Survival Rate of Zygomatic Implants in Atrophic or Partially Resected Maxillae Prior to Functional Loading: A Retrospective Clinical Report

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Purpose: *The purpose of this article was to evaluate the survival rate of 34 remote anchorage implants placed in 18 patients from placement to uncovering, prior to any prosthetic loading.* ***Materials and Methods:*** *A total of 18 patients (9 women and 9 men with a mean age of 63 years) who required rehabilitation with a fixed prosthesis because of severely atrophic maxillae (including 1 patient who had undergone primary and secondary cleft lip and palate repair), traumatic maxillary bone loss, and maxillectomy procedures received 1 or 2 zygomatic implants and 2 to 4 standard maxillary dental implants. The survival rate of the 34 zygomatic implants from placement to uncovering was investigated. Aspects of the placement technique or postoperative complications related to surgical procedures likely to affect the implant failure rate were detected and critically discussed.* ***Results:*** *Osseointegration was evaluated using the reverse torque test and percussion after uncovering. Only 1 patient (5.6%) sustained postoperative clinical complications during the evaluation period which resulted in the loss of both zygomatic implants (5.9%).* ***Conclusion:*** *Although the handling of this anchorage implant system is somewhat complex, and the design has certain shortcomings, it might be an alternative to more extensive bone augmentation procedures. However, rehabilitation of partially or completely edentulous patients with fixed implant-supported prosthesis is only feasible when 2 to 4 standard implants are placed in the anterior maxilla and splinted with the zygomatic implants.* (Case Series) Int J Oral Maxillofac Implants 2006;21:413–420

Key words: *atrophic maxilla, bone augmentation, bone grafting, maxillectomy, osseointegration, reconstruction, zygomatic implants*

Both surgical and prosthetic rehabilitation of severely atrophic or partially resected maxillae are challenging, irrespective of otherwise complete or partial residual dentition. Many surgical techniques have been described in the literature to improve the severely atrophic maxilla and facilitate prosthetic rehabilitation. Vestibuloplasty,[1,2] with or without free split-skin grafting,[3] free oral mucosa,[4] or intestinal mucous membrane[5] has become an accepted means for augmentation of the alveolar crest. In cases where vestibuloplasty alone has not provided better results for prosthetic reconstruction, transplantation of autologous rib and cartilage[6,7] or bone[7–9] has been performed. In 1980, Boyne and James[10] grafted the sinus floor with autogenous marrow and bone to anchor prostheses with blade implants in atrophic edentulous alveolar ridges in the maxilla. Within the last 13 years, a number of retrospective studies have been published on the success and failure of conventional dental implants in the maxilla.[11–14] Combining bone grafting with implant-supported prostheses has resulted in successful oral rehabilitation.[15–18]

In 1978, Aramany[19,20] proposed a classification system for obturators and basic principles of obturator design for partially edentulous patients. Several inves-

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tigators have studied the use of anatomic undercuts and obturator prosthesis design to improve stabilization, support, and retention of obturator prostheses.[21–25] Nevertheless, partially resected maxillae, regardless of residual dentition, remain among the most difficult defects to restore with a prosthesis[26] because of lack of support in the resection area.[27]

Since the introduction of osseointegrated implants in preprosthetic surgery for edentulous jaws, endosseous implants have also been placed in residual maxillae and zygomatic bones after partial maxillary tumor resection as a means of improving the stability of obturator prostheses.[27–33] Tamura and colleagues[33] proposed that implant-supported obturator prostheses may be advantageous for various kinds of primary and secondary reconstruction of maxillary defects described in English literature.[34–38] For cases of severely resorbed maxillae with large pneumatized sinuses and less than 3 mm in posterior residual ridge height, or for restoration after various types of maxillectomies, Brånemark[39] introduced the zygomatic implant. After preparing an intraoral access, the implant is led to the zygomatic buttress area through a transantral approach, thereby gaining implant support from osseous sites in remote locations. This extension of the prosthesis anchorage points into defect areas minimizes cantilever forces on teeth and implants in residual ridge tissue.[40] Several authors have reported their experiences using this implant system,[40–42] which has contributed to improvement in the surgical technique.[43,44]

The purpose of the present article was to assess the survival rate of this anchorage implant system from implantation to uncovering in human patients. Probable pitfalls during placement and postplacement complications were identified in describing critically the clinical experience at the Department of Cranio-Maxillofacial Surgery, University Hospital of Zurich, Switzerland.

MATERIALS AND METHODS

Patients

Thirty-four zygomatic implants (Nobel Biocare, Göteborg, Sweden) in 18 consecutive patients (mean age, 63 years; 9 women ranging in age from 51 to 87 years, and 9 men ranging in age from 48 to 83 years) were analyzed from the time of placement to uncovering at the Department of Cranio-Maxillofacial Surgery of the University Hospital in Zurich, Switzerland. Two female patients were not included in the statistical evaluation; 1 died as a result of a tumor 4 months after implant placement, and the other was excluded because of poor bone in the zygomaticomaxillary buttress. The charts of all patients were carefully reviewed in conjunction with clinical and radiographic pre- and postoperative examinations, including lateral cephalometric and panoramic radiographs. By means of panoramic radiographs the alveolar height in the maxillary premolar region was measured bilaterally. Using lateral cephalometric radiographs, the degree of maxillary alveolar resorption was assessed according to the classification of Cawood and Howell.[45] The number of anterior implants placed in addition to the zygomatic implants was recorded. Complications recorded from implantation to uncovering and their management were identified.

The patients were allocated to 1 of 3 groups according to the etiology of their maxillary bone deficiency.

Post-traumatic Maxillary Bone Deficiency. Three patients, 1 woman and 2 men, ranging in age from 57 to 72 years (mean, 64.3; SD 7.5), were each provided with 2 zygomatic implants. Two additional conventional implants were placed anteriorly in 2 patients. One patient was partially edentulous, with 4 residual incisors.

Severely Atrophic Maxillae. Ten edentulous patients, 4 women and 6 men, ranging in age from 48 to 77 years (mean, 56.3 years; SD 9.7), were each treated with 2 zygomatic implants, except for 1 woman with severe maxillary atrophy, who was provided with 1 zygomatic implant. One male patient of this group had a bilateral cleft lip and palate with maxillary atrophy.

Postmaxillectomy Bone Deficiency. In 5 patients, 4 women and 1 man, ranging in age from 57 to 87 years (mean, 76.6 years; SD 10.6), zygomatic implants were placed into the defect area for remote anchorage. A total of 9 zygomatic implants were placed. In 1 women only 1 implant could be placed because of insufficient implant support on the opposite side in 1 case and lack of bone structure in the second case.

Surgical Protocol for Severely Atrophic Maxillae and Posttraumatic Maxillary Bone Deficiency

Since general anesthesia was used, elderly patients were admitted to the hospital the day before the operation to assess their general condition. Younger individuals in good general health were admitted to the day clinic after a fasting period of 6 hours. All patients received nasotracheal intubation. Infiltration of a local anesthetic agent (1% lidocaine and epinephrine 1/200,000) ensued. A single dose of corticosteroid was given intraoperatively to limit postoperative swelling. An intra- and postoperative antibiotic regimen with Augmentin (GlaxoSmith Kline, London, UK) was administered.

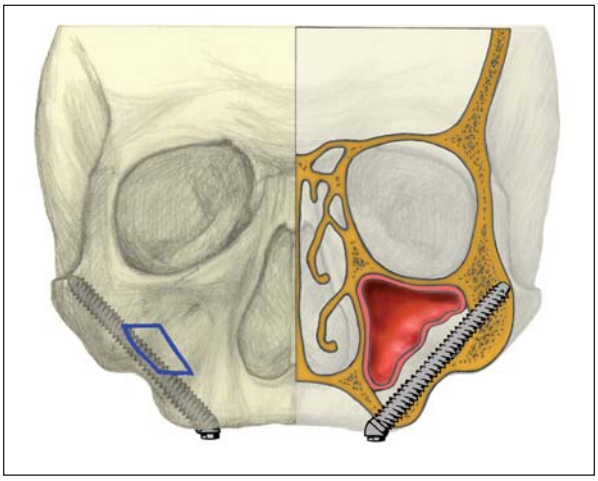

Fig 1a The outline of the rectangular window in the lateral wall of the maxillary sinus is shown on the right. On the left side of the face, the position of the zygomatic implant within the maxillary sinus, as well as the position of the intact sinus membrane after its lift from the sinus wall, has been highlighted.

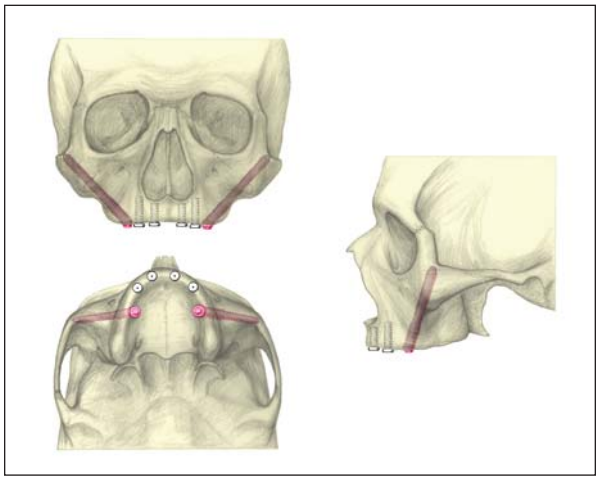

Fig 1b Three-dimensional illustration of zygomatic and standard implants in an edentulous, atrophic skull.

In edentulous, severely atrophic maxillae a palatally placed alveolar ridge incision was made from right to left in the zygomaticomaxillary region (except in the patient with 4 residual incisors, where an additional vertical buccal relief incision was performed at the canine region on each side. Vertical vestibular relief incisions were placed at the maxillary tuberosities. The mucoperiosteum was deflected, revealing the alveolar crest, the anterior and lateral walls of the maxillary sinus, and the piriform aperture. For anatomic orientation, the deflection was completed up to the zygomatic notch between the zygomatic arch and the frontal process of the zygomatic bone, preserving the infraorbital nerves. Removal of the osteosynthesis material was performed in this particular region in the posttraumatic group. A rectangular window was cut into the lateral wall of the maxillary sinus near the zygomaticomaxillary buttress without penetrating the sinus membrane. The sinus membrane had to be lifted carefully with a periosteal elevator from the area where the zygomatic implant passed through the maxillary sinus (Fig 1); care was taken to avoid tearing it.

For 3-dimensional orientation, a retractor was positioned in the zygomatic notch prior to implantation. A palatal mark was made in the premolar region using a round bur (Nobel Biocare). Using the retractor as a means of guidance, the round bur was used to drill into the maxillary sinus. Under visual control, it penetrated the maxillary sinus in the direction of the zygomatic notch, while the elevated sinus membrane was gently retracted. Another mark was set into the bone of the zygomatic body.

Protecting the soft tissue of the temporal fossa, the outer cortical layer of the bone in the region of the zygomatic notch was penetrated with the twist drill with a width of 2.9 mm (Nobel Biocare). The prepared site was measured with a depth gauge to determine the length of implant needed. The bone site was widened by turns of a pilot drill with a width of 3.5 mm and a final twist drill with a width of 3.5 mm. The initial implant mount was performed with a KaVo Blue Band handpiece (Novimed, Dietikon, Switzerland). Final seating of the implant was achieved with a hand wrench (Nobel Biocare).

The zygomatic implants ranged from 30 to 50 mm long (Fig 2). The implants were 4 mm in diameter (4.5 mm near the abutment). The hexagonal head allowed prosthesis attachment because of its 45-degree angulation to the axis of the implant. At least 2 conventional implants were placed within the remaining residual crest, as shown in Fig 1b, and splinted with the 2 zygomatic implants by a rigid bar, thereby achieving stable 3-dimensional support for functional loading (Fig 3). After a total operation time of about 2 hours, wound closure was performed in a 2-layered water-type technique (Vicryl; Johnson & Johnson/Ethicon, Somerville, NJ). The patients were placed on antibiotics for 7 days; 1 g Augmentin twice a day was preferred. For patients sensitive to penicillin, cephalosporin or clindamycin was substituted.

Surgical Protocol for Partially Resected Maxillae

Preoperative and early intraoperative procedures did not differ from the protocol used for severely atrophic maxillae. Piloting and placement of the zygomatic implants were carried out with direct visualization. Granulation tissue was elevated in the region of the zygomaticomaxillary buttress. It was

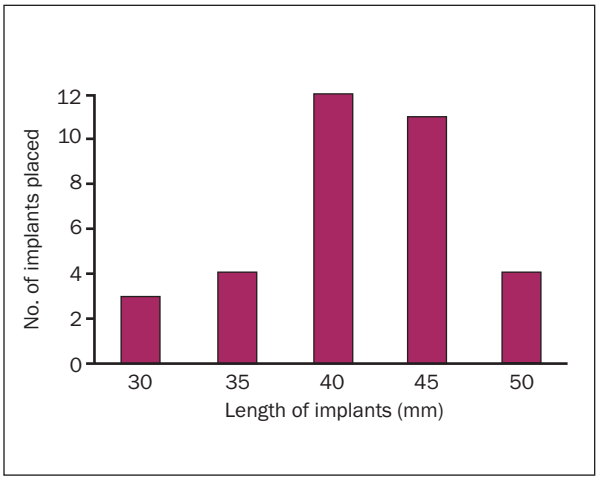

Fig 2 The relation between the length and the number of the zygomatic implants placed.

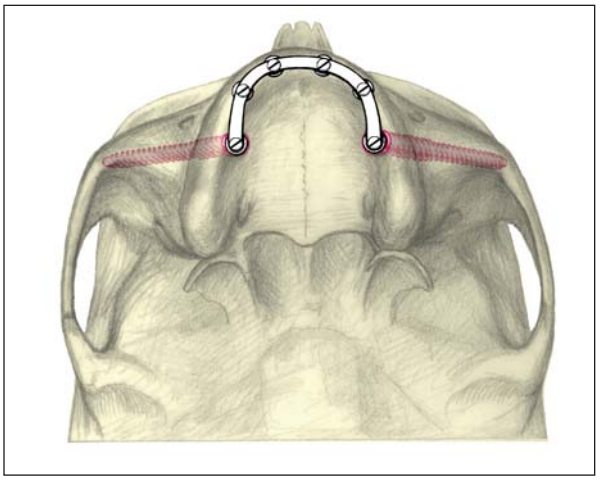

Fig 3 To avoid rotational or lateral forces on the zygomatic implants, splinting to the standard implants by a rigid bar is mandatory.

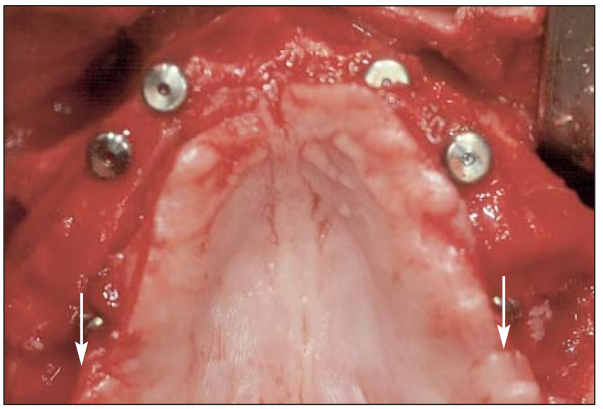

Fig 4 Intraoperative view after implantation prior to wound closure. White arrows indicate the position of the zygomatic implants.

important to drill the implant through the thick bone of the zygomaticomaxillary buttress and upward through the zygomatic body. It was found that shortening the implant cantilever improved primary stability of the implant even if the implant's thread was not covered entirely by the bone of the zygomaticomaxillary buttress.

During the osseointegration period, which lasted an average of 8 months, a surgical obturator was suspended from the zygomatic arch using wires. To avoid potentially damaging off-axis loading of the zygomatic and additional conventional implants, the use of a rigid bar joining the implants was necessary.

After an uneventful healing, patients were discharged 2 days postoperatively. They were next examined 10 days postoperatively in the outpatient clinic. Remnants of the resorbable sutures were removed, and postoperative lateral cephalometric and panoramic radiographs were obtained. The patients were allowed to wear a prosthesis after removal of the sutures. The prostheses were relieved in the regions of the implants. Until abutment connection 6 months after the operation, patients were examined monthly in the outpatient clinic. After the implants were reverse torque-tested (10 Ncm) to verify osseointegration, abutment connection and splinting of the implants with a rigid bar were performed under general anesthesia. Postoperative clinical and radiographic views are shown in Figs 4 to 8.

Examination

The following data were collected:

- Lateral cephalometric and panoramic radiographs to determine maxillaryatrophy according to the classificationof Cawood and Howell[45]
- Number and length of zygomatic implants originally placed
- Number and length of zygomatic implants lost from implantation to uncovering
- Number of anterior implants placed to be splinted to the zygomatic implants
- Number of anterior residual teeth
- Age of the patients at implantation at the end of the osseointegration period
- Adverse events from implantation to uncovering
- Management, including medication and/or removal of implants, from implantation to uncovering

Assessment of Success and Statistical Methods

Implant success was evaluated 6 months after implantation at the time of implant uncovering prior to prosthetic loading. Two categories of failures were distinguished:

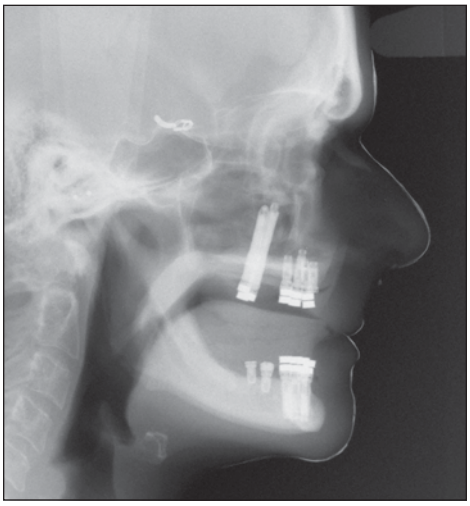

Fig 5a Lateral cephalometric radiograph prior to uncovering.

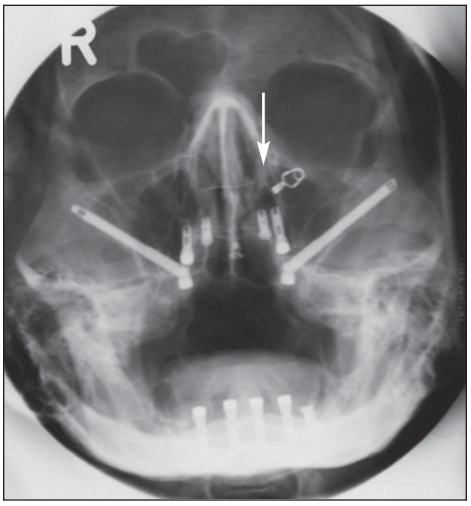

Fig 5b Water's view radiographic examination of the same patient. The white arrow shows a clamp placed after the patient experienced an intracerebral aneurysm prior to implantation.

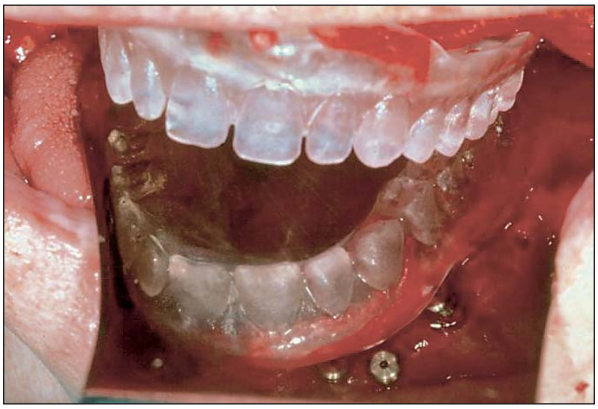

Fig 6 After partial maxillary resection the future implant sites within the residual alveolar process were determined using a template.

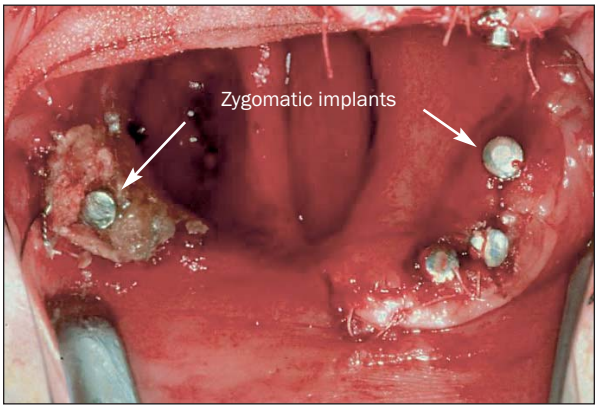

Fig 7 Two standard implants were placed in the residual alveolar crest near the zygomatic implant on the right side (Note: photographic mirror intraorally).

- Implants that failed to become osseointegrated. Osseointegration of the implants was tested after an average period of 8 months using a reverse torque test (10 Ncm), which is an indicator of clinical stability, and by percussion of the healing abutment.
- Implants that failed because of surgical complications from implantation to uncovering. Implants were examined clinically and radiographically; successful implants showed neither signs of pain, swelling, or infection nor clouding of the maxillary sinuses or osteolytic margins.

All statistical data were analyzed using Microsoft Excel (Microsoft, Redmond, WA).

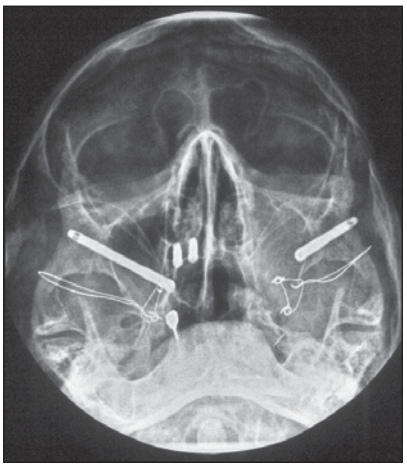

Fig 8 Postoperative examination of the implants. Wiring of the surgical obturator prior to functional loading of the implants is evident.

Table 1 Number of Standard Anterior Maxillary Implants in Relation to the Number of Zygomatic Implants

implants received	No. of patients	No. of residual anterior teeth	No. of pre-existing standard implants
1 zygomatic implant	2		
0 anterior	1	0	3
1 anterior	0	0	0
2 anterior	1	0	1
3 anterior	0	0	0
4 anterior	0	0	0
2 zygomatic implants	16		
0 anterior	2	5	0
1 anterior	1	3	0
2 anterior	6	0	0
3 anterior	1	0	0
4 anterior	6	0	0

RESULTS

Thirty-four zygomatic implants were placed in a total of 18 patients, 9 women and 9 men (age range: 48 to 87 years, average age: 63 years, SD 12.5). Two female patients were excluded from evaluation. Bilateral placement of zygomatic implants was performed in 16 patients. Because of existing standard Brånemark System implants in the residual maxilla or the possibility of placing them in the opposing residual alveolar ridge, unilateral implantation of a zygomatic implant was performed in 2 female patients 55 and 87 years of age (11.1%).

An average of 2 (range, 0 to 4) standard Brånemark System implants were placed into the residual maxillary alveolar process. These implants were splinted with the zygomatic implants by a rigid bar, thus reducing lateral and rotational forces onto the long lever-arm of the zygomatic implant. Three (16.7%) patients, 2 women (55 and 57 years) and 1 man (57 years) did not receive any anterior standard implants because of existing standard implants in the residual anterior and opposite maxilla in 1 case, because of a pyramidal midfacial resection in 1 case, and because of stable anterior residual dentition in 1 case. In 1 male patient (83 years) with 3 stable anterior residual teeth, only 1 standard implant was placed. In 2 female patients (11.1%), 69 and 76 years old, bone-augmenting onlay procedures were performed in the anterior maxillae. Standard implants were placed simultaneous with grafting in a 1-stage procedure. Table 1 provides an overview of the relation between number of anterior maxillary implants and number of zygomatic implants in the posterior sector.

The profiles of the atrophic maxillary alveolar ridges were classified using panoramic and cephalometric radiographs according to Cawood and Howell[45] for each patient in the severe atrophy group. The median classification stage was class IV (range, class III to V). The number of the residual anterior teeth is shown in Table 1.

The patients' charts were reviewed for postoperative complications. Only 1 patient (a 48-year-old man) suffered from complications. He presented in the outpatient clinic with bilateral maxillary sinusitis 7.1 months after implantation. On examination an oroantral fistula was detected on the right side, just adjacent to the hexagonal head of the implant, which required surgery. Under general anesthesia the vestibular scar was incised. After deflection of the mucoperiosteum, a small piece of the sinus floor was detected to be infractured palatally adjacent to the hexagonal head of the implant on the right side. On the left side the alveolar crest was intact around the hexagonal head. Enlargement of the bony windows in the anterior sinus walls and excision of the inflamed sinus membrane was carried out on both sides. Because of mobility on the right side and positive reverse torque tests bilaterally, the zygomatic implants were removed. A nasal antrostomy was performed on both sides. The oroantral communication on the right side was closed by palatal flap. Postoperatively an oral antibiotic regimen (1 g Augmentin twice a day for 5 days) was administered as described previously. Complications occurred in 5.6% of the study population from placement to uncovering.

DISCUSSION

This remote-anchorage implant system was first introduced by Brånemark in 1998.[39] Few reports have been published about zygomatic implants in the English literature.[32,33,40,41–44,46,47] To the authors' knowledge, only 1 retrospective study over a time span of 6 to 48 months has been performed.[46]

Type 4 bone quality is often found in the posterior maxilla, and the poor quality of bone found in this region has been considered a factor in increased implant failure.[14] The zygomatic bone has an osseous density of 98%, as calculated by Gosain and colleagues,[48] which is much better for solid anchorage of dental implants. However, the remoteness of its anatomic position from the occlusal level necessitates a long implant cantilever. To avoid high cantilever forces, additional implantation is required in the anterior residual alveolar process,[40–44,47] with or without onlay bone grafting. In this patient population, onlay bone grafting was necessary in 2 cases; it was carried out simultaneous with the placement of 4 conventional implants. On average, 2 anterior implants were placed and splinted by a rigid bar to share the increased leverage forces of prosthetic loading. Depending on the bone quality, either Brånemark System Mark III implants (in thin cortical bone with good strength) or Mark IV implants (in thin cortical bone with poor strength) were used.

Originally this anchorage implant system was developed for use in patients with maxillary defects.[40] Its potential to allow prosthesis anchorage in defect areas,[32,33,40] thereby minimizing cantilever forces on teeth and implants in the residual alveolar ridges, is considered its most significant and immediate benefit. Bone grafting procedures involving complex surgery and sometimes considerable donor site morbidity can be avoided.[48] This is especially important in patients with compromised general health.

This remote anchorage implant system may be considered an alternative to bone grafting because it offers a shortened preprosthetic time-span together with diminished donor site morbidity, shorter hospitalization, and generally, less pain.

Zygomatic implants generally fail as a result of 1 of the following:

- **Hardware design flaws:** Not only is the placement angle limited by the ever-changing anatomic site of the zygomatic bone, it is also limited because of the 45-degree angulation of the hexagonal head to the axis of the implant. As highlighted in Fig 1, placement of the implant also depends on the midfacial height. Because of the unique angulation of the implant's hexagonal head, if the midfacial height is too small, the position of the implant head may be too palatal; if it is too large, the position of the head may be too buccal. Although various placement aids have been described[43,44] to guide the zygomatic implant safely through the maxillary sinus to its final destination, no target instrument has been provided by the manufacturer.
- **Surgical technique:** The surgical technique is demanding. In severely resorbed maxillae it is important to maintain the sinus membrane intact to avoid adverse effects such as maxillary sinusitis. After maxillary resection it is difficult to drill through the zygomaticomaxillary buttress to obtain additional anchorage when the alveolar process is lacking. Fortunately operative skill generally improves with experience.
- **Biologic risks:** If splinting of the implants is not feasible, the long lever-arm of the zygomatic implant will be exposed to lateral and rotational forces which could result in implant loss. Therefore, patients with sufficient bone volume in the residual maxillary alveolar ridge have to be selected, as stated by Malevez and associates.[46]

CONCLUSION

While the zygomatic implant has shortcomings, it could become an alternative to more complex bone augmenting procedures in completely edentulous patients. The use of zygomatic implants may result in shortened treatment time and reduced pain and expense for the patient. Because of its long lever-arm, however, the implantation of standard implants in the anterior maxillae is essential. Only by splinting the implants together with a rigid bar is it possible to diminish lateral and rotational forces on this remote anchorage implant system.

With zygomatic implants, patients who have undergone maxillary resection of tumors can enjoy the advantage of implant-supported fixed prostheses without having to undergo autologous bone grafting procedures and without the risk of donor site morbidity. In addition, an acceptable functional and esthetic outcome can be achieved. In addition, this treatment method readily allows inspection of the resection cavity. Future long-term results with this implant system will hopefully result in the correction of hardware flaws and in the development of clinical and radiologic criteria for assessing the osseointegration of these implants.

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