Rehabilitation of Severely Resorbed Maxillae with Zygomatic Implants: An Evaluation of Implant Stability, Tissue Conditions, and Patients' Opinion Before and After Treatment

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Purpose: *The aim of the present study was to describe experiences of 11 consecutively treated patients who received zygomatic implants. Patient results were assessed through clinical and radiographic evaluations of tissue conditions, including resonance frequency analysis (RFA).* ***Materials and Methods:*** *Eleven patients were treated with implant-retained fixed prostheses. A total of 64 implants were placed, 22 of which were placed in the zygoma. Fixed prostheses were removed to allow clinical and radiographic evaluations at a follow-up visit 18 to 46 months following implant placement. RFA was performed on all implants. A visual analog scale was used to assess patient satisfaction before and after treatment.* ***Results:*** *All patients received implant-supported prostheses. All zygomatic implants demonstrated clinical signs of osseointegration. One anterior implant was lost during follow-up. Mean ISQ values for the zygomatic and anterior implants were 65.9 (range, 42 to 100) and 61.5 (range, 48 to 71), respectively. Twenty-four implants showed moderate inflammation, with 3 exhibiting severe inflammation. Most anterior implants (75.6%) showed a marginal bone recession of 1 thread or less. Four zygomatic implants showed bone loss of 4 to 5 threads, and 5 zygomatic implants exhibited no marginal bone support. Patients described significant improvement in chewing ability and esthetics but did not describe changes in speech.* ***Discussion:*** *The use of zygomatic implants can help the clinician avoid the need for bone grafting and reduce morbidity. In addition, it can shorten the treatment time considerably.* ***Conclusion:*** *This preliminary report demonstrates that zygomatic implants can provide posterior support to fixed prostheses in patients who lack bone volume to place conventional implants without encroaching upon the maxillary sinus.* (Before-and-After Study) INT J ORAL MAXILLOFAC IMPLANTS 2006;21:399–404

Key words: *dental implants, maxillary sinus, resonance frequency analysis, zygomatic implants*

The severely resorbed edentulous maxilla presents challenges to reconstruction. Bone grafting is generally recommended to create adequate bony volume for the placement of dental implants. Historically, different bone grafting procedures have been applied for augmentation of the edentulous resorbed maxilla. These procedures include crestal onlay grafting,[1] inlay grafts into the floor of the maxillary antrum,[2] and Le Fort I osteotomy with interpositional bone grafting.[3,4] Donor bone may be harvested from the iliac crest; however, these procedures are associated with postoperative morbidity.[5,6] Furthermore, healing time after grafting may extend the overall treatment time during which the patient may be limited to cosmetic prostheses rather than using prostheses that provide masticatory function in addition to cosmetic benefits. This problem may lead to refusal of treatment by bone graft candidates.

Zygomatic implants, described by Brånemark in 1988, have provided the clinician with an alternative to grafting procedures.[7] This technique was originally developed for patients who had undergone maxillary resection for malignant disease and required retention of an obturator. Since inception of this technique, Brånemark and coworkers have reported a success rate of 97% based on 164

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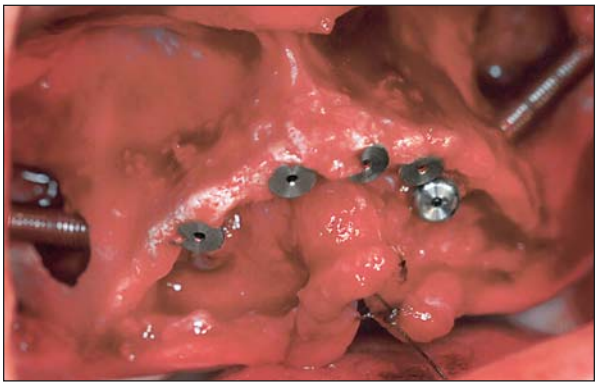

Fig 1 Four anterior implants placed subnasally and 2 zygomatic implants.

implants placed into 81 patients.[7,8] The zygomatic implant is an extended-length (30 to 52.5 mm) titanium implant placed through the palatal bone in the second premolar region. The implant penetrates transantrally and is cortically anchored in the compact bone of the body of the zygoma. A strict surgical protocol is followed in which at least 2, preferably 4, additional implants are placed in the anterior maxilla to assist in retention of a fixed prosthesis. In some cases of extreme atrophy, limited anterior onlay or nasal inlay grafts may be necessary to allow placement of these supplementary implants.

Resonance frequency analysis (RFA) is a recently developed method that has been used to evaluate implant stability.[9,10] No clinical studies have used RFA to assess stability of zygomatic implants. The purpose of this study was to describe experiences with 11 patients treated with zygomatic implants through clinical, RFA, and radiographic evaluations. A further aim was to evaluate the patient reports on chewing, esthetics, and speech before and after treatment.

MATERIALS AND METHODS

All consecutively treated patients who received zygomatic implants (Nobel Biocare, Göteborg, Sweden) at the department of Oral and Maxillofacial Surgery, Central Hospital, Västerås, between March 2000 and October 2002 were included in this review. Data regarding patient age and gender were recorded. All patients had an edentulous atrophic maxilla with insufficient bone volume for routine placement of implants in the posterior maxilla.

Participation in the study demanded that implant placement candidates be free from symptoms of disease in the maxillary sinus. Smokers (n = 7) agreed to discontinue smoking for a period of at least 2 months before surgery and during the healing period. All 7 smokers managed to fulfill this obligation. Preoperative panoramic radiographs, lateral cephalograms, and computerized tomographic (CT) scans were obtained for all patients.

All patients were admitted to the hospital 1 day prior to surgery, and implants were placed using general anesthesia. Betamethasone (Betapred; Glaxo, Middlesex, England) was given orally. The first dose was given 10 hours before surgery, and patients continued to receive the medication postoperatively 3 times per day for 2 days to reduce postoperative swelling.[11] Each patient also received 3 g of benzylpenicillin intravenously before undergoing surgery, with 2 additional doses at 8-hour intervals.

The surgery was performed following a standard protocol.[12] Whenever possible, the platform of the zygomatic implants was placed close to the alveolar ridge. After placement of the zygomatic implants, 2 or 4 conventional implants (Nobel Biocare) were placed subnasally (Fig 1). All patients were discharged from the hospital the day following surgery. Oral antibiotics (1 g of phenoxymethylpenicillin 3 times a day for 1 week; Kåvepenin, Astra) were prescribed. The patients rinsed with chlorhexidine (Hibitane Dental, Middlesex, England) twice daily for 1 week and were advised to use nasal decongestants if necessary. The patients were subjected to a liquid or semiliquid diet for the first 2 weeks. Sick leave was 2 weeks for all patients.

The patients were instructed not to use the maxillary denture during the first 4 weeks after implant placement. The dentures were relined with resilient denture reliner (Coe-Soft; GC, Alsip, IL) and thoroughly relieved at the location of the zygomatic implant. This generally resulted in the creation of a hole through the denture base. Reline procedures were performed every 6 to 8 weeks during the implant healing period. Patients were instructed to contact the clinic if they experienced any discomfort or pain. Abutment connection was performed after a healing period ranging from 6 to 11 months. Implant-supported fixed prostheses were all fabricated with the Procera Implant Bridge titanium framework (Nobel Biocare) with acrylic resin teeth (Figs 2 and 3) following a standard prosthetic protocol that included impression (Impregum; 3M ESPE, Seefeld, Germany), bite registration, and try-in.

Patients were seen to document the condition of the oral soft tissue and implant stability 18 to 46 months after treatment. Fixed prostheses were removed, and the following variables were registered: implant stability (ie, RFA), which was measured using Osstell (Integration Diagnostics, Sävedalen, Sweden); esthetics inflammation (none = no signs of inflammation, moderate = erythema/swelling, or severe =

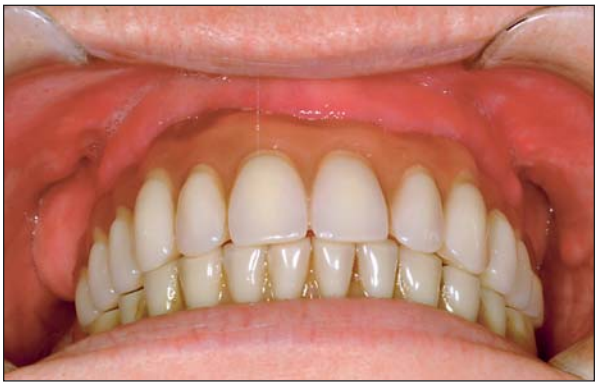

Fig 2 Finished restoration with acrylic resin teeth (anterior aspect).

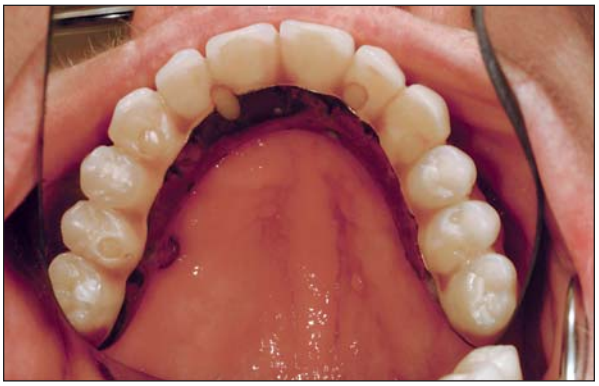

Fig 3 Finished restoration with acrylic resin teeth (palatal aspect).

Table 1 Median VAS Differences Regarding Chewing, Esthetics, and Speech Before and After Treatment

Questions	Mean difference before and after treatment	95% CI
How is your chewing ability today?	–	–
How was your chewing ability before treatment?	4.3*	2.1;6.1
How do you experience the esthetic results of the treatment?	–	–
How did you feel about the overall appearance of your teeth before treatment?	4.0*	1.0;5.0
How is your speech today?	–	–
How was your speech before treatment?	1.0	−1.2;3.3

*Significant differences ($P < .05$) were found for chewing and esthetics but not for speech (Wilcoxon test).

bleeding on pressure or suppuration); tenderness to percussion (yes or no); implant mobility (yes or no); and radiographic bone loss (measured by number of threads). All patients were examined with intraoral periapical radiographs (paralleling technique),[13] orthopantomograms, and posterio-anterior radiographs. Radiographic bone loss was defined as vertical bone level shift, measured in relation to the most inferior exposed thread of the implant. The following additional variables were also registered: implant length, number of teeth in the fixed prosthesis, cantilever length, opposing dentition, and complications.

Furthermore, patient response to treatment was assessed with a questionnaire (Table 1) using a visual analog scale (VAS), where endpoints of the scale were defined as "best possible" and "worst possible" results. The length of this scale was exactly 10 cm, so that a "VAS value" could be calculated for each question. Descriptive statistics were used to analyze and present data. A nonparametric procedure using the Wilcoxon method was performed to test for differences between the views of the patients on chewing, esthetics, and speech before and after treatment. A difference was considered significant at $P < .05$.

RESULTS

All 11 patients agreed to participate in the follow-up registration 18 to 46 months after treatment. These patients received bilateral zygomatic implants combined with implants in the anterior region (Table 2). In total, 22 zygomatic implants and 42 anterior implants were placed (Table 3). Only machined-surface implants were used—14 standard implants and 28 Mark III (Nobel Biocare). Six implants were placed in 10 patients and 4 implants were placed in 1 patient. Angulated abutments were used on 14 zygomatic implants, with 12 angulated to 17 degrees and 2 angulated to 30 degrees (EsthetiCone or Multi Unit Abutments; Nobel Biocare). The remaining implants were provided with multiunit or mirus-cone abutments (Nobel Biocare). All patients were provided with fixed prostheses. The prostheses included 10 to 12 units; cantilever lengths ranged from 8 to 16 mm. Natural opposing dentition was found in 7 patients, while in 2 patients implant-supported fixed prostheses were present.

Two patients complained of mild maxillary sinus discomfort after surgery, but this resolved sponta-

Table 2 Characteristics of 11 Patients Treated with Zygomatic Implants

Patient	Age	Gender	No. of implants placed	Opposing dentition	Cantilever length (L) in mm	Cantilever length (R) in mm	No. of units in prosthesis	Follow-up period from implant placement (mo)
1	72	F	6	IFP	8	11	10	20
2	53	F	6	ND	10	10	12	18
3	51	F	6	ND	15	14	12	34
4	63	F	4	ND	15	12	12	45
5	55	F	6	ND	14	15	12	43
6	61	F	6	ND	8	8	10	22
7	63	F	6	IFP	15	10	12	18
8	56	F	6	ND	12	10	10	33
9	69	F	6	ND	16	10	10	46
10	41	F	6	FR	9	9	11	44
11	50	M	6	E	15	15	12	41

IFP = implant-supported fixed prosthesis; ND = natural dentition; FR = fixed and removable prostheses; E = edentulous.

Table 3 Distribution of Implants by Length

Length (mm) and type of implants	No. of implants placed
Anterior	
8.5	4
10	14
13	20
15	3
18	1
Zygomatic	
45	17
50	5

neously. In a third patient, sinus discomfort was experienced on the right side after implant placement, but the sinus symptoms did not resolve spontaneously. For this reason, a nasal antrostomy was performed on the right side 2 months following implant placement. After the antrostomy, the patient remained well and free from any symptoms.

The time from zygomatic implant placement to the follow-up registration ranged from 18 to 46 months. One anterior implant was lost at the time of abutment surgery, resulting in a survival rate of 97.7% for the anterior implants. None of the zygomatic implants was lost. Mean implant stability quotient (ISQ) values were determined to be 65.9 ± 17.0 (range, 42 to 100) for the zygomatic implants and 61.5 ± 5.0 (range, 48 to 71) for the anterior implants. Twenty-four implants showed moderate esthetics inflammation (12 zygomatic and 12 anterior), and in 3 more cases (2 zygomatic and 1 anterior) severe inflammation was observed. Most anterior implants (75.6%) demonstrated a marginal bone shift of 1 thread or less. Ten anterior implants (24.4%) showed marginal bone loss of 2 to 4 threads. Four zygomatic implants (18.2%) demonstrated bone loss of 4 to 5 threads, and 5 zygomatic implants (22.7%) exhibited no marginal bone support. Implants without marginal bone support were found not to be stable at the coronal part. These implants were rotationally stable but able to move slightly. Another observation was that these 5 implants had ISQ values lower than 50. All other zygomatic implants (77.3%) demonstrated ISQ values over 50. None of the 63 surviving implants was tender to percussion. The median differences and 95% CIs for the VAS values from the questionnaire on chewing, esthetics, and speech before and after treatment are shown in Table 1.

DISCUSSION

The present prospective follow-up study of the first 11 consecutively treated patients who received zygomatic implants indicated that treatment with these implants can be used in patients with insufficient bone in the edentulous maxilla. Before treatment none of these patients had sufficient bone to allow placement of conventional implants. The patients were generally satisfied with the treatment outcome; their VAS scores showed that they experienced improved chewing function and esthetics.

Few reports have been published about zygomatic implants.[14–21] In the present study only 1 of the 42 anterior implants was lost; this occurred at the time of abutment surgery. No other implant failures occurred during the follow-up period, and all prostheses remain in full function. These findings indicate a 100% survival rate for the zygomatic implants and a 97.7% survival rate for the anterior implants. Previously reported survival rates have ranged from 94.2% to 100% for the zygomatic implants[15,17,20,21] and from 73% to 91.8% for the anterior implants.[15,17,21] Taken together, these

reports suggest that zygomatic implant therapy may provide a predictable treatment modality in the rehabilitation of the severely resorbed maxilla.

To the authors' knowledge, there are no other published reports on assessing the stability of zygomatic implants using RFA. Furthermore, until now, no report has included an evaluation of the marginal bone level around zygomatic implants. The retrieval of all prostheses enabled more thorough analysis of the implant success parameters, RFA measurements, and tissue condition registration for all 63 implants, and thorough assessment of all implants individually. RFA is considered a reliable and valid way to assess osseointegration.[22,23] For the anterior implants, a mean ISQ value of 61.5 (range, 48 to 71) was obtained. Only 1 anterior implant showed an ISQ value below 50; because of this low ISQ value, this implant should be followed carefully over time. ISQ values for the zygomatic implants ranged from 42 to 100, with a mean value of 65.9. The majority (13 of 22) of the zygomatic implants showed ISQ values equal to or higher than 60. Five zygomatic implants, however, showed ISQ values below 50. These implants had no marginal bone support. Since they showed marginal mobility but were rotationally stable, it was assumed that they were osseointegrated at the zygoma level but not in the marginal bone. Another 4 zygomatic implants exhibited marginal bone resorption, exposing between 4 and 5 threads. However, ISQ values for these implants were between 55 and 60. On the basis of the current findings, the presence of marginal alveolar bone clearly results in higher ISQ values. Patients with low implant stability could be at higher risk of future implant failure and should be observed closely over time.

In the present report some degree of esthetics inflammation was found in 14 of 22 zygomatic implants. The soft tissue cuff around zygomatic implants appears to be susceptible to infection; this would explain the increased number of patients with dental hygienic problems. Although it has been shown that late failures caused by peri-implant infection is a rare occurrence in relation to the conventional Brånemark System implants,[24] the long-term consequences for zygomatic implants demand ongoing scrutiny.

The use of zygomatic implants eliminates the need for bone grafts and any related donor site morbidity and shortens the length of treatment significantly. This treatment modality is an alternative to other surgical approaches but, as with any other procedure, it has some disadvantages. Extensive dissection of the zygoma for implant placement makes pain control quite challenging during surgery, necessitating the performance of the procedure under deep intravenous sedation or, preferably, general anesthesia.[14] Surgical access may be difficult and limit optimal implant placement and position, and there is some risk of orbital injury or sinusitis.

CONCLUSION

The use of zygomatic implants in conjunction with anterior implants provided sufficient support to allow fabrication of fixed dental prostheses. Patient satisfaction with this treatment modality was high. Bone loss in the coronal aspect of the zygomatic implants is a concern and demands ongoing scrutiny.

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