

A Prospective Clinical Study on Titanium Implants in the Zygomatic Arch for Prosthetic Rehabilitation of the Atrophic Edentulous Maxilla with a Follow-Up of 6 Months to 5 Years

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ABSTRACT

Background: Prosthetic rehabilitation with implant-supported prostheses in the atrophic edentulous maxilla often requires a bone augmentation procedure to enable implant placement and integration. However, a rigid anchorage can also be achieved by using so-called zygomatic implants placed in the zygomatic arch in combination with regular implants placed in residual bone.

Purpose: The aim of the present study was to report on the clinical outcome of using zygomatic and regular implants for prosthetic rehabilitation of the severely atrophic edentulous maxilla.

Materials and Methods: Sixty-nine consecutive patients with severe maxillary atrophy were, during a 5-year period, treated with a total of 69 fixed full-arch prostheses anchored on 435 implants. Of these, 131 were zygomatic implants and 304 were regular implants. Fifty-seven bridges were screw-retained and 12 were cemented. The screw-retained bridges were removed at the examination appointments and each implant was tested for mobility. In addition, the zygomatic implants were subjected to Periotest® (Siemens AG, Bensheim, Germany) measurements. The patients had at the time of this report been followed for at least 6 months up to 5 years in loading.

Results: Two regular implants failed during the study period giving a cumulative survival rate of 99.0%. None of the zygomatic implants was removed. All patients received and maintained a fixed full-arch bridge during the study. Periotest measurements of zygomatic implants showed a decreased Periotest values value with time, indicating an increased stability. Three patients presented with sinusitis 14–27 months postoperatively, which could be resolved with antibiotics. Loosening of the zygomatic implant gold screws was recorded in nine patients. Fracture of one gold screw as well as the prosthesis occurred twice in one patient. Fracture of anterior prosthetic teeth was experienced in four patients.

Conclusions: The results from the present study show that the use of zygomatic and regular implants represents a predictable alternative to bone grafting in the rehabilitation of the atrophic edentulous maxilla.

KEY WORDS: atrophy, clinical study, dental implants, edentulous maxilla, zygomatic arch

Prosthetic rehabilitation with implant-supported dental bridges in the atrophic edentulous maxilla constitutes a challenge for the treating team. The placement of implants in such cases often results in a biome-

chanically compromised situation due to the association of risk factors like the use of short implants, the presence of soft bone, and high loads in the posterior regions.^{1–3}

Various bone augmentation techniques such as sinus floor augmentation and onlay bone grafting have been described with the common goal to enable placement and integration of implants.^{4–6} To date, there still remain doubts on the need and efficacy of sinus augmentation techniques prior to implant placement. Much of the available literature describing these techniques lacks defined implant success and failure criteria, descriptions of initial bone height, and standardized

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radiographic follow up.^{7–12} Moreover, our experience is that patient acceptance is restricted due to the complexity of the technique, possible donor site morbidity, and higher costs. Further, most often the survival rate of implants is on a 90% level^{9–11} and should be compared to 95–98%, which is commonly reported for implants in none-grafted cases.

The use of iliac crest bone grafts has been proposed for the treatment of maxillae with severe atrophy, which fall into classes D and E according to the classification of Lekholm and Zarb.¹³ Follow-up studies on this technique using immediate or delayed implant placement have reported failure rates in the range of 10–30%.^{13–16}

Studies have reported problems with the placement of implants in the maxillary tuberosity in a poor-quality residual bone situation,¹⁷ while similar results have been obtained on alveolar crests from other zones when utilizing an adequate surgical technique for the individualized preparation of the implant bed.^{2,18} Some authors have suggested the use of the pterygo-maxillary suture as an alternative site for implant placement.^{19–22} Implants can be effectively harbored in the cortical bone of the pterygoid process of the sphenoid bone and the pyramidal apophysis of the palatal bone, but this treatment modality is associated with a potential risk of vascular damage due to the presence of the descending maxillary artery.²³

The placement of implants in an angulated position has been proposed to avoid the use of bone grafts.^{24–29} Aparicio and colleagues²⁶ compared angulated (>15°) and axially placed implants in the posterior maxilla during a 3- to 7-year follow-up period. The results showed no differences in the maintenance of the peri-implant marginal bone height; they suggested that angulated placement of implants can substitute most sinus lift procedures.

The use of the zygomatic bone for anchorage of long oral implants was originally developed by Brånemark and colleagues and first described by Aparicio and colleagues³⁰ for rehabilitation of the atrophied maxillae. In 1997, Weischer and colleagues³¹ cited the use of implants in the zygoma as retaining elements after hemimaxillectomy. Subsequently, Brånemark and colleagues³² presented a study with 77 patients and 156 implants, out of which 24 presented lengths were superior to the “standard model” and the rest responded to a specific implant design. The cumulative success rate of the zygomatic implants was 96.8%. No data of the pro-

theses outcome were reported. More recently, other authors have reported good results on the use of zygomatic implants to stabilize a fixed prostheses.^{33–35} However, because of the novelty of the technique, there are insufficient prospective studies published that endorse it. In this prospective study, we present the preliminary results obtained by a task team on the use of the zygomatic bone to provide anchorage for oral implants used to completely rehabilitate the severely atrophied maxilla.

MATERIALS AND METHODS

Patients

Sixty-nine consecutive patients (22 males and 47 females), aged between 38 and 82 years (average: 56 years) with severely atrophic edentulous ($n = 63$) or partially dentate ($n = 6$) maxillae were included in the study. Forty-five patients had an implant-supported bridge and 24 patients had their natural dentition in the opposing mandible. Signs of occlusal abrasion were detected in 18 patients. Twenty-seven patients smoked 20 or more cigarettes per day.

The following were the inclusion criteria:

- The presence of residual alveolar crest with less than 4 mm in width and height, immediately distal to the canine pillar
- The possibility to place a minimum of three implants per quadrant

The exclusion criteria were general and local health conditions that prevented the use of general anesthesia and/or intraoral surgery.

Surgery

The presurgical radiographic examinations included computerized tomography scans and orthopantomograms (Figure 1).

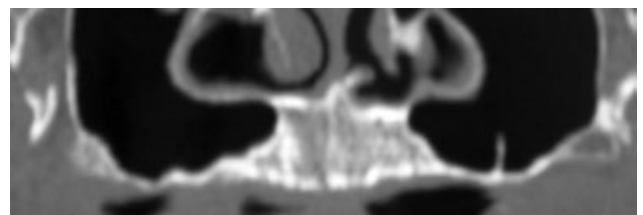


Figure 1 Panoramic computerized tomography image of one case showing severe maxillary atrophy.

TABLE 1 Lengths of Zygomatic Implants

Implant Length (mm)	Number	%
30	1	0.8
35	2	1.5
40	31	23.6
42.5	19	14.5
45	51	28.9
47.5	8	6.1
50	19	14.5
52.5	1	0.8
Total	131	100

A total of 435 titanium implants were placed by the same surgeon between November 1998 and February 2004. Three hundred four implants were regular platform (RP) Brånemark System® (Nobel Biocare AB, Göteborg, Sweden) with lengths that varied from 7 to 18 mm and diameters from 3.75 to 4 mm. One hundred thirty-one implants were zygoma fixtures (Nobel Biocare AB) with lengths from 35 to 52.5 mm (Table 1).

Of the RP implants, 220 were anchored in the residual bone between the canine pillars including 15 implants that were placed in the anterior nasal spine and 70 implants intentionally protruded from the nasal cavity (Table 2). Eighty-four implants were placed in the pterygoid process of the sphenoid bone and the pyramidal apophysis of the palate bone for anchorage. The 131 zygomatic implants were placed in the zygomatic bone. All the zygomatic implants except five, which rotated, achieved good primary stability at insertion time.

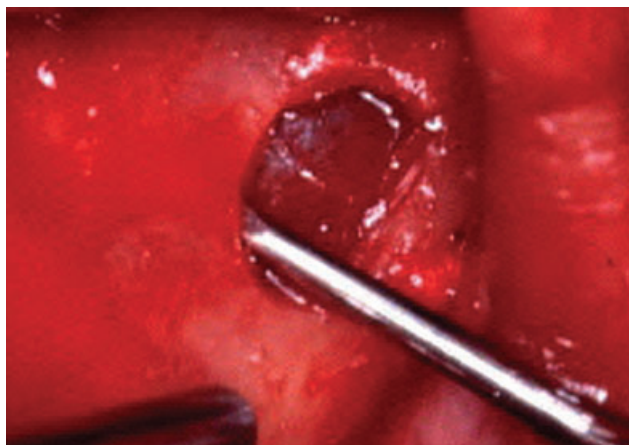


Figure 2 Clinical photo showing the opening to the maxillary sinus. The sinus window, using a diamond bur that will permit us to control the drill direction. An elevator is introduced in the window to lift the sinus membrane from the planned implant trajectory.

TABLE 2 Implant Placement Areas

Type of Implant Position	Number of Implants
Zygoma (zygomatic implant)	131
Pterygoid area (RP)	84
Intranasal (RP)	70
Nasal spine (RP)	15
Residual crest (RP)	135
Total	435

RP = regular platform.

A two-stage procedure with 5–6 months of healing between placement and abutment connection was used.³⁶ The technique applied for the zygomatic implants was described by Aparicio and Malvez³³ (Figures 2–4). After the removal of sutures 1 week after surgery, the patients followed a monthly visit follow up to assess the soft tissue health and to adjust the provisional prosthesis. Twenty to twenty-seven weeks later, the healing abutments are placed (Nobel Biocare AB), which were substituted by the final abutments following soft tissue healing.

Prosthesis

Fifty-seven fixed bridges, supported by 112 zygomatic and 287 standard implants, were cemented to titanium cones screwed on Multi-Unit® abutments (Nobel Biocare AB) approximately 4 weeks from the second-stage surgery using a technique previously described.³⁷ Twelve (seven full arch and five partial) prostheses used different cements as a retention (Figures 5 and 6).

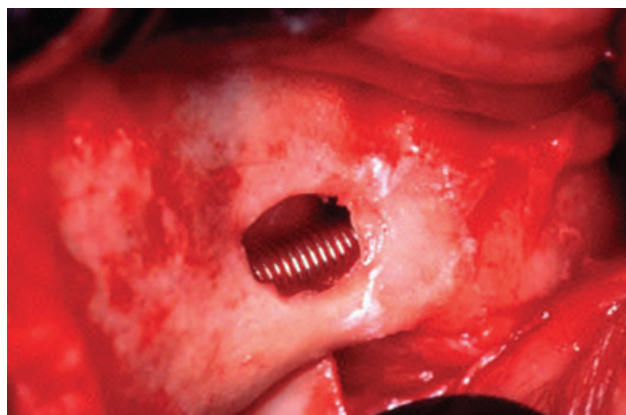


Figure 3 Clinical photo showing a zygomatic implant after its installation. The window helps to control implant direction in its transsinusal orientation. The sinus membrane is kept intact behind the implant.

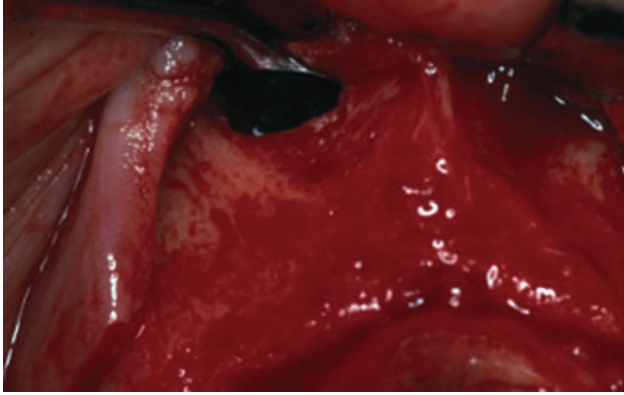


Figure 4 Clinical photo showing opening to the nose for better drilling control when placing ordinary implants in the residual alveolar crest.

Forty-seven bridges were constructed with prefabricated teeth over a rigid metal structure and the remaining 22 by sintered porcelain over metal (Figure 7, A and B).

Follow Up

The mean follow up was 25.1 months after placement of the prosthesis with a minimum of 6 months. The patients were scheduled for checkup 1, 3, 6, and 12 months after prosthesis delivery. After the first year of function, the patients were examined every 6 months. The screwed prostheses were removed on every appointment. The checkup included assessments of oral hygiene, soft tissue health, prosthesis stability, gold screw loosening, and other mechanical complications. In addition, implant stability was evaluated individually on the 57 screwed prostheses using Periotest® (Siemens AG, Bensheim, Germany) measurements. Standardized intraoral x-rays of the zygomatic implants could not be



Figure 5 Mucosal view of a bridge (ceramic fused to metal) with cementable abutments. The emergence profile of the zygomatic implants varies depending on the patient's anatomy.



Figure 6 Oclusal view of a bridge with cementable abutments.

made, and consequently the implants could not be evaluated with regard to marginal bone resorption. All implants were classified as either failures or survivals using the following definitions^{38,39}:

- Failure – implants removed from the patient irrespective of the cause
- Survival – stable implant without signs of pathology

Periotest Measurement

The stability of each implant, supporting a screwed prostheses, was measured using the Periotest method according to Olive and Aparicio.⁴⁰ The measurements were made at the day of bridge delivery, after 1, 3, and 2 months and thereafter annually. The implants were measured individually aiming the tip of the device 2 mm below the rim of the coronal platform. When measuring during the follow-up period, the bridge was removed to uncover the implant head or abutment. The Periotest values (PTVs) obtained were compared to the PTV established previously for implants of a 3.75-mm diameter placed on the maxilla.

RESULTS

The postoperative phase included intense facial edema and facial hematoma (six cases) that were resolved in 10 days; lip laceration (five cases) due to friction caused by rotary surgical instruments; and paresthesia occurring on the cheek and paranasal zones (six cases), which subsided 3–8 weeks postoperatively. Moderate nasal bleeding was seen in seven cases for 1–3 days.

After an abutment connection of the zygomatic implants, swelling of the palate mucosa surrounding the

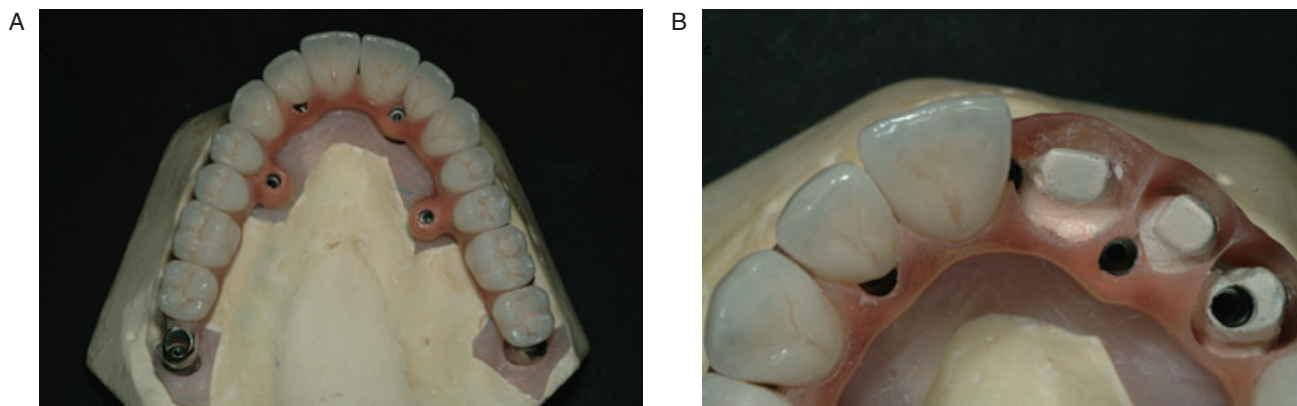


Figure 7 Oclusal view (A) of a screw-retained bridge and detail (B) of the framework confection.

abutment was observed in eight patients. The problem was solved by lifting a mucoperiosteal flap and thinning by cutting off the excess adipose tissue surrounding the abutments.

Three patients experienced acute sinus infection after 14, 23, and 27 months postsurgery. One of them had a recurrent suppuration of the sinus/nasal cavities. The infections could be cured by antibiotic treatment (Figure 8). Two of the three patients had been using an oral hygiene system based on high-pressure water spraying.

One RP implant placed in the pterygoid process failed 1 month after abutment connection, previous to prostheses installation (Table 3). One more regular implant failed after 27 months in function. The 1-year survival rates for the RP implants were 99.7 and 99.0%

after 2–5 years. None of the zygomatic implants failed (Table 4). All patients received and maintained a fixed bridge during the study period.

The Periotest measurements of the zygomatic implants showed decreasing values with time which indicated an increased stability (Table 5).

Few mechanical problems were experienced during the follow up. Loosening of the zygomatic implant gold screws was recorded in nine patients. Fracture of one gold screw as well as the prosthesis occurred twice in one patient who was a bruxer. Four patients with a metal-resin prosthesis showed repeated fracture of the anterior prosthetic teeth. The problem was solved by adjusting occlusion and allowing more space between the upper and the lower teeth in excursions. A metallic occlusal plate had to be used in one patient.



Figure 8 Computerized tomography showing soft tissue obstruction of the right nasal and frontal sinus cavities due to an infection 2 years after the surgery.



Figure 9 The radiograph shows an example of a solution of a case. Four subnasal implants, two implants in the pterygoid process and two zygomatic implants, serve as anchorage for a bridge.

TABLE 3 Life Table of Regular Implants

Follow-Up (months)	Number of Implants	Failures	Survival in Interval	Cumulative Survival Rate
Placement –prosthesis	304	1	99.7	99.7
Prosthesis – 6	304	0	100	99.7
6–12	282	0	100	99.7
12–24	215	0	100	99.7
24–36	142	1	99.3	99.0
36–48	98	0	100	99.0
48–60	41	0	100	99.0

DISCUSSION

This prospective study showed that zygomatic implants can be used for successful rehabilitation of patients with atrophic maxillae. Before the zygomatic implants were available, the only treatment option for these patients had been a bone grafting procedure. Having in mind that the present study includes the learning curve of this method, it is our opinion that the zygomatic implant technique is less invasive and more predictable than bone grafting procedures. Bone grafting requires a donor site for harvesting of a graft with risks for post-operative morbidity. Moreover, relative high failure rates have been presented for bone grafting procedures.^{9–11}

The zygomatic implant technique results in a different biomechanical situation compared to conventional implants: (1) the zygomatic implant is much longer (35–52.5 mm) and the anchorage point is located far away from the loading point, (2) the implant has to be angulated 40–50° to engage the zygomatic process, and (3) the implant head has a 45° angle. All of these factors result in an unfavorable biomechanical situation when they are considered in an isolated manner. In other

words, it would be fairly simple to overload a solitary implant in an angulated position. Nevertheless, various authors, us included, have shown the effectiveness of tilted implants provided that they are connected with other implants.^{24–29,41–43} For this reason, a rehabilitation that includes the use of zygomatic implants must be conceived as a one-piece, rigid bar that includes two to four regular implants in the anterior maxilla (Figure 9).

The success criteria for the evaluation of osseointegrated implants include the maintenance of the marginal bone height during loading.^{38–39} With respect to zygomatic implants, intraoral periapical radiographs could not be used to assess marginal bone levels in a standardized manner. This was due to the difficulty to place an intraoral film correctly, because of the lack of palate curvature in these patients whose residual alveolar crest had literally disappeared, and of the angulated design of the implant head. Moreover, since the stability of the zygomatic implants is mainly achieved by engagement of the zygomatic arch, the importance of integration in the residual alveolar bone is not known.

The present study showed few incidences with infections in the maxillary sinus after zygomatic implant

TABLE 4 Life Table of Zygomatic Implants

Follow-Up (months)	Number of Implants	Failures	Survival in Interval	Cumulative Survival Rate
Prosthesis – 6	131	0	100	100
6–12		0	100	100
12–24		0	100	100
24–36		0	100	100
36–48		0	100	100
48–60		0	100	100

TABLE 5 Results from Periotest Measurements of Zygomatic Implants

PTV	Right Zygomatic Fixtures	Ranges	Left Zygomatic Fixtures	Ranges
Mean PTV upon abutment placement	−1.95	(4) (−6)	−1.95	(3) (−7)
Mean PTV 1 month from prostheses placement	−1.7	(5) (−5)	−2.18	(5) (−5)
Mean PTV 1 year from prostheses placement	−3.5	(3) (−5)	−2.4	(3) (−6)

PTV = Periotest value.

installation. Other authors have reported more extensive problems with intraoral soft tissue problems,⁴⁴ as well as the removal of zygomatic implants due to recurrent sinusitis.⁴⁵ The problem may be due to lack of contact between the residual alveolar crest and the implant, thereby creating a communication between the oral and sinus cavities. Since the zygomatic implant situation is unique with parts of the implant exposed to the maxillary sinus, controlling of the health of the maxillary sinus should be part of the maintenance program. It can be anticipated that the relatively smooth machined surface is to prefer in this environment to minimize the colonization of bacteria. According to the reported 100% survival rate of the current machined zygomatic surface, we have serious concerns to justify the use of a roughened-surface implant in the maxillary sinus due to the eventual risk of accumulation of tissue debris and bacteria.

CONCLUSIONS

It is concluded that rehabilitation of the severely atrophic maxillae by means of fixed implant-supported bridges using zygomatic implants is a valid alternative to bone grafting procedures. However, more prospective studies are needed to assess the long-term prognosis for this technique.

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