Use of zygomatic implants to deal with resorbed posterior maxillae

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For some 40 years, osseointegration has been clinically applied in both the maxilla and the mandible.

With a high predictability for some systems (19), increased applications have been developed for compromised patients.

Unfortunately, restrictions have appeared in the use of oral implants. One of them is the lack of sufficient bone volume, especially in the posterior maxilla. This insufficient bone volume can be due to bone resorption as well as to pneumatization of the sinus or to a combination of both. In any case, insertion of implants in this region remains extremely unpredictable.

According to some clinical reports, the minimal bone height for a standard implant in the posterior region should be at least 10 mm (33) to ensure acceptable success rate. This is confirmed by a retrospective study of 660 implants using the Brånemark system in the posterior maxilla followed for 5–12 years showing a cumulative success rate of 94.4% but with a loss of 10 implants on 49 implants with a length of 7 mm and a diameter of 3.75 mm (22).

With the introduction of wide implants 5 and 6 mm in diameter (17, 18) the contact surface between implant and bone is increased and assumes a cortical anchorage with an initial stability in bone type IV even if the bone height is no greater than 6 mm. Implants of wide diameter limit the biomechanical complications in the treatment of the posterior maxillae.

Pterygomaxillary implants have also been proposed for posterior anchorage in totally edentulous patients (3).

Although wide implants could be a solution for crestal heights up to 6 mm, many patients present a maxillary height of 0.8–6 mm (39). For these cases, several solutions have been proposed to augment the volume of bone in this region, such as onlay/inlay bone grafting (33).

Although autologous bone grafting remains the gold standard, different types of grafting materials have been proposed for these procedures: demineralized bone from human cadavers, bovine bone and synthetic materials. Although many have claimed good clinical results, there is insufficient long-term data from histologic and histomorphometric investigations to provide real guidelines for these procedures.

Contraindications for sinus lifting (33), such as Caldwell Luc operations, Underwood’s septae, severe sinus floor convolutions and narrow sinuses, limit the use of this clinical technique. Perforation of the Schneiderian membrane could also jeopardize the final result.

The gold standard for sinus-lifting procedures uses autogenous bone (25) but bone harvesting is most often performed under general anesthesia and, as in a majority of these cases these procedures necessitate a two-stage since surgery, since the implants are not inserted at the moment of the bone grafting.

Complications like sinusitis or loss of grafts have also been described with the sinus graft technique. Final results (15) show a success rate of up to 75% for the sinus-lifting procedure together with simultaneous insertion of implants and it is recommended to avoid this one-stage procedure.
Vertical ridge augmentation using membrane has also been proposed. In short series of prospective and retrospective clinical studies histologically documented (34, 35), it was proven that a ridge augmentation of 4.95 mm could be obtained around implants inserted and covered by barrier membrane. In a retrospective multicenter study (29) on 123 implants with a follow-up of up to 5 years, a ridge augmentation of a maximum of 3 mm was found.

However, in a histologic and histomorphometric analysis of 30 patients (24) with provisional implants inserted with threads only covered by bone chips, membranes and soft tissue, there was a lower (43.5%) bone density around the exposed threads of the implants than around the threads (60.3 %) in the nonexposed regions.

Surprisingly, in a recent animal study (26), no bone growth appeared after 12 weeks of healing around the noninserted part of the implants inserted in the mandible of beagle dogs.

Distraction osteogenesis is a quite new procedure for bone augmentation. However, although this new procedure is in some areas well documented, no publication concerning bone lengthening in the posterior severely resorbed maxilla could be found.

From his own experience based on animal research and human experiments, P. I. Bränemark (8) knowing that the introduction of an implant in the sinus would not necessarily jeopardize sinus health – considered using the zygoma bone as an anchorage for prosthetic rehabilitation in hemimaxilllectomy patients as well as for other defects. As these reconstructions (23) were successful and long-term stability of these implants was established, in 1997, Bränemark developed a specific implant called the zygomaticus fixture to provide fixed solutions even when the conditions for implant insertion were poor in the posterior maxilla. This new technological development offers alternatives to bone grafting or sinus-lifting procedures, which involve rather invasive surgery.

Description of the zygomatic implant

The zygomatic implants (Fig. 1) are self-tapping screws in c.p. titanium with a well-defined machined surface. They are available in eight different lengths ranging from 30 to 52.5 mm. They present a unique 45° angulated head to compensate for the angulation between the zygoma and the maxilla. The portion that engages the zygoma has a diameter of 4.0 mm, and the portion that engages the residual maxillary alveolar process a diameter of 4.5 mm. At the maxillary level the angulated implant platform extremity offers the possibility to screw any kind of abutment from the Bränemark system®. However, for the newest generation of abutments a separate slightly shorter abutment screw must be utilized for the construction of conventional screwed prosthesis.

Fig. 1. The zygomatic implant.

Fig. 2. Three-dimensional CT image and occlusal view showing connection of the zygoma with the maxilla.
Indications for the use of the zygomatic implant

Resorption of the maxilla appears in two dimensions – height and width. Posterior resorption can lead to a maxillary bone height of 0.8 mm in the posterior region. In the anterior region, height and width can also be dramatically reduced (39).

Zygomatic implants are indicated in cases of severe resorption of the maxilla: free end situations in the maxilla where insufficient bone height is...
available for standard implant insertion and in total edentulism, when together with reduced bone height of the posterior region, pneumatization of the sinuses decreases the anterior area of the maxilla, allowing the placement of only 2, 3 or 4 implants. Because of its insertion in the zygoma region, the zygomatic implant can be used in all of these situations.

In cases of very severe resorption of the anterior maxilla in totally edentulous patients, when bone grafting cannot be avoided, the use of zygomatic implants reduces the dimensions of the bone graft and the surgery is made easier.

The zygoma as an anchorage

The zygoma (Fig. 2) bone can be compared to a pyramid, offering an interesting anatomy for the insertion of implants (16, 38). Histologic analysis (12) of the zygoma shows regular trabeculae and compact bone with an osseous density of up to 98%. Due to this high bone density, the zygoma bone has also been used in the treatment of maxillofacial fractures, for the insertion of miniplates (11) and during orthodontic treatment, offering a fixed anchorage to allow dental arch retractions (21).

In an animal study (30) the zygoma bone provided an anchorage place for implants to obtain protraction of the maxilla by means of distraction. In maxillofacial prosthesis, the zygoma bone is also utilized as an anchorage for the placement of extraoral implants sustaining a facial prosthesis (22, 27, 36). After maxillectomy, zygomatic implants were connected with standard ones to anchor a screwed prosthesis (14, 23).

In a recent study on cadavers (31) it could be established that the mean length of the zygoma was 14.1 mm, allowing the insertion of zygomatic implants as described above.

![Fig. 6. Reflection of the soft tissue (a) with identification of the zygoma and suborbital nerve and (b) achievement of the sinusal window.](image1)

![Fig. 7. Reflection of the Schneidarian membrane with a gauze mesh (a) and drilling with the first bur (b).](image2)
For all these reasons, the zygoma should be considered as an extended anchorage in a region situated at an important distance from the occlusal level. This can make a crucial difference to patients with compromised maxillary anatomy.

**Presurgical evaluation of feasibility**

Inserting implants (Fig. 3) from the maxillary level through the sinus and up to the zygoma is a challenging venture. Three levels have to be investigated: the maxillary level, the sinus and the zygoma. Clinical examination is not sufficient for this evaluation and radiologic assessment has to be considered. The OPG can give distorted information and therefore, the examination of choice is the spiral or helicoid computed tomography (CT) scan, which makes two- and three-dimensional imaging possible (Fig. 4a,b) (40).

Oralim® (Medicim, Leuven) provides appropriate software. The implants can be placed via virtual images and the surgeon only has to convert these images to the reality of the clinical situation (Fig. 5).

The CT scan also gives the opportunity to visualize the health of the maxilla and the sinus. Sinusitis, polyps or any sinusal pathology can be excluded. The density, length and volume of the zygoma can be evaluated and special templates for inserting the zygomatic implants can be constructed on stereolithographic models to facilitate the orientation of the zygomatic implants during the surgery with minimal errors in angulation and position (31).

**Surgical procedure**

The zygomatic implant surgical procedure should involve atraumatic surgery, avoiding overheating in the zygoma bone as well as in the maxilla under sterile circumstances with what is in reality still a two-stage approach.

Although the operation can be carried out under local anesthesia, for the patient’s comfort, it has been done up to now under total anesthesia or neuroleptic deconnection (13). After a palatal 45° incision of the soft tissue along the entire maxillary crest, the soft tissue is completely reflected from maxillary crest to zygomatic buttress and the suborbital nerve identified. A window is then made by drilling at the upper limit between the zygoma and the sinus (Fig. 6b) to determine the orientation of the zygoma and to reflect the Schneidarian membrane. This window will also be helpful during the surgical procedure for cooling the drills to avoid overheating (Fig. 7a,b).

![Fig. 8. Insertion with a low speed motor of the zygomatic implant. The head of the implant is seen at the top of the zygoma.](image)
Different drills are used with increasing diameters, ending with the insertion at low speed of the self-tapping zygomatic implant (Fig. 8). The length of this is carefully chosen by means of a special gauge.

After insertion of the implant, a cover screw is placed on the top of the zygomatic implant and the soft tissue closed. There are no evidence-based arguments that advocate the use of a membrane to cover the hole made in the sinus.

The other implants are placed during the same surgical procedure. At the second stage surgery 6 months later, the abutments are screwed on the implants and an immediate (same day) provisional prosthesis is provided for the patient (Fig. 9).

**Prosthetic procedure**

The prosthesis is made of gold and acrylic or gold and porcelain routinely like a standard screwed reconstruction on standard implants (Figs 10 and 11). Although screwed bridges allow a better adjustment of the occlusion, overdentures retained by rigid bars are also considered sometimes because of the important cantilever due to the palatal emergence of the zygomatic implants and to the distance between the two maxillas or simply the resorption of the maxilla.

Considering the biomechanical aspects of the prosthetic reconstructions on zygomatic implants, it is well known that when masticatory load is applied to a rigid semicircular arch connecting four anterior implants and two zygomatic ones, the masticatory load in the posterior region is transferred to the bony support situated in the zygoma (Fig. 12).
Results

Although this new development of a specially designed implant has been elaborated for more than 10 years in Sweden and has, since 1997, been the subject of a worldwide multicenter prospective study, so far, few data are available from the literature (4–6, 13, 37). Case reports as well as technical reports show satisfactory results and a high success rate.

In our own experience of 55 edentulous patients involving 103 zygomatic implants, the survival rate is 100% with an observation period up to 48 months (20).

Conclusions

The zygomatic implant – the zygomatic fixture - appears to be a promising development in implant technology. It offers an interesting alternative solution to heavy bone grafting in the severely resorbed posterior maxilla. It has been in use for more than 10 years and gives a predictable outcome in the rehabilitation of totally as well as partially edentulous patients. More published reports are needed and more follow-up has to be provided to assess its final goal and predictability.

References