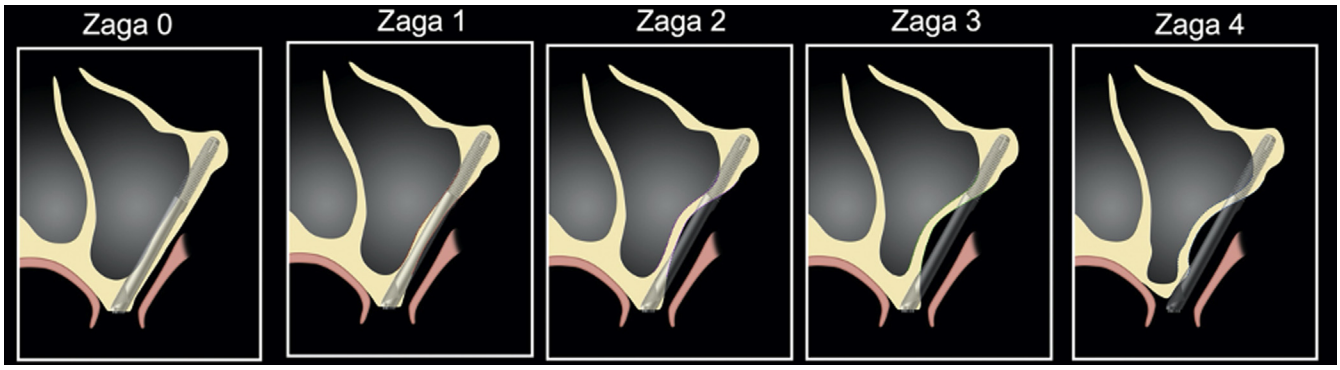

Fig. 4 Zygoma-guided anatomic approach (ZAGA) classification.

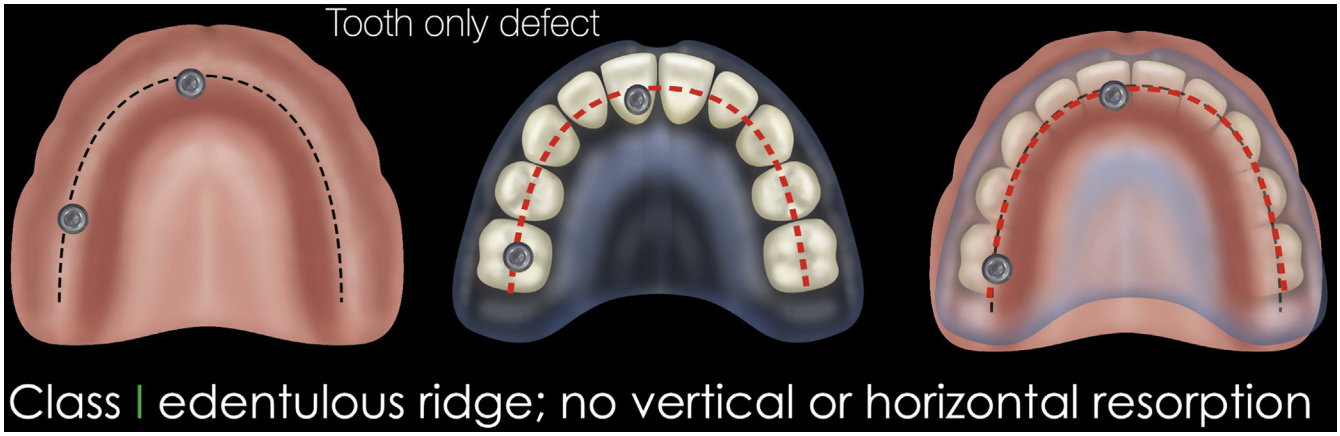

Fig. 5 Class I, nonresorbed edentulous ridge.

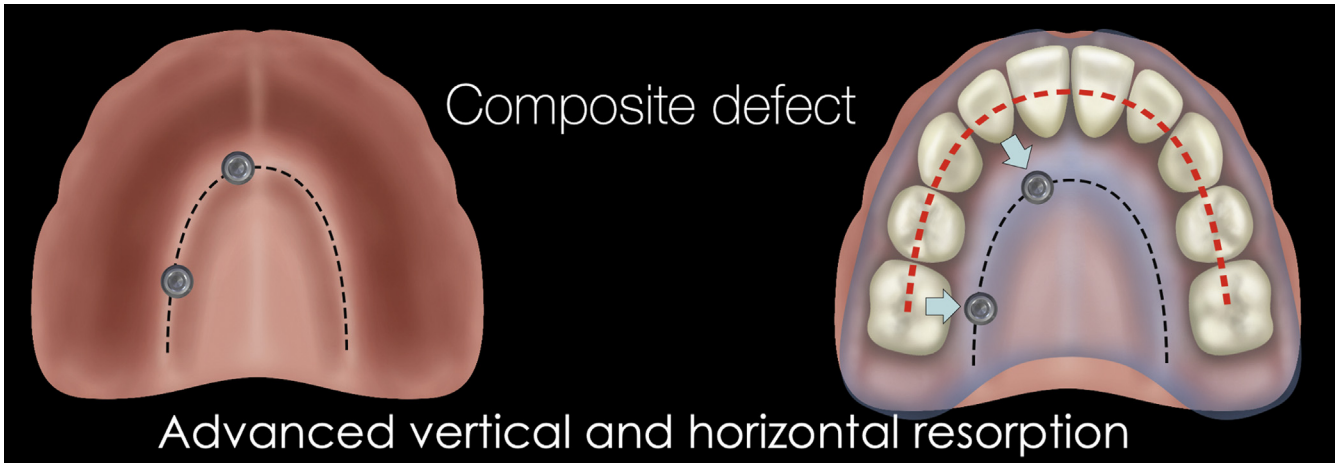

Fig. 6 Resorbed ridge with access screws palatal to the arch form of the teeth.

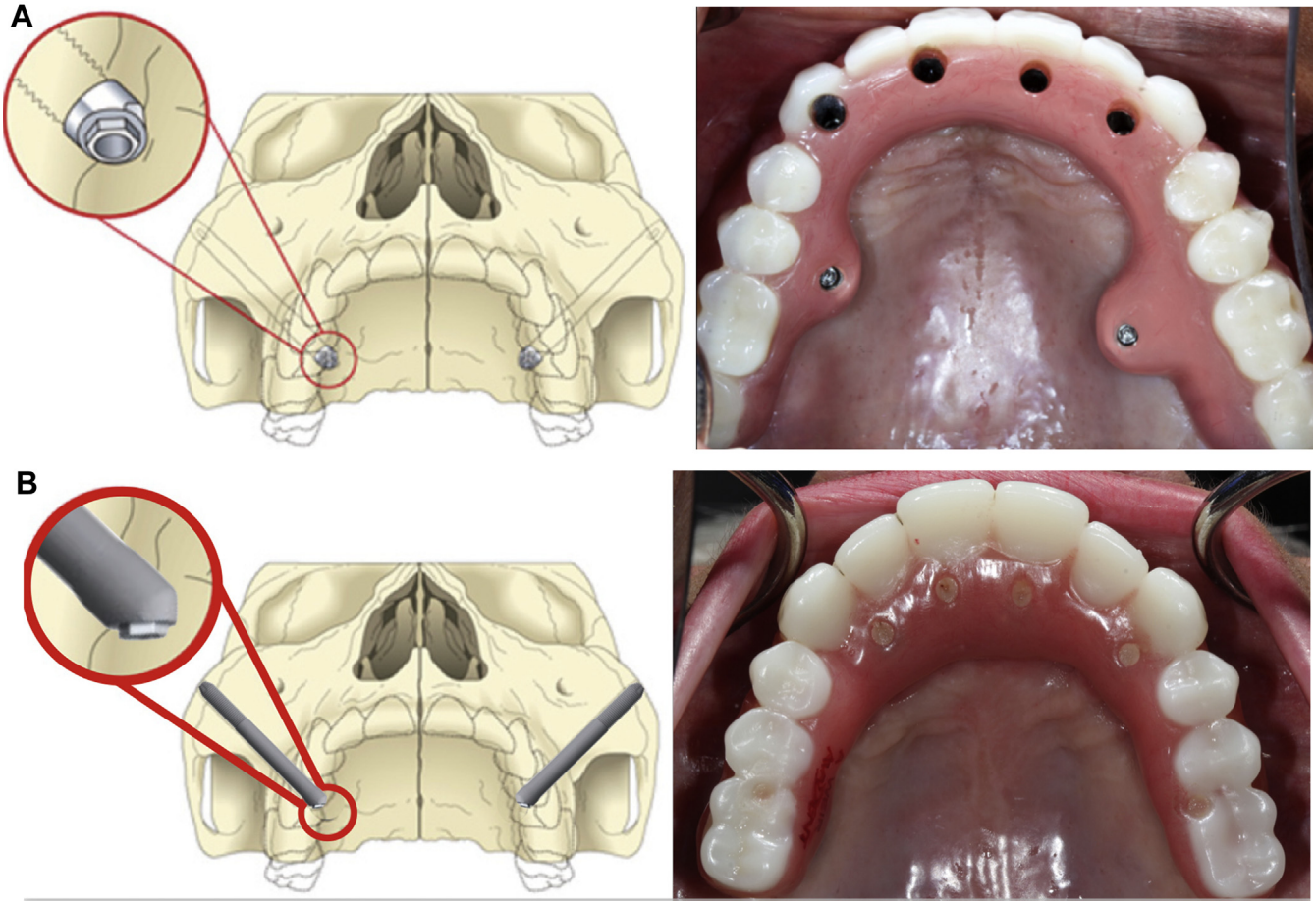

Fig. 1 (*A*) Diagram of the original approach of placing head of the zygoma at the crest of the residual maxillary ridge and resulting palatal placement with respect to proposed tooth position and improper contours of the prosthesis. (*B*) Diagram of the extramaxillary approach placing the head of the zygoma implant in the ideal position with respect to the proposed tooth position and the resulting ideal contours of the prosthesis.

temporary prosthodontic cylinders (Fig. 7). The conversion denture is adjusted to fit around the temporary cylinders (Fig. 8).

A soft, flowable mix of auto polymerizing acrylic is carefully injected around the temporary prosthetic cylinders (Fig. 9) and the conversion denture seated. The opposing dentition is closed in the acquired centric position to establish optimal orientation of the dentition. When the acrylic has polymerized, the conversion prosthesis is removed from the patient and refined. This process will include the addition of acrylic to fill

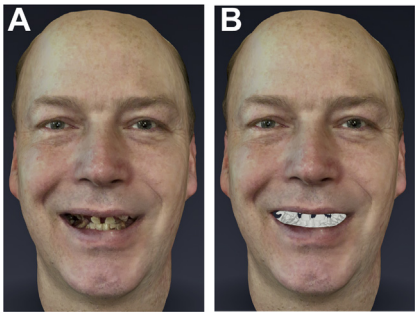

Fig. 2 (*A*) Facial scan using smartphone surface scanning technology. (*B*) Merged STL file from an intraoral scan with the facial scan.

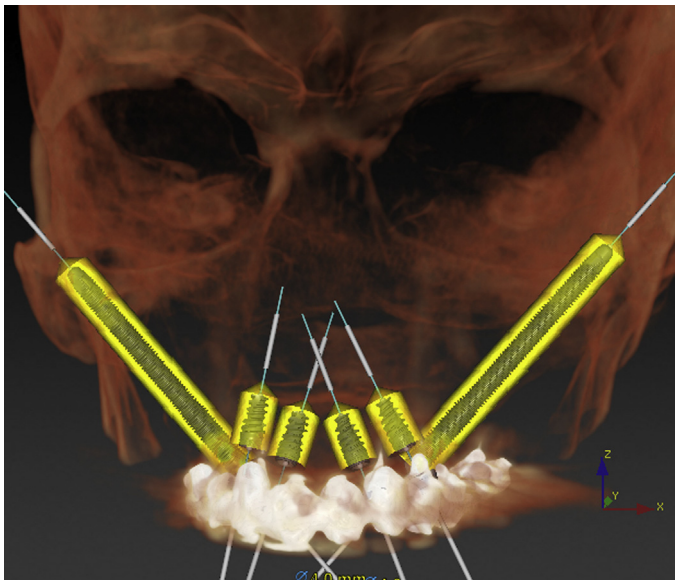

Fig. 3 Implant planning software with zygoma implants in implant library catalog for virtual planning.

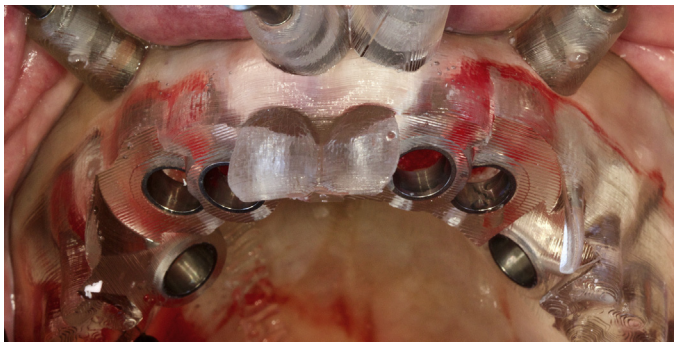

Fig. 4 Stereolithic printed surgical guide for the placement of conventional length implants in the anterior maxilla and initial osteotomy for the placement of the head of the zygoma implants in the posterior maxilla.

obtained as needed. Specific oral hygiene instructions are provided for the patient and an additional oral hygiene visit is schedule six to 8 weeks after surgery. At that session, again the conversion prosthesis is maintained in its position while the hygienist preforms standard cleaning procedures.

Fabrication of the definitive prosthesis

At 12 weeks or later, the patient presents for the initiation of the definitive phase of therapy for the construction of the definitive prosthesis. The first step of the process is to record information from the interim conversion prosthesis including:

- Smile analysis
- Lip and cheek support analysis

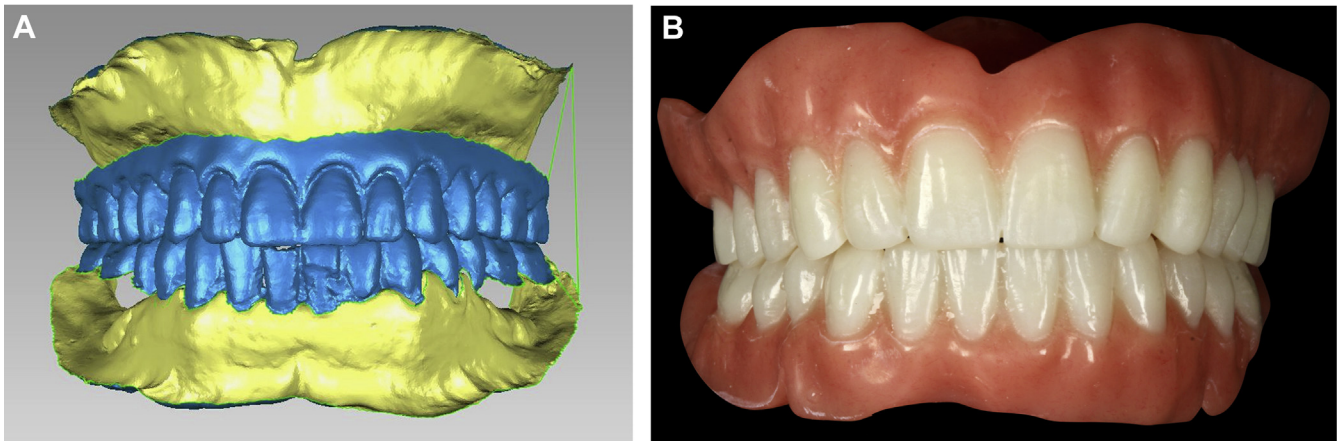

Fig. 5 (*A*) CAD/CAM design of dentures in software based on information acquired with cone beam computed tomography, intraoral scans, and facial surface scan. (*B*) Milled monolithic dentures based off of software generated design.

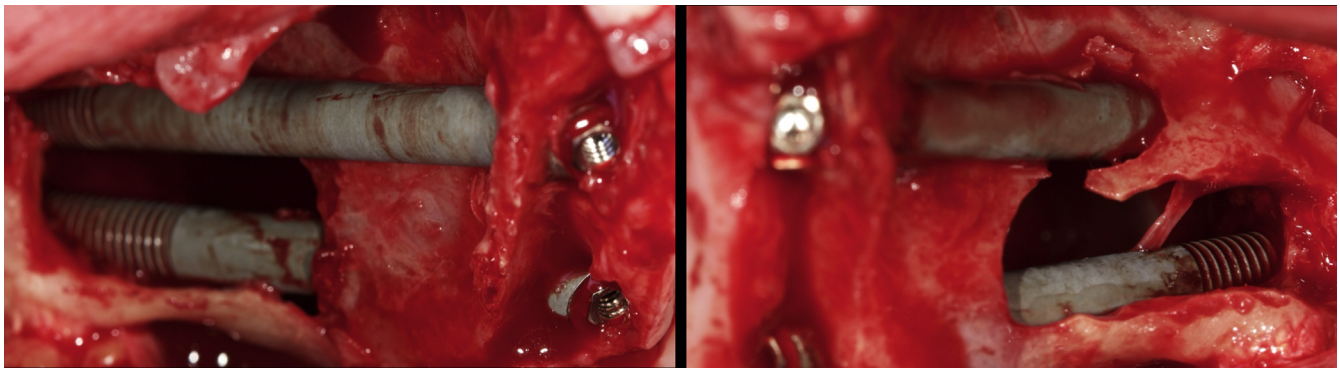

Fig. 6 Zygoma implants placed in ideal location based on the prosthetic plan.

any voids and the removal of the palate and flanges to establish a cleansable intaglio surface, and the entire conversion prosthesis is highly polished (Fig. 10).

One to 2 weeks after surgery, the patient returns for follow-up care. This visit includes suture removal and any additional occlusal adjustments if indicated, but it is important to remember that the conversion prosthesis should not be removed. Postoperative radiographic records can be made at this visit and a smile analysis and photographic records are also

- Occlusal analysis
- Confirmation of tooth and gingival shade
- Photographic records
- Intraocclusal bite registration
- Facebow registration

The next step is to make a final impression of the implant positions, which can be done in 2 ways. The first is to use the existing prosthesis[5] following a protocol including:

Fig. 10 Milled conversion denture with luted titanium copings modified to fixed full arch provisional prosthesis with convex, highly polished intaglio surface.

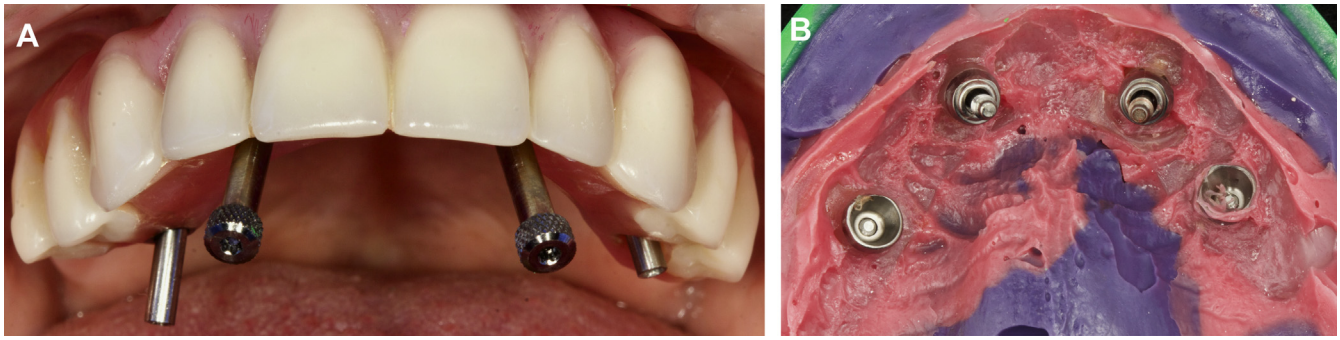

Fig. 11 (*A*) Long guide pins attached to the fixed full arch provisional prosthesis with a PVS wash on the intaglio surface. (*B*) PVS impression in stock impression tray with embedded fixed full arch provisional.

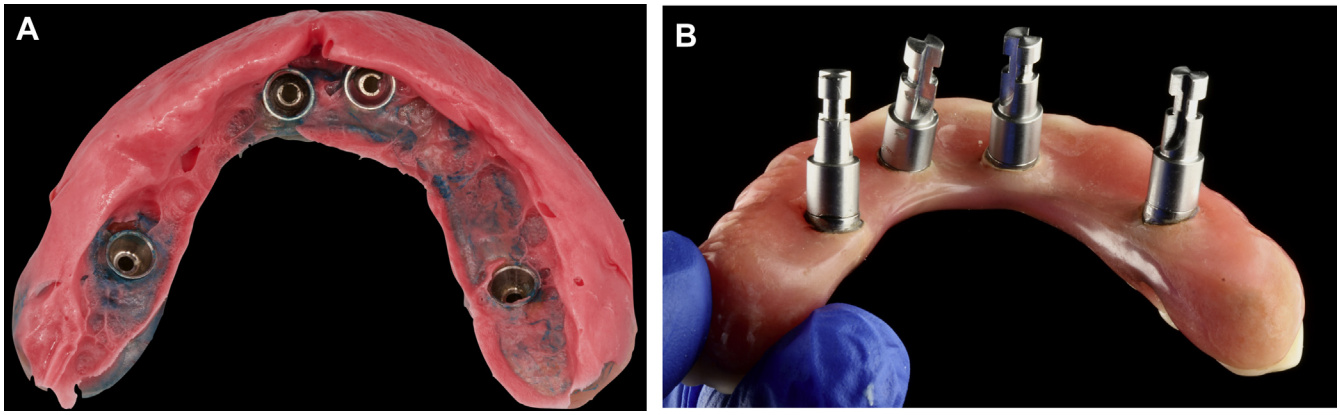

Fig. 12 (*A*) Intaglio surface of fixed full arch provisional with light-body PVS wash impression. (*B*) Multiunit abutment analogs placed into the fixed full arch provisional for master cast fabrication.

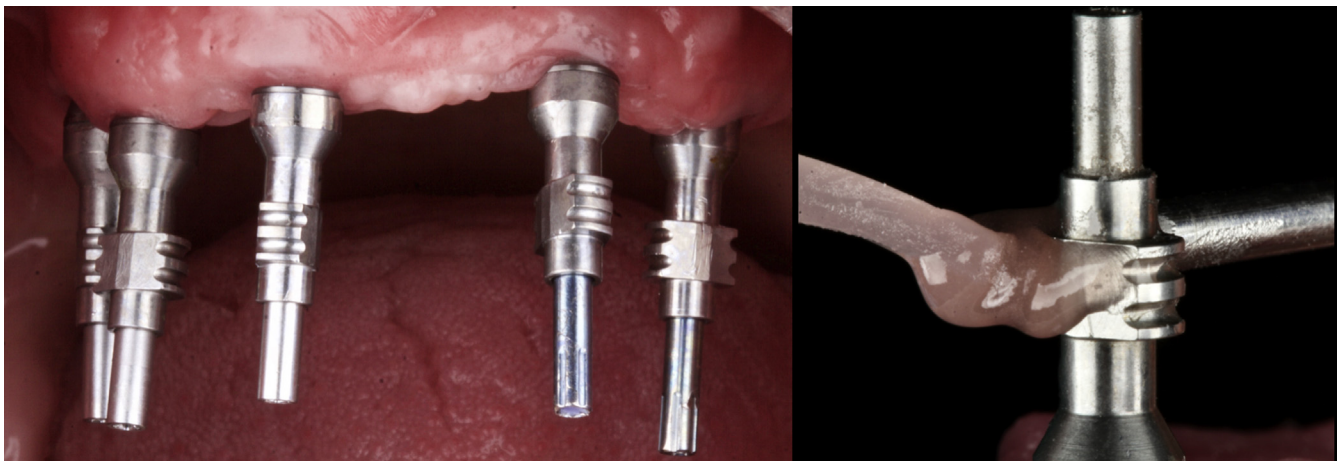

Fig. 13 Open tray impression copings seated on the multiunit abutments and luted with rigid wire connectors.

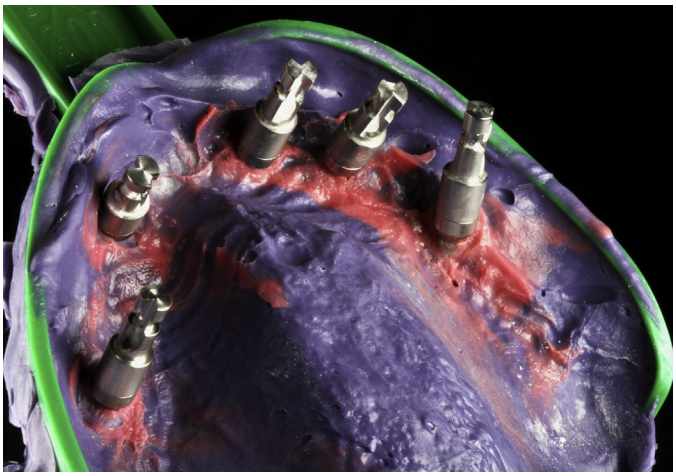

Fig. 14 Conventional fixed full arch impression with open tray impression copings embedded and multiunit abutment analogs seated into it.

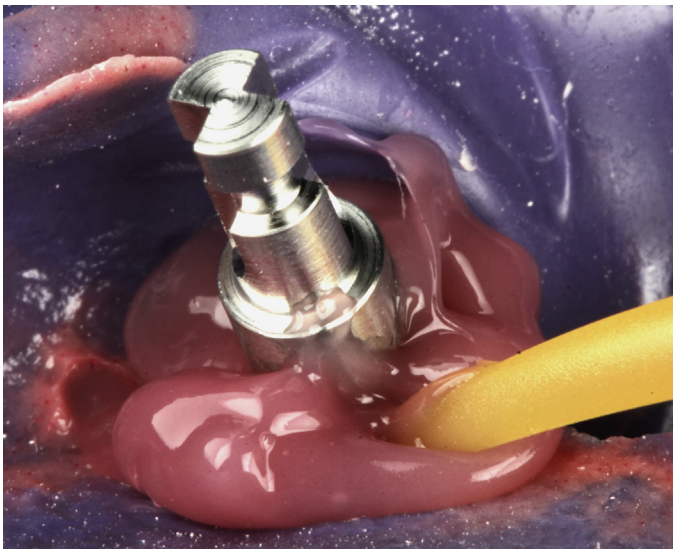

Fig. 15 Gingival moulage injected around the impression coping/analogue interface.

Assuming all records are accurate, and the tooth position of the conversion prosthesis is acceptable, these records can be imported into CAD/CAM software from which the definitive prosthesis is constructed. The definitive prosthesis can be manufactured with various designs,[7,8] the most common of which are (1) milled acrylic on a CAD/CAM milled or 3-dimensional printed titanium framework (Fig. 18), (2) monolithic Zirconia with or without minimal facial and gingival layering of porcelain (Fig. 19), or (3) a combination prosthesis, consisting of a fully milled framework, individually milled zirconium crowns, and a gingival veneer of ceramic, composite, or milled high-density PMMA (Fig. 20).

Delivering the definitive prosthesis

The delivery of the definitive prosthesis is a routine procedure composed of the following protocol:

- Removal of the conversion prosthesis
- Delivery of the definitive prosthesis
- Check and adjustment of occlusion if necessary
- Check soft tissue contact with the intaglio surface of the prosthesis
- Seal the screw access channels with an easily retrievable silicone-type material
- Postdelivery radiographic imaging
- Postdelivery photographs
- Postdelivery intraoral digital impressions for night guard
- Schedule hygiene re-care visits.

Potential complications during the restorative process

Of note is that the most important factor in efficient restorative protocols is that all records, including the fit and tooth position of the interim conversion prosthesis, must be appropriate. If the initial intraoral records have erroneous recordings, or the interim conversion prosthesis is inaccurate, there may be a need to do a subsequent milled PMMA provisional to reestablish the correct occlusal relationships. This should only be done after 3 months of healing once

Fig. 16 Maxillary and mandibular fixed full arch provisional prostheses intraorally and on the master casts in articulation.