Surgical Modifications to the Brånemark Zygomaticus Protocol in the Treatment of the Severely Resorbed Maxilla: A Clinical Report

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Purpose: *The Zygomaticus dental implant, designed by Nobel Biocare, was developed for the treatment of the severely resorbed maxilla. Brånemark has reported an overall success rate of 97.6% with the placement of 183 implants over the last 12 years. The purpose of this article was to present a modification to the original Brånemark surgical approach to achieve better access and optimal implant placement.* ***Materials and Methods:*** *There are parameters within the patient's resorbed skeletal frame that guide the surgical placement of the currently used implant. However, there are shortcomings in the current surgical protocol. This report describes a simplified surgical approach in 45 patients (77 implants) using an implant with a modified head angulation of 55 degrees and a placement appliance to assist the surgeon in placing the implant as close to the crest of the edentulous ridge as possible.* ***Results:*** *The placement appliance identifies accurately the anatomic constraints of the resorbed skeletal frame that limit implant placement. This, together with the modified surgical protocol, has resulted in improved access and in ideal positioning of the restorative head.* ***Discussion:*** *The present technique allows restorative clinicians to achieve a more ideal restorative result in the posterior maxillary alveolus using the zygomatic implant, while reducing the buccal cantilever, improving tongue space, and access for maintenance.* ***Conclusion:*** *By placing the implant closer to the crest of the alveolar ridge using the placement appliance and an implant with a 55-degree head, the emergence of the restorative head and resultant buccal cantilever can be reduced by as much as 20%.* (INT J ORAL MAXILLOFAC IMPLANTS 2003;18:232–237)

Key words: *dental implants, maxillary sinus, zygomatic implants*

To restore the severely resorbed maxilla with a fixed implant-supported prosthesis, extensive bone grafting has been advocated to create adequate bone volume for the placement of endosseous implants.[1–3] These bone-grafting procedures include iliac crest bone grafts, which can be placed onto the labial and buccal surface of the maxilla (onlay technique),[4] inlay grafts into the floor of the maxillary antrum,[5] and Le Fort I maxillary osteotomy with advancement and downgrafting techniques.[6,7] The Le Fort I osteotomy also corrects the anteroposterior skeletal discrepancy associated with horizontal bone loss in the region of the labial plate and restores adequate bone volume to accommodate implant placement into the maxilla.

According to Rasmussen and coworkers,[8] the newly grafted maxilla should remain relatively load free for a period of 6 months to allow for consolidation of the grafted bone and to allow for revascularization of the bone graft in the grafted sites. Implants may only be placed after a 6-month healing period. If this is done, Lekholm and associates report that these procedures have a 76% to 84%

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Table 1 No. of Implants Placed by Type of Implant and Reconstruction Protocol

	Southern 55-degree head		Southern 45-degree head		Brånemark 45-degree head		Total	
Reconstruction	Implants	Patients	Implants	Patients	Implants	Patients	Implants	Patients
Full zygoma	20	10	2	1	36	18	58	29
Partial zygoma (unilateral)	3	3	2	2	1	1	6	6
Partial zygoma (bilateral)	4	2	0	0	2	1	6	3
Partial oncology	2	2	0	0	0	0	2	2
Partial gunshot	1	1	1	1	3	3	5	5
Total	30	18	5	4	42	23	77	45

success rate.[9] This staged bone graft technique has increased treatment time, which is sometimes a tedious and socially unacceptable period for the patient.

The advent of the zygomatic implant has provided the clinician with an alternative to grafting procedures in the reconstruction of the severely resorbed maxilla. Brånemark originally designed the technique in 1989 and since then has reported a total of 164 implants placed into 81 patients, with an overall success rate of 97% since inception of this implant technique.[10,11] Although the Zygomaticus implant (Nobel Biocare, Göteborg, Sweden) has had a remarkable success rate in the severely resorbed maxilla,[12] there are shortcomings in both the surgical and prosthodontic techniques as originally advocated by Brånemark.[13]

The purpose of this article was to present a modification to the original Brånemark surgical approach to achieve better access during the surgical procedure and decrease postoperative morbidity. Secondly, a proposed design of an appliance that may be used intraoperatively to assist the surgeon in accurately placing the implant in an optimal position on the edentulous ridge is described. It involves the use of an implant with a 55-degree head angulation to decrease the buccal cantilever of the final restorative prosthesis.

MATERIALS AND METHODS

Placement of Zygomatic Implants

There are many factors that contribute to the optimal placement and ultimate long-term success of the zygomatic implant protocol. It is important to evaluate clinically the patient's skeletal and facial profile. This is followed by radiologic investigations to assess the horizontal and vertical jaw relationships and amount of residual bone available for implant placement into the maxilla and zygoma. Finally, articulated diagnostic casts are used to define any skeletal discrepancy between the maxilla and mandible.

Optimal surgical placement of the zygomatic implant depends on the patient's pre-existing bony anatomy. The authors, in treating 45 patients using the Zygomaticus protocol (Table 1), have identified 2 basic facial skeletal forms associated with severe maxillary bone loss. This may be the result of normal physiologic bone resorption, traumatic bone loss associated with oncologic resection, or facial gunshot wounds. Two facial forms are readily identified using anteroposterior cephalometric radiographs, namely either a long, thin face or short, wide face.

The placement of a zygomatic implant with a 45-degree angulated head has a profound effect on both the emergence profile and buccal cantilever and may not be indicated for both facial forms. Thus, optimal placement of zygomatic implants is governed by patients' pre-existing surgical anatomy. Optimal placement is dictated by the position of 3 distinct anatomic sites (Fig 1):

- The position of the zygomatic notch, ie, the point where the forward projection of the zygomatic arch meets the frontal process of the zygomatic bone (point A)
- The confines of the lateral wall of the maxillary antrum (point B)
- The thickness of the existing alveolar crest (point C)

For optimal implant placement, the position of the zygomatic notch is very often non-negotiable and provides the superior pivot point of the zygomatic implant. In some instances, the surgeon can

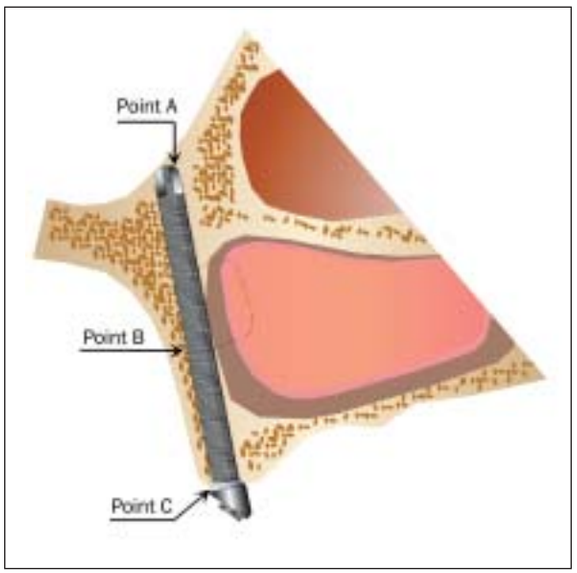

Fig 1 Optimal positioning of zygomatic implants.

place the exit point of the implant more medially, toward the inferolateral orbital margin; however, great care should then be taken not to perforate the bony orbit with subsequent disruption of the orbital contents. This allows for a more upright implant position and brings the restorative head of the implant into the first molar site rather than the second premolar site, thus providing a more satisfactory restorative result.

The lateral wall of the sinus must be engaged as far laterally as possible by the implant body to obtain the most lateral position of the implant body in the sinus. The exit point of the head of the implant in the maxillary alveolus should also be placed as close to the mid-alveolar position of the ridge as possible. This is achieved by placing the initial pilot drill hole as high up the ridge and as far laterally as the confines of the maxillary antrum will allow. This positions the implant platform as far buccally into the crest of the ridge as possible. The use of a placement appliance can assist in the initial placement of the pilot drill in the palatal alveolar bone (Southern Implants, Irene, South Africa) (Fig 2a). The placement appliance lines up the initial entrance hole of the implant preparation site in the palatal bone with the entrance hole into the body of the zygoma at the superolateral aspect of the maxillary antrum. This assists the surgeon in placing the initial drill preparation site as far laterally into the alveolus as possible and minimizes operator error, which usually results from surgical inexperience.

Modified Zygomatic Implant Protocol

Patient Selection. The primary indication for the zygomatic implant protocol is the patient with a severely atrophied maxilla. In some cases, initially a Le Fort I maxillary osteotomy and inlay bone graft may be indicated. This procedure is then followed by zygomatic implant placement and restoration with a fixed maxillary prosthesis. Unilateral reconstruction with zygomatic implants following tooth loss, ablative surgery (ie, hemimaxillary defects), or traumatic bone loss has also been performed using this technique.

Contraindications to the use of this technique include patients with acute or chronic sinusitis with mucosal hypertrophy. These patients need to be initially managed conservatively by first eliminating the sinus disease prior to zygomatic implant placement.

Patient Preparation. The placement of zygomatic implants is performed under general anesthesia. Infiltration anesthesia with 8 mL of 2% lignocaine with 1:80,000 adrenaline is administered for mucosal vasoconstriction. After completion of the surgical procedure, infiltration of a longer-acting local anesthetic agent, 10 mL of 0.5% bupivicaine with 1:200,000 adrenaline can be distributed submucosally from the zygomatic buttress regions bilaterally for postoperative pain control. Perioperative intravenous dexamethasone (16 mg) and intravenous amoxicillin (1.2 g) are administered.

Operative Technique. A crestal incision is made extending from 1 cm anterior to the maxillary tuberosity to the same position on the contralateral side. A 1.5-cm vertical releasing incision is made bilaterally at the posterior extent of the incision in the maxillary second molar region. A vertical incision is made anteriorly in the region of the anterior nasal spine to facilitate flap mobilization to beyond the infraorbital margin.

Periosteal elevation of this flap results in the same exposure as the traditional Le Fort I incision, but with a less bulky palatal mass of tissue than that associated with the Le Fort I incision. The dissection then extends around the base of the piriform rim up to the inferior aspect of the infraorbital nerves, and finally the inferior aspect of the body of the zygoma bilaterally, as is described in the original Brånemark protocol.[11]

The superior and lateral aspects of the zygoma are exposed by a tunneling technique, and a custom-designed retractor (Southern Implants) is placed into the zygomatic notch. This acts as a good guide for placement of the exit point of the implant body at the superior aspect of the zygomatic bone.

A 0.12-inch round bur is then used to create a lateral window in the superior wall of the antrum,

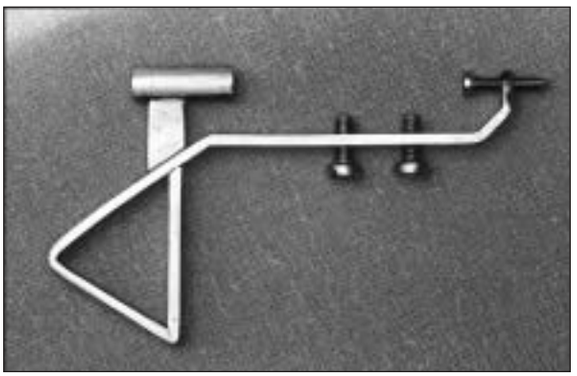

Fig 2a Placement appliance to optimize implant placement.

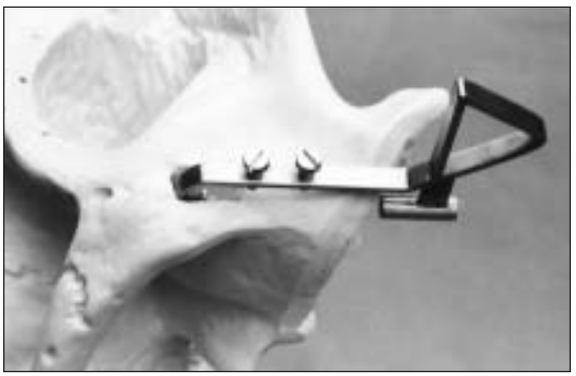

Fig 2b Placement appliance in situ on a model skull. The screw at the end of the appliance is placed into the preparation site in the zygoma. The tube guides the placement of the initial pilot in the palate, allowing for optimal palatal placement.

taking care not to perforate the exposed sinus mucosa. The sinus mucosa is then reflected and, using a round bur, the proposed point of entry of the implant into the zygomatic bone is demarcated through the sinus window. To place the head of the implant as close to the crest of the edentulous ridge as possible, the specially designed placement appliance is used for the initial pilot drill (Fig 2b). This allows for optimal placement of the implant head in the alveolar crest, as far laterally to the crest of the ridge as is possible. It not only decreases the undesirable buccal cantilever but also improves the emergence profile of the definitive prosthesis. Final implant site preparation is achieved by enlargement using graded pilot and twist drills. The authors prefer to place the exit point of the implant more medially toward the inferolateral orbital margin. This allows for a more upright implant position and brings the restorative head of the implant into the first molar site. Care should be taken to avoid perforation of the bony orbit and possible subsequent disruption of the orbital contents.

Modification to Implant Design and Placement. In addition to the standard head angulation of 45 degrees, an implant with a head angulation of 55 degrees has been designed (Southern Implants) to further improve the emergence profile and decrease the buccal cantilever at the level of the occlusal plane. An additional modification to the design of the implant is that it has been surface enhanced (SLA) using a large-grit, acid-etched technique.[14] The implant had been surface enhanced along the entire length in order to maximize contact with the bone, namely the body of the zygomatic bone, and within the wall of the maxillary sinus wall and alveolar bone areas. The decision as to whether to use an implant with a 45- or 55-degree head is determined with the aid of implant analogs (Southern Implants) (Fig 3). The trial implant analogs are of varying lengths (between 35 and 50 mm), with head angulations of either 45 or 55 degrees placed into the final implant preparation site.

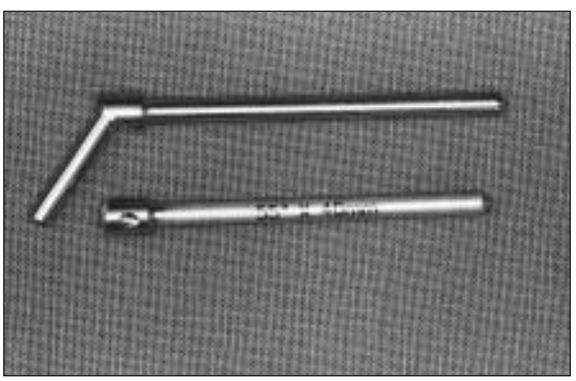

Fig 3 Implant analogs, which assist in choosing the best head angulation.

To avoid the implant protruding too far out of the lateral aspect of the body of the zygoma and becoming palpable to the patient, an implant length that is 2.5 mm shorter than the estimated length should be chosen. Final placement of the implant is accomplished using the standard protocol.[11] To achieve the appropriate angulation of the implant platform, a hexagonal machine screwdriver is placed in the implant mount screw, and the implant is subsequently adjusted so that the abutment is as parallel as possible to the implants in the canine sites.

Table 2 No. of Implants Placed by Type of Implant and Loading Period

	Southern 55-degree head		Southern 45-degree head		Brånemark 45-degree head		Total	
Loading period	Implants	Patients	Implants	Patients	Implants	Patients	Implants	Patients
6–12 months	5	4	0	0	0	0	5	4
12–18 months	15	9	2	2	15	8	32	19
18–24 months	10	5	3	2	19	11	32	18
24–30 months	0	0	0	0	8	4	8	4
Total	30	18	5	4	42	23	77	45

RESULTS

In this clinical study, the authors have treated 45 patients using the Zygomaticus implant protocol, and a total of 77 implants have been placed (Table 1). Of the 77 implants placed, 47 implants have 45-degree angulated heads and 30 implants have 55-degree angulated heads.

The first 10 implants were placed according to the standard Brånemark surgical protocol and were 45-degree Brånemark System implants (Nobel Biocare).[11] The next 67 implants were placed according to the modified surgical protocol described above and were placed with the aid of the placement appliance. These implants were either 45- or 55-degree angulation and were selected according to the patients' resorbed skeletal profiles.

The implants were exposed 6 months after placement, and an impression of the restorative head of the implants was made by the prosthodontist at the time of implant exposure. All 77 implants were integrated at the time of abutment and prosthesis placement and were subsequently loaded with a fixed or fixed/removable overdenture prosthesis. The oncology and gunshot patients were reconstructed with a Dolder bar and an overdenture, while the completely edentulous and partially dentate patients were reconstructed with fixed, screw-retained prostheses.

Patients were recalled 6 months after initial implant loading, with the longest loading period in this study being 30 months (Table 2). Implant survival was assessed using the following criteria:

- Radiographs taken 6 months after implant loading revealed no residual sinus pathology or signs of bone loss around the implants.
- The implant-supported prosthesis had been loaded for a minimum of 6 months, with no clinical signs of implant loss.

Thereafter, patients were followed up at 6-month intervals and assessed for both clinical and radiologic signs of implant loss or sinus pathology. The authors report no implant loss at 30 months.

DISCUSSION

The Zygomaticus implant has had a remarkable success rate in the treatment of the severely resorbed maxilla. When compared to more conventional treatment modalities advocated for maxillary reconstruction for the resorbed maxilla, the zygomatic implant has the highest success rate of all of the traditional treatment modalities, despite the small number of implants placed so far and the short time that the implants have been loaded.[9,10] The authors and others have found that once the initially difficult surgical approach of the original Brånemark protocol has been mastered, it can be simplified and the shortcomings of the surgical and prosthodontic protocols circumvented.

The recommended Le Fort I incision provides excellent buccal access to the nasal aperture and lateral aspect of the zygoma. This leaves a large palatal mass of tissue, which has to be stripped over the alveolar ridge and then retracted palatally for palatal access and eventual palatal implant placement. The authors suggest that a crestal incision circumvents this large palatal mass of tissue by the use of 3 strategically placed vertical incisions up into the labial and buccal sulcus. This technique also allows for a hemimaxillary flap that can be raised unilaterally for placement of a unilateral zygomatic implant.

The sinus slot technique as described by Stella and Warner[13] mentions that perforation of the lateral antral wall is not an important factor. The authors concur with Stella and Warner, in that if the threads of the implant are slightly exposed outside the confines of the lateral antral wall, the implant

can be deemed to be optimally placed at the lateral antral wall position. Stella and Warner also felt that it was not necessary to make the buccal access window in the superolateral aspect of the maxillary antrum. However, the authors disagree with the sinus slot technique, since *(1)* it does not allow direct visualization of the access point of the implant into the body of the zygoma, and *(2)* perforation of the posterior antral wall is possible because of lack of visibility. This may result in either placement of the implant in the infratemporal fossa or introduction of muscle fibers into the implant site. The latter could result in recurrent postoperative pain or nonintegration of the implant. Good visibility of the maxillary antrum is especially important when the implant is to be uprighted and placed more medially toward the inferolateral aspect of the orbit.

A placement appliance has been proposed and designed to facilitate optimal implant placement closer to the crest of the alveolar ridge, thus enhancing restorative potential. The use of this apparatus has permitted a more predictable and accurate approach to the surgical protocol and, in so doing, has significantly decreased the risks associated with the long buccal cantilever that results from a palatal placement position. The long buccal cantilever can be further reduced by the use of the modified implants, which have a 55-degree angulation of the restorative head.

CONCLUSION

Modifications to the surgical procedure for the placement of zygomatic implants has both shortened the operative time and postoperative morbidity for patients treated using this protocol. In addition, when the implant is placed closer to the crest of the alveolar ridge using an adjunctive placement appliance and implants with either a 45-degree or 55-degree head are used, the emergence of the restorative head can be optimized. This has resulted in the buccal cantilever being reduced by as much as 20% in some patients,[15] measured at the occlusal plane. Modifications to the implant design, as well as surgical technique, have expanded the indications for the use of the zygoma protocol.

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