Zygomatic Implants

Placement Considerations in Implant-Supported Maxillary Prosthesis

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KEYWORDS

• Zygomatic implants • Armamentarium • Surgical approaches • Guided surgery

KEY POINTS

- The armamentarium for zygomatic implants includes zygoma retractors, specific drills and burrs, depth gauge, inserting hand tools, prosthetic tools, and multiple angulated abutments from 0° to 60°.
- When a guided system is used, the armamentarium also includes the surgical guides, guiding drilling sleeves, and fixing pins and screws.
- The surgical approach is dictated by the maxillary bone volume availability and the prosthetic demands upon which the implant layout is chosen.
- The extramaxillary approach is prosthetically derived. The emergence profile is located at the alveolar crest and the prosthetic work is easy and intuitive.

Introduction

Zygomatic implants were first introduced by Brånemark[1] in 1988 as an alternative treatment for patients with extensive defects of the maxilla caused by tumor resections, trauma, and congenital defects. Later, uses for these implants were expanded to other indications, including rehabilitation of completely edentulous patients with severe maxillary atrophy, excessive maxillary sinus pneumatization, and in cases of failed maxillary sinus augmentation procedures.[2,3]

The zygomatic implants are anchored in the zygomatic basal bone, and usually there is no need for additional bone augmentation or grafting in these patients.[4] Different surgical approaches and implant placement techniques and configurations have been proposed, with the reported success rate ranging between 95.8% and 99.9%, all aiming for full-arch maxillary rehabilitation.[5–9]

Multiple neighboring structures are included in the anatomic geography of the implantation region of zygomatic implants, including the orbit and its content, maxillary artery, pterygoid venous plexus, and skull base. As such, extensive anatomic knowledge alongside a comprehensive 3-dimensional orientation is mandatory when surgically installing these implants.

Contraindications for the use of zygomatic implants are acute sinusitis, zygomatic or maxillary pathologic condition, and an underlying disease deeming the patient unfit for implant surgery. Relative contraindications include heavy smoking, treatment with bisphosphonates or other anti-resorptive medications known to cause medication related osteonecrosis of the jaw, and chronic sinusitis.[10]

The purpose of this article is to describe the different surgical approaches and armamentarium for the installation of zygomatic implants.

Surgical approaches

The original Brånemark technique, the intrasinus technique, uses a 4-cortex anchorage of the zygomatic implant. The zygomatic implant is installed from the palatal aspect of the edentulous alveolar ridge and is directed toward the zygomatic bone, passing through the maxillary sinus. This is intended to give the implant maximal stability by engaging both the maxilla and the zygoma in a bicortical fashion.

However, this installation layout may result in a prosthetic challenge, as the prosthetic emergence profile of the implants tends to be palatal, thus requiring bulky palatal prosthetic rehabilitation, which may lead to patient discomfort[11] (Fig. 1A and B). In addition, the intrasinus passage of the implant may be contraindicated in cases of chronic sinusitis.

In an attempt to overcome the prosthetic and anatomic challenges of the intrasinus approach, the extrasinus approach was developed.[12] This prosthetically and anatomically driven approach aims to position the prosthetic emergence profile of the zygomatic implant at the desired occlusal position at the alveolar crest, and to avoid, as much as possible, implant pathway through the maxillary sinus (Fig. 2A–C), thus minimizing the risk for postoperative sinusitis.[13]

This approach mandates a one-piece full-arch prosthetic rehabilitation with cross-arch stabilization, in order to

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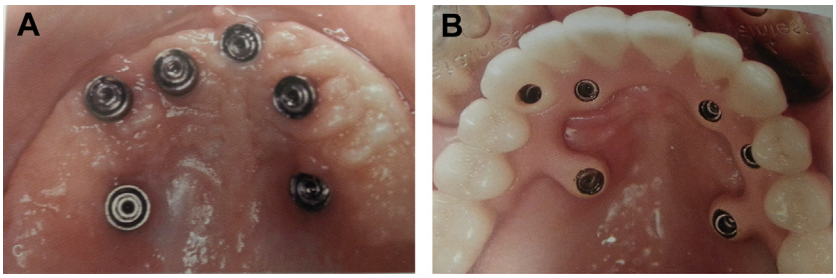

Fig. 1 The intrasinus approach. (*A*) Implants emergence profile. Notice the palatal position of the zygomatic implants. (*B*) Screw-retained restoration with palatal extension for the zygomatic implants. (*From* Casap N, Alterman M. Guided extra-sinus zygomatic and pterygoid implants. In: Ole T. Jensen, ed. The sinus bone graft. 3rd ed. Quintessence Publishing Co Inc; 2019: 152; with permission.)

maintain a stable and immobile maxillary prosthesis. Because of the position of the implants' emergence profile at the peak of the alveolar crest, the prosthetic flow for the prosthodontist remains the same as for standard full-arch dental implants.

Implant layout

The surgical approach should also be dictated by the maxillary bone volume availability and the prosthetic demands, which will guide the choice of implant layout and the type and number of implants installed. Anatomic considerations and guidelines are discussed in detail in the preceding article in this text.

Bedrossian[14] divided the maxilla into 3 zones: zone 1 (the premaxilla); zone 2 (the premolar area); and zone 3 (the molar area) (Fig. 3, Table 1). When graftless implantation with immediate rehabilitation is planned, the bone volume availability in the different zones should dictate the surgical approach and implant layout.

In cases of adequate bone volume in zones 1 and 2, a choice of 4 to 6 standard implants with tilting of the most distal implants may be favored.

In cases of adequate bone volume only in zone 1, the implant layout includes the use of 2 to 4 axial dental implants placed in the premaxillary region for anterior prosthetic support together with 1 zygomatic implant emerging at the premolar area on each side for posterior prosthetic support[15] (Fig. 4A and B).

In cases of severe maxillary atrophy with inadequate bone volume in all 3 zones, 4 zygomatic implants may be used[16] (Fig. 5).

Implant planning and positioning

Proper installation of a zygomatic implant in the correct spatial position requires comprehensive anatomic 3-dimensional understanding and visualization. Inappropriate placement of a zygomatic implant may lead to severe complications, including uncontrolled bleeding, damage to the orbit and its content,

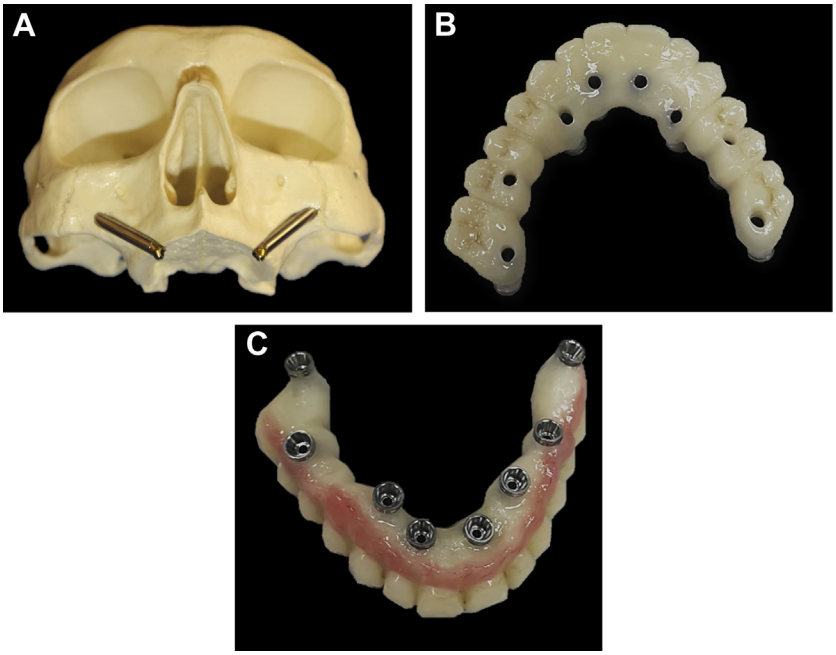

Fig. 2 The extrasinus zygomatic approach. (*A*) A stereolithographic model with 2 extrasinus zygomatic implants. (*B*) Screw retained bridge for extrasinus zygomatic implants—occlusal plane. (*C*) Screw-retained bridge for extrasinus zygomatic implants—tissue surface plane.

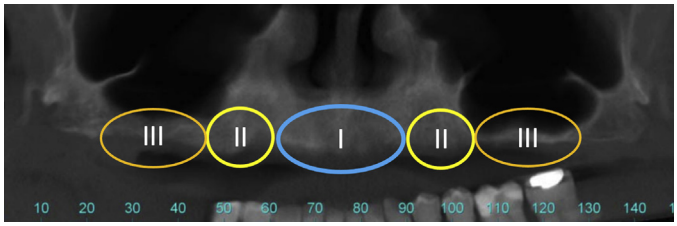

Fig. 3 The Bedrossian classification for maxillary bone availability for dental implants. Zone 1, intercanine region; zone 2, premolars region; zone 3, molars region.

damage to the maxillary sinus, and traumatic fractures to the orbital and zygomatic bones.[8]

The surgical procedure should be planned based on a high-resolution maxillary cone beam computed tomography (CBCT; 200–400-μm slices). The scanning protocol should include the full extent of the lateral orbital wall and the temporal process of the zygomatic bone. When the patient has metallic prosthetics or dental implants, high-resolution CBCT (thin slices) may result in metallic artifacts, which may lead to loss of information and inability to use a virtual planning system in order to properly plan the surgery. To some extent, these artifacts may be removed using designated software, but in cases of widespread artifacts, the use of the hospital-based multidetector computed tomography with thicker slices (500 μm) may be advised. For correct prosthetic-derived surgical planning, the scan should be performed with a denture carrying fiducial markers (eg, barium sulfate, gutta percha), or with a prosthodontic setup of the desired prosthetic work (Fig. 6).

Zygomatic implants can be installed freehand or using presurgical virtually planned navigation and guiding systems. A detailed description of guided and navigation techniques for zygomatic implants is presented elsewhere in this text.

When planning the positioning of zygomatic implants, the vertical plane and the horizontal plane must both be taken into consideration.

The vertical plane, or the "up/down" plane, determines the position of the implant apices between the inferolateral border of the orbit cranially and the inferolateral border of the zygomatic complex caudally. This surgical axis is visible, allowing a skilled surgeon to position the implant in a relatively accurate position (Fig. 7).

The horizontal plane, or the "in/out" plane, of the implant vector determines the apical position of the implant between the anterior and posterior surfaces of the zygomatic complex. This plane is somewhat invisible in its nature without wide surgical exposure and is assessed mainly by the surgeon's personal experience rather than by objective landmarks (Fig. 8). The notch of the zygomatic process is a safe landmark to engage a zygoma retractor for improved visibility and can aid in trajectory guidance to avoid the orbital confines.

Table 1 Maxillary implants supported reconstruction according to the Bedrossian classification of maxillary zones bone availability

Available maxillary bone	Surgical implants layout
Zones 1, 2, 3	Standard dental implants (axial)
Zones 1, 2	4–6 standard dental implants (tilting of the distal implants)
Zone 1	2–4 standard dental implants in the premaxilla and 1 zygomatic implant on each side (optional: pterygoid implants for distal support)
No bone available	Quad-zygomatic layout: 2 zygomatic implants on each side (optional: pterygoid implants for distal support)

The first step of surgical planning is the positioning of the crestal emergence point of the zygomatic implants. This should facilitate the correct prosthetic layout for full maxillary prosthetic rehabilitation.

In cases of 1 zygomatic implant on each side of the maxilla, the preferred crestal emergence point should be at the position of the second premolar. This should provide posterior support for the prosthesis (Fig. 9).

When 2 zygomatic implants are planned, the anterior implant's crestal emergence point should be positioned at the area of the canine. This positioning provides the prosthetic appliance with anterior support. The posterior implant's crestal emergence point should be positioned at the area of the first molar (Fig. 10).

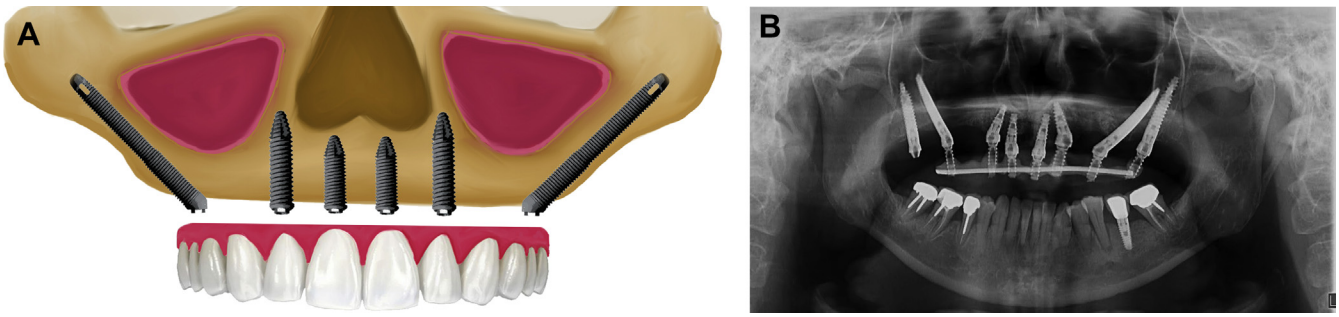

Fig. 4 Implants layout for maxillae with bone availability in zone 1 only. (*A*) A scheme showing 4 axial implants in the premaxilla and 1 extramaxillary zygomatic implant on each side. (*B*) Immediate restoration of 4 axial implants in the premaxilla, 1 extramaxillary zygomatic implant, and 1 pterygoid implant on each side. (*From* Casap N, Alterman M. Guided extra-sinus zygomatic and pterygoid implants. In: Ole T. Jensen, ed. The sinus bone graft. 3rd ed. Quintessence Publishing Co Inc; 2019: 152; with permission.)

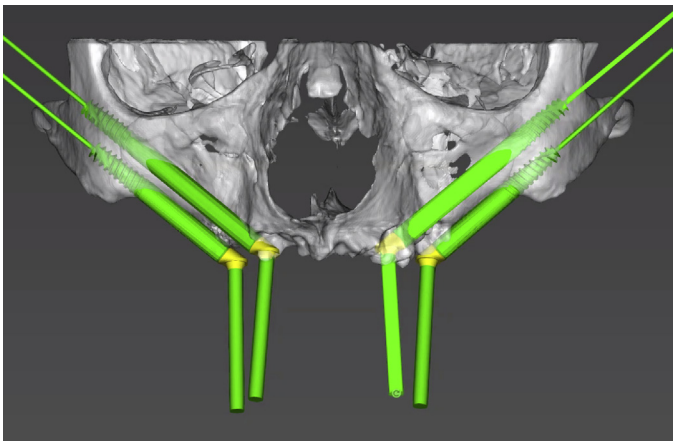

Fig. 5 Virtual planning of quad-zygomatic layout.

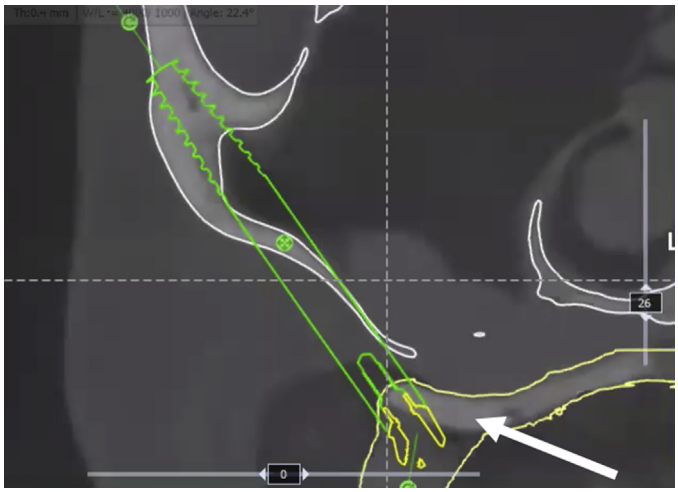

Fig. 6 Virtual planning of a zygomatic implant according to the prosthetic setup. (*arrow*) The CBCT scanned prosthetic setup.

Once the crestal emergence position of the zygomatic implants has been decided, the apical positioning of the implants should be performed. In cases of extramaxillary zygomatic implants, this is the only true anchorage of the implants, because the alveolar crest is mainly used for implant/prosthetic support. Hence, the apical part of the implants should be directed to the areas with maximal bone volume in the zygomatic complex. Extreme care should be taken not to compromise neighboring anatomic structures, especially the orbit and infratemporal fossa.

In cases of a single zygomatic implant on each side of the maxilla, the preferred apical zygomatic anchorage point is the center of the zygomatic complex, in the direction of the zygomatic notch, which is located at the intersection of the lateral orbital wall and the zygomatic arch (Fig. 11).

In cases of 2 zygomatic implants on each side, the anterior implant should be planned first, in order to protect the orbit. The apical zygomatic anchorage of the anterior implant should be distanced at least 5 mm away from the inferolateral border of the orbit, with the apical zygomatic anchorage of the posterior implant placed in a lower and more posterior position (Fig. 12). Intuitively, the angle in the vertical plane is relatively easier to determine. Nevertheless, care should be taken in the horizontal plane as well, in order to achieve correct positioning of the apical zygomatic anchorage. Some orbital floors are more concave than others, and mispositioning of the apical zygomatic anchorage in the horizontal plane may result in violation of the orbital floor.[17]

Armamentarium and surgical procedure

The surgery for the installation of zygomatic implants may be performed either under general anesthesia or under local anesthesia and intravenous sedation. The choice should be made according to the surgeon's experience, and patient's preferences and compatibility.

The armamentarium for zygomatic implant surgery includes the basic oral and maxillofacial surgical armamentarium, including a variety of tissue retractors for maximal tissue exposure (Fig. 13), and, in addition, special surgical kits for zygomatic implants, that include diamond tract burrs, zygoma implant-specific drills, depth gauge, implant inserting hand tools, manual hex driver, prosthetic tools, and multiple angulated abutments from 0° to 60° (Fig. 14). When using a guided system, the armamentarium also includes the surgical guides, guiding drilling sleeves, and fixing pins and screws (Fig. 15).

After general anesthesia or intravenous sedation is achieved, a throat pack should be placed to prevent foreign body

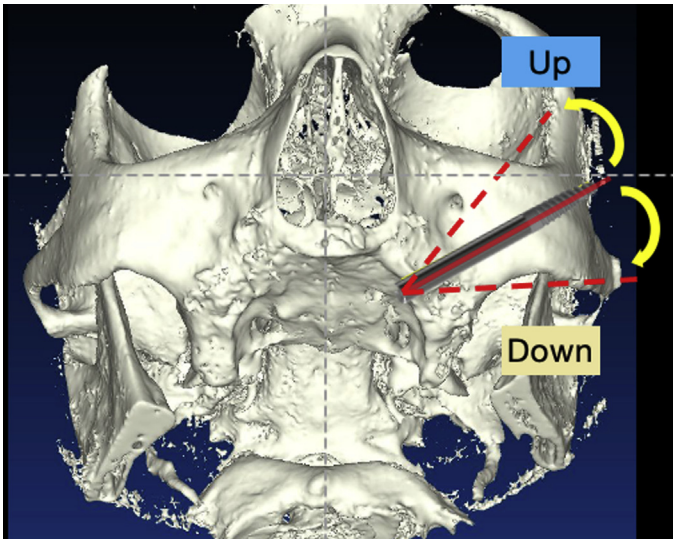

Fig. 7 Up/down plane.

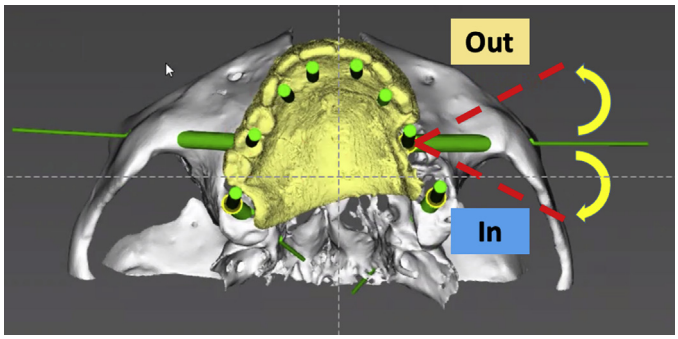

Fig. 8 In/out plane.

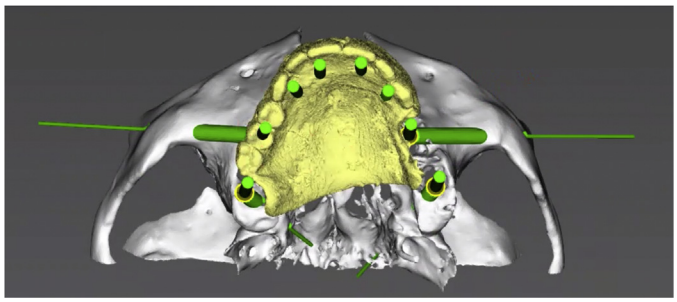

Fig. 9 Single zygomatic implant planning with emergence profile at the second premolar region.

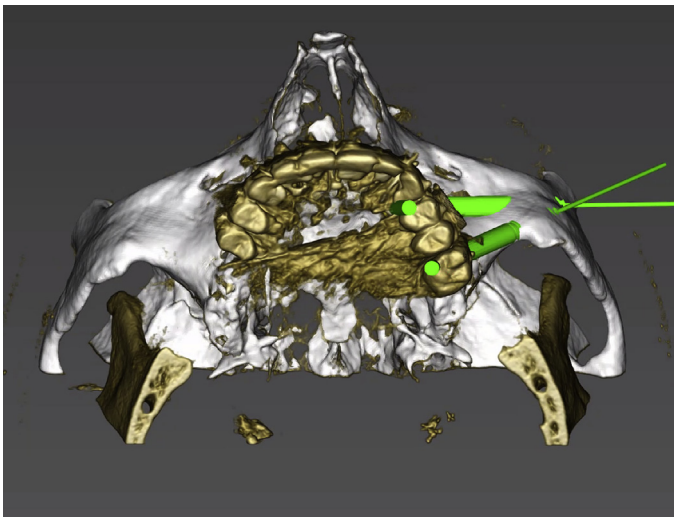

Fig. 10 Two zygomatic implants planning with emergence profiles at the canine and first molar.

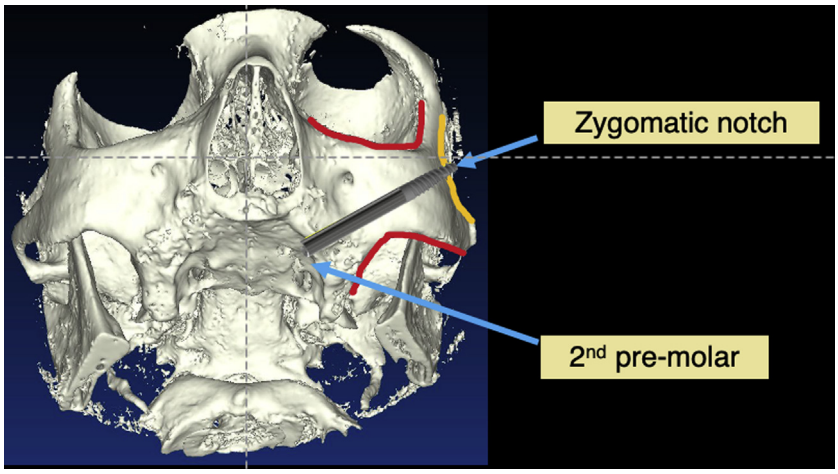

Fig. 11 Apical anchorage planning of a single zygomatic implant.

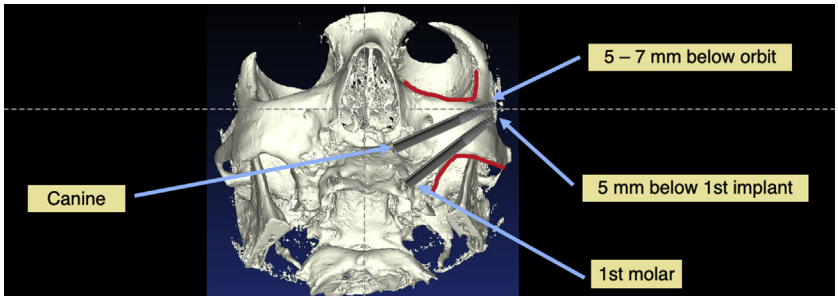

Fig. 12 Apical anchorage planning of 2 zygomatic implants.

Fig. 13 Surgical armamentarium for zygomatic implant surgery. Various tissue retractors are used for maximal tissue exposure.

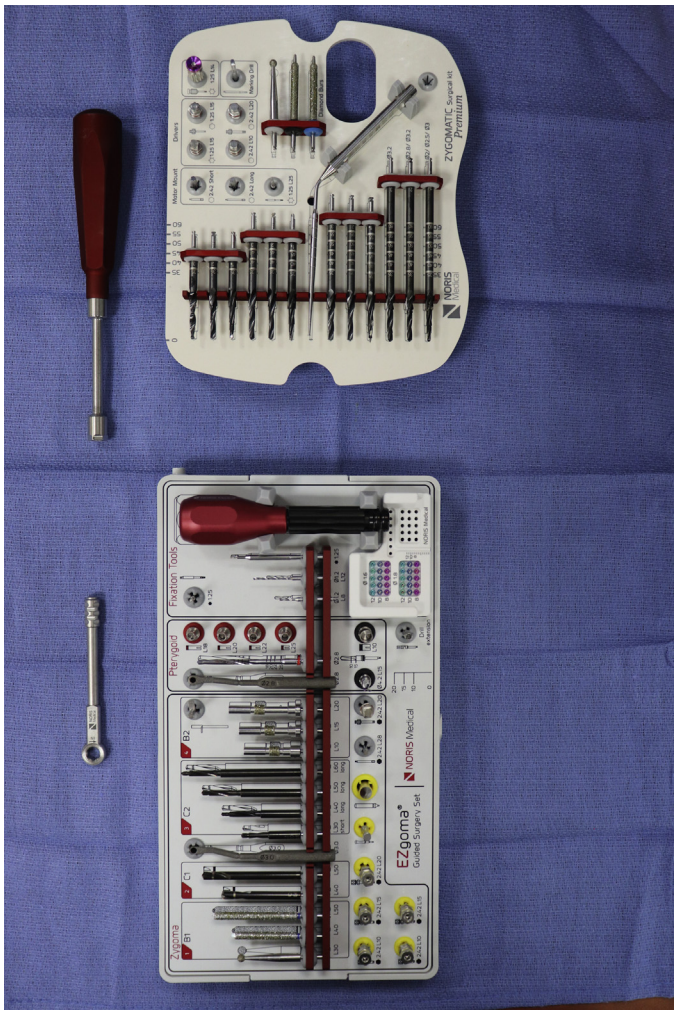

Fig. 14 Specialized zygomatic implant surgery kits (Noris Medical, Nesher, Israel). The basic kit includes diamond tract burrs, zygoma implant-specific drills, depth gauge, implant inserting hand tools, manual hex driver, and prosthetic tools. The guided surgery kit also includes fixing screws, drilling sleeves, and guided diamond burrs. (*Courtesy of* Noris Medical Inc, Nesher, IL; with permission)

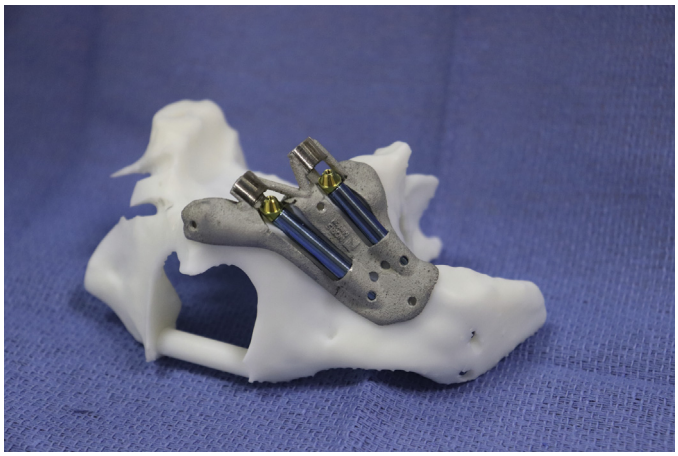

Fig. 15 Titanium surgical guide. (*Courtesy of* Noris Medical Inc, Nesher, IL; with permission)

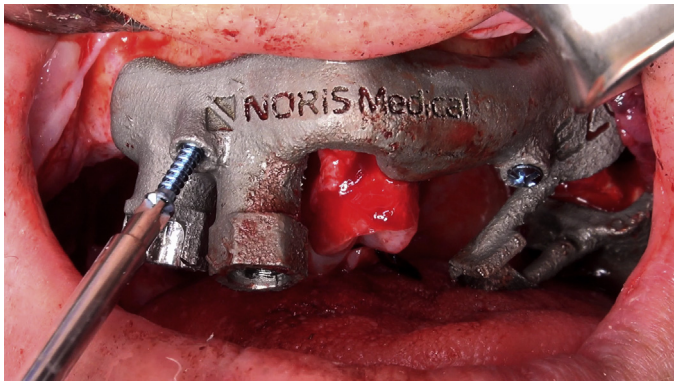

Fig. 16 Fixating of titanium guide using fixing screws. (*Courtesy of* Noris Medical Inc, Nesher, IL; with permission)

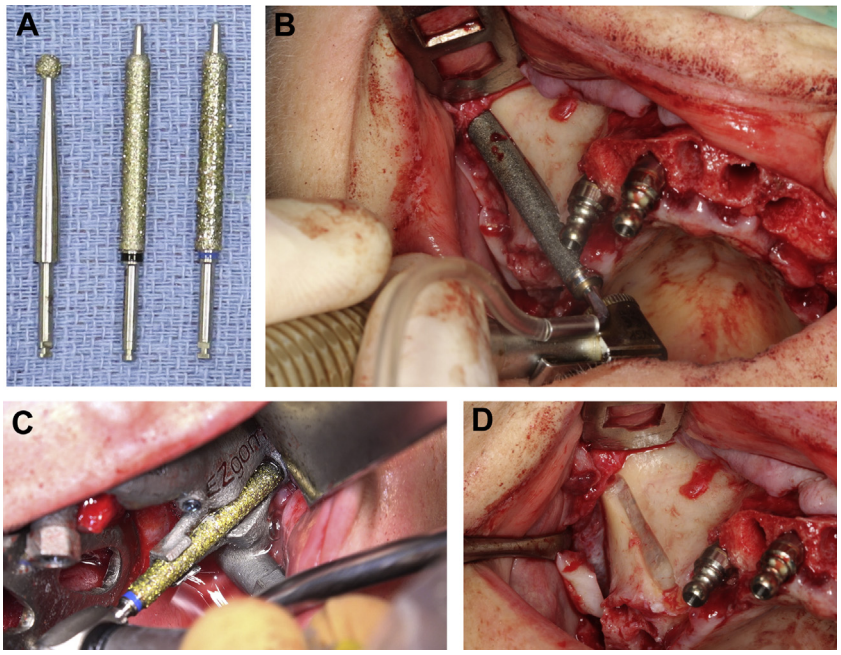

Fig. 17 Preparation of the drilling trough. (*A*) Diamond tract burrs. (*B*) Freehand preparation. (*C*) Guided preparation. (*D*) Drilling path ready for zygoma drilling. (*From* Casap N, Alterman M. Guided extra-sinus zygomatic and pterygoid implants. In: Ole T. Jensen, ed. The sinus bone graft. 3rd ed. Quintessence Publishing Co Inc; 2019: 152; with permission.)

aspiration. Local anesthesia with hemostatic agents should be used for pain control and maximal hemostasis throughout the procedure.

A midcrestal incision with bilateral vertical releasing incisions along the posterior part of the zygomatic buttress should be performed, and a mucoperiosteal flap should be raised to expose the surgical field.

Special care should be taken to identify the anterior border of the zygomatic arch, the inferior and lateral borders of the orbit, and the infraorbital nerve, all marking the geographic borders of the zygomatic bone.

When surgical guides are used, they must be firmly fixed to the maxilla using fixation pins/screws (Fig. 16).

The first surgical step is the determination of the implant position and vector. When performing freehand implant insertion, this is marked using an indicator that is used to determine the drilling direction according to the surgical plan. Next, the drilling path is prepared using a diamond tract burr (Fig. 17A–D). In a gradual manner and under controlled power and fine motion, the burr should create a trough at the lateral surface of the maxilla and the lateral wall of the maxillary sinus that will allow for drilling and correct positioning of the zygomatic implant. If the lateral wall of the maxillary sinus is absent after implant preparation, elevation of the Schneiderian membrane should be performed in order to avoid its violation and the penetration of the zygomatic implant to the maxillary sinus.

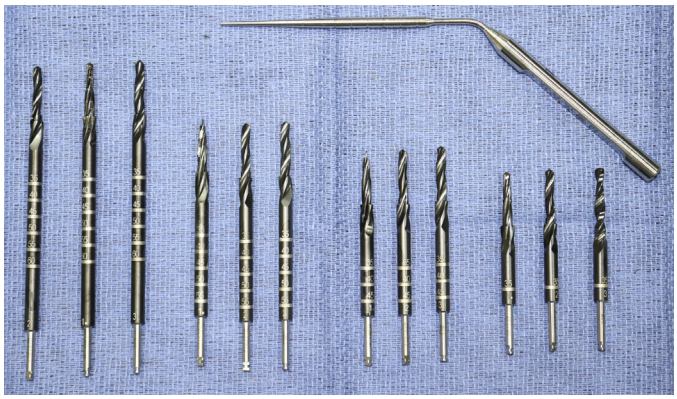

Fig. 18 Ascending diameter zygomatic implant drills.

The drilling protocol for zygomatic implant uses a sequenced drilling with ascending diameter drills (Fig. 18). The final drill is chosen according to the manufacture instructions and should take into account the density of the zygomatic bone. A minimum of 7 mm of zygomatic anchorage is needed for immediate stability of zygomatic implants.[18]

The drills should exit the cortical aspect of the zygoma in order to provide a bicortical anchorage for the implants. This should be palpated using the depth probe and a finger placed on the covering skin of the zygoma (Fig. 19A).

When a freehand technique is used, the correct implant length is chosen using a depth probe. The edge of the probe should rely on the zygomatic cortex at the exit point, and the distance between this point and the crestal groove should be measured. From this measurement, 2.5 mm should be reduced in order to allow for the angulated abutment to connect to the implant and emerge at the planned prosthetic position (see Fig. 19B).

After the drilling is performed, space should be prepared for the angulated abutments using diamond burrs. This may be performed using special guided burrs or using round diamond burrs (Fig. 20). It is crucial that the angulated abutments will be able to connect to the implants without any bone interference.

Implants may be installed using the rotatory handpiece or using inserting hand tools (Fig. 21). The implants' insertion

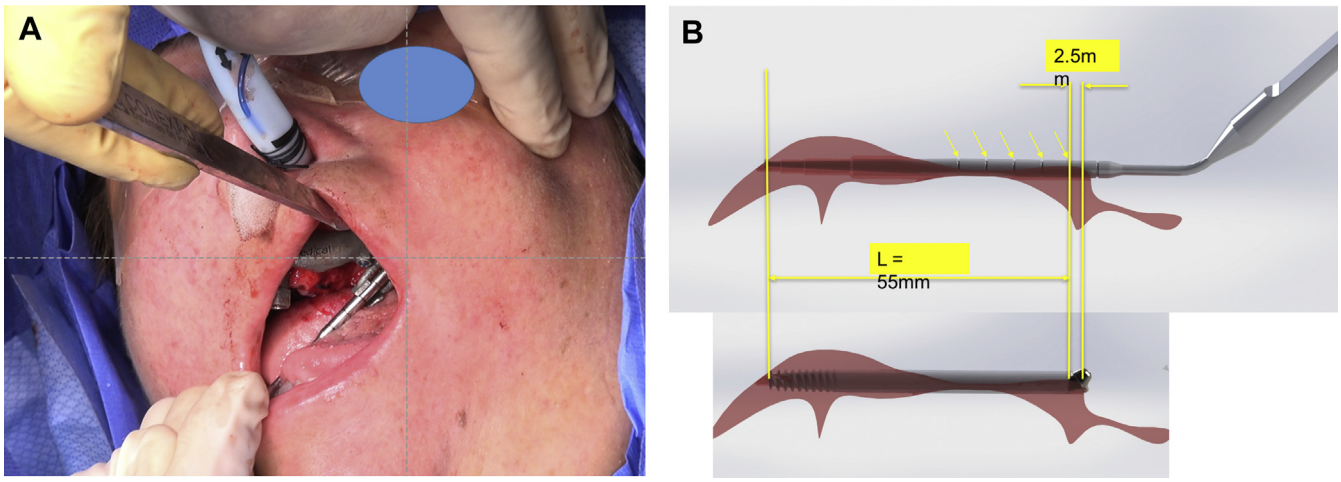

Fig. 19 Freehand determination of the zygomatic implant length. (*A*) The depth probe is inserted through the drilled preparation and is palpated using a finger placed on the covering skin of the zygoma. (*B*) 2.5 mm is deducted from the probe measurement for the angulated prosthetic abutment. (*From* Casap N, Alterman M. Guided extra-sinus zygomatic and pterygoid implants. In: Ole T. Jensen, ed. The sinus bone graft. 3rd ed. Quintessence Publishing Co Inc; 2019: 152; with permission.)

Fig. 20 Diamond burrs for bone reduction to allow a passive fixation of the prosthetic abutments.

Fig. 21 Implant insertion tools.

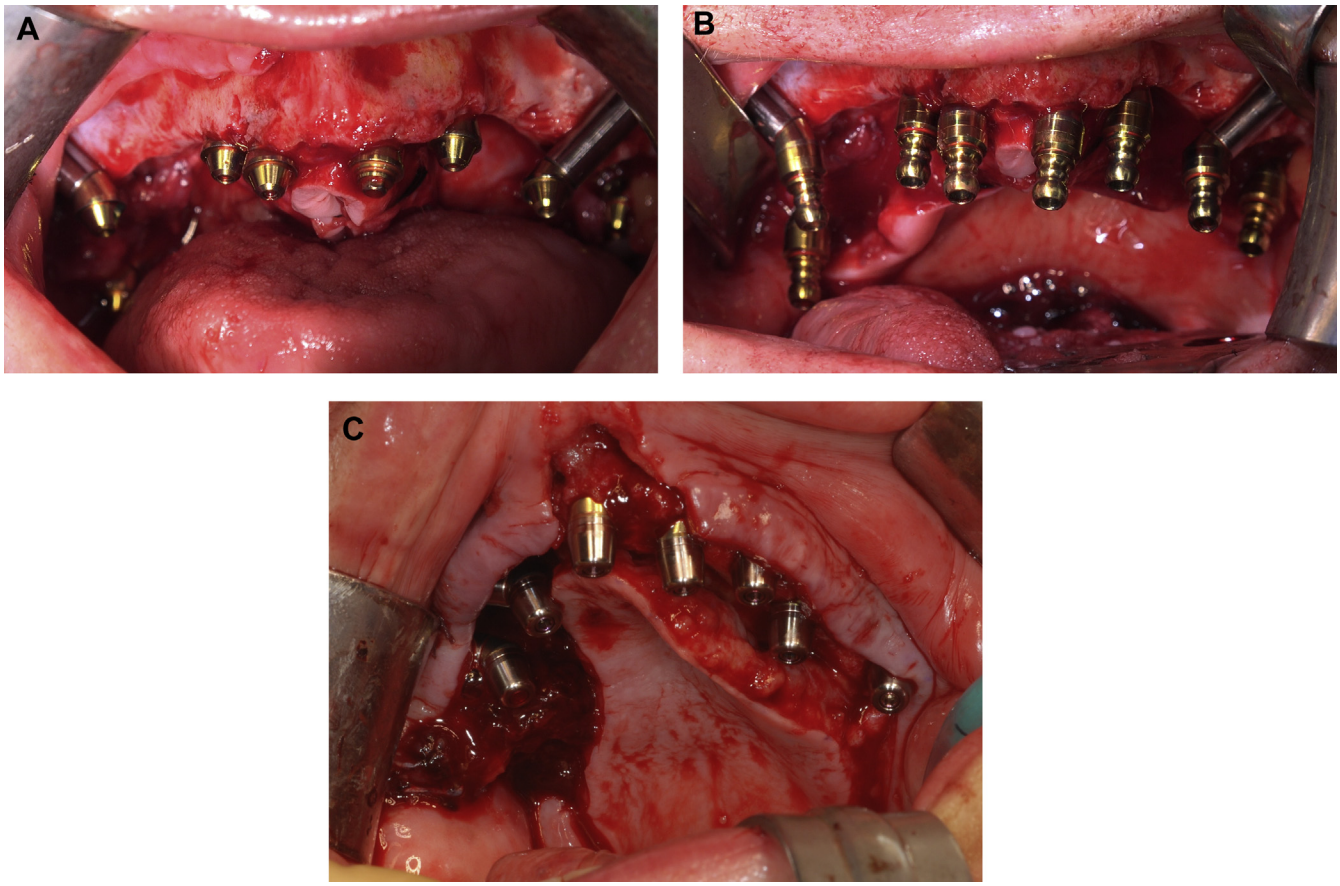

Fig. 22 Installation of prosthetic abutments. (*A*) A variety of angulated abutments between 0° and 60° may be used for a uniform prosthetic path of insertion. (*B*) Transfers for immediate impressions. (*C*) Angulated abutments covered with cover-screws.

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.

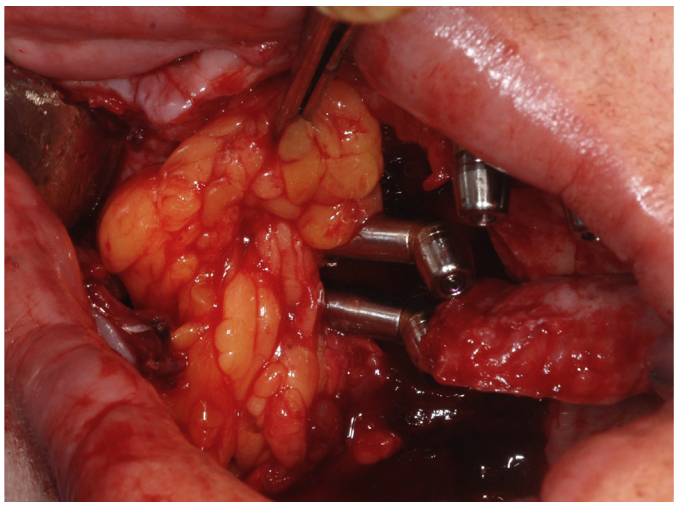

Fig. 23 Covering of the zygomatic implants using buccal fat of pad.

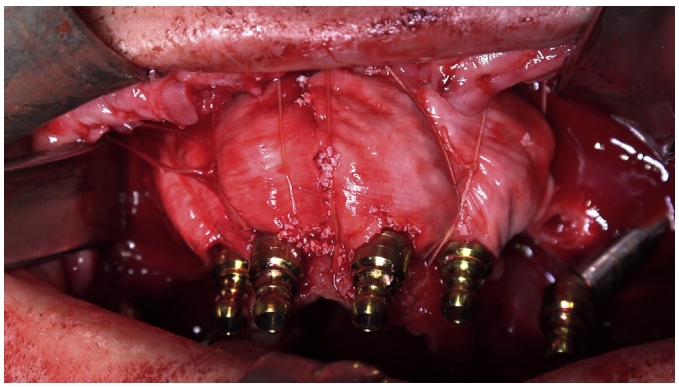

Fig. 24 Guided bone reaeration around the axial implants in the premaxilla.

Summary

Zygomatic implants have been proven to be an alternative treatment option for the rehabilitation of atrophic maxillae, with or without the combination of standard dental implants and pterygoid implants. These may allow for a graftless treatment course, and in compatible conditions, enable immediate restoration.

Several approaches have been offered over the years. The original intrasinus approach uses a 4-cortex anchorage of the zygomatic implants and may provide superior stability of the implants over the extramaxillary approach. However, the palatal position of the emergence profile of the implants may result in a challenging and suboptimal rehabilitation. The extramaxillary approach allows for a prosthetic-driven layout of the implants, with the use of standard prosthetic protocols for implant-supported maxillary rehabilitation. In addition, it enables a better visibility for the surgeon, discarding the need for maxillary sinus visual slotting, and in many cases, maintains the Schneiderian membrane, lowering the risk for postoperative maxillary sinus complications.

The implant layout is decided according to bone volume availability in the different zones of the maxilla. The different layouts commonly used are 2 to 4 standard implants in the premaxillary region combined with 1 zygomatic implant on each side of the maxilla, and 4 zygomatic implants for a full maxillary arch rehabilitation.

The implant positioning must take into consideration the vertical and horizontal planes, and care must be taken not to misposition the implant apices in both axes. This may be challenging when performed freehand, and virtual 3-dimensional planning with the manufacturing of surgical guides is advised.

The armamentarium for zygomatic implants includes the basic oral and maxillofacial armamentarium, with an emphasis on a set of tissue retractors for proper maxillary exposure during the surgical procedure. In addition, special surgical kits, including a variety of diamond burrs, zygoma implant-specific drills, depth gauge, implant inserting hand tools, manual hex driver, prosthetic tools, and multiple angulated abutments from 0° to 60°. When guided systems are used, guiding sleeves and fixating pins are added, together with special tools for the precise spatial positioning of the implants according to the prosthetic plan.

Clinics care points

- The reported average long-term survival rate of zygomatic implants ranges between 95.8% and 99.9%.
- Cone beam computed tomography for virtual planning should be performed with 200- to 400-μm slices. When extended metallic prosthetics or multiple dental implants exist, the scattering may result in metallic artifacts, which may lead to loss of information. In such cases, multidetector computed tomography with thicker slices (500 μm) may be advised.
- The decision regarding the implant layout should be based on the bone availability in the 3 zones of the maxilla.
- The extramaxillary approach offers a simpler and more intuitive prosthetic design that resembles the standard full-arch screw-retained restoration.
- A minimum of 7 mm of zygomatic anchorage is needed for immediate stability of zygomatic implants.
- The zygomatic implants insertion torque should be between 35 and 45 Ncm to ensure primary stability and to avoid damage to the zygomatic bone.
- The coverage of the zygomatic implants with buccal fat pad may augment and improve the soft tissue quality around the implants.
- Misplacement of a zygomatic implant may lead to uncontrolled bleeding, damage to the orbit and its content, damage to the maxillary sinus, and traumatic fractures to the orbital and zygomatic bones.

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