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Treatment of the edentulous atrophic maxilla using zygomatic implants: evaluation of survival rates over 5–10 years

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Abstract. The aim of this retrospective observational cohort study was to analyse and report the 5–10-year survival rates of endosseous zygomatic implants used in the rehabilitation of the atrophic maxilla. Forty-three consecutive zygomatic implant placements in 25 patients were evaluated over a 5–10-year period. All zygomatic implant surgery was carried out under general anaesthesia. Nobel Biocare zygomatic machined-surface implants were used, and placement was undertaken using the modified sinus slot method. The main outcome measures and determinants for success were survival of the restored implants and the proportion of originally planned prostheses delivered to patients. Of the 25 patients treated, 12 were male and 13 were female; 19 were non-smokers, and the mean age at time of surgery was 64 years. Patients were treatment-planned for implant-retained bridgework, a removable prosthesis retained by fixed cast gold or milled titanium beams, or magnet-retained removable prostheses. A combination of zygomatic and conventional implants was used in all but one patient. In this study it was shown that the overall success rate for zygomatic implants was 86%, with six of the implants either failing to integrate or requiring removal due to persistent infection associated with the maxillary sinus. All patients received their planned prosthesis, although in six cases the method of retention required modification. This study illustrates that zygomatic implants are a successful and important treatment option when trying to restore the atrophic maxilla, with the potential to avoid additional augmentation/grafting procedures and resulting in a high long-term success rate.

Key words: atrophic maxilla; dental implants; modified sinus slot technique; zygomatic implants.

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The atrophic maxilla represents a significant treatment dilemma in the management of the edentulous upper jaw. Whilst the provision of implants remains the treatment of choice in cases where conventional prosthetic measures have failed, a lack of available bone may highly compromise the ability to deliver a successful long-term, implant-based solution. The importance of long-term success is iterated by the potential for a dire clinical scenario upon failure of whichever solution is delivered.

A major prerequisite for optimal implant placement lies in identifying bone of adequate dimensions and quality to support a suitable fixture. Whilst computed tomography (CT)-based imaging has drastically improved our ability to identify suitable regions of adequate bone, even in the atrophic case, clinicians may still be presented with bone in which standard implant placement is not feasible.[1] A number of augmentation procedures, most of which predate CT-based assessment, have been developed to achieve a satisfactory result in such cases.[2] Whilst most of these procedures, including guided bone regeneration, onlay/interpositional grafting, and sinus augmentation,[3–6] have looked to directly augment a site that in its very nature is substandard, a novel solution has been to accept the lack of direct bone availability within the maxilla and instead utilize support from the zygomatic bone.[7]

Zygomatic implants not only carry an advantage in engaging a reliable site of pre-existing bone, but also forego the necessity to undertake significant augmentation procedures, which often have to be completed under general anaesthesia and carry additional morbidity. This may be a highly desirable prospect given the age and related co-morbidities with which many patients with atrophic jaws present. Furthermore, the risk of failure and resorption associated with grafted bone is not a concern, as the quality and quantity of the zygomatic bones is inherent within each patient and will persist largely independent of age or tooth loss.

Due to the small proportion of edentulous patients ultimately progressing to advanced methods of implant placement, direct comparison of zygomatic implant success against augmentation procedures through a suitably powered, randomized controlled trial was not considered possible. We therefore present our experience of the success of machined zygomatic implants placed within a teaching hospital, with follow-up of over 5–10 years. Particular reference is given to the surgical technique, and a final comparison is made to the success of alternative procedures, as described in the literature.

Materials and methods

A retrospective observational cohort study was undertaken of all patients receiving zygomatic implants over a 6-year period. A total of 25 patients underwent placement of one or more zygomatic implants between 2000 and 2006. After initial clinical and radiographic (orthopantomogram, OPT) and/or CT-based assessment in an outpatient setting, all cases were treated under general anaesthesia utilizing Nobel Biocare Zygoma machined-surface implants (Nobel Biocare, Gothenburg, Sweden). The authors recognize the potential for zygomatic implants to be placed successfully under local anaesthesia alone or with sedation, however the reassurance of general anaesthesia to achieve optimal operating conditions and provide every opportunity to deal with unexpected complications was considered justifiable.

All patients were considered generally fit and well with no medical conditions deemed significant enough to have a direct effect on the long-term prognosis of the dental implants or to affect the patients' ability to withstand surgery under general anaesthesia. There were no reports of sinus pathology, and no patient reported symptoms relating to their sinuses.

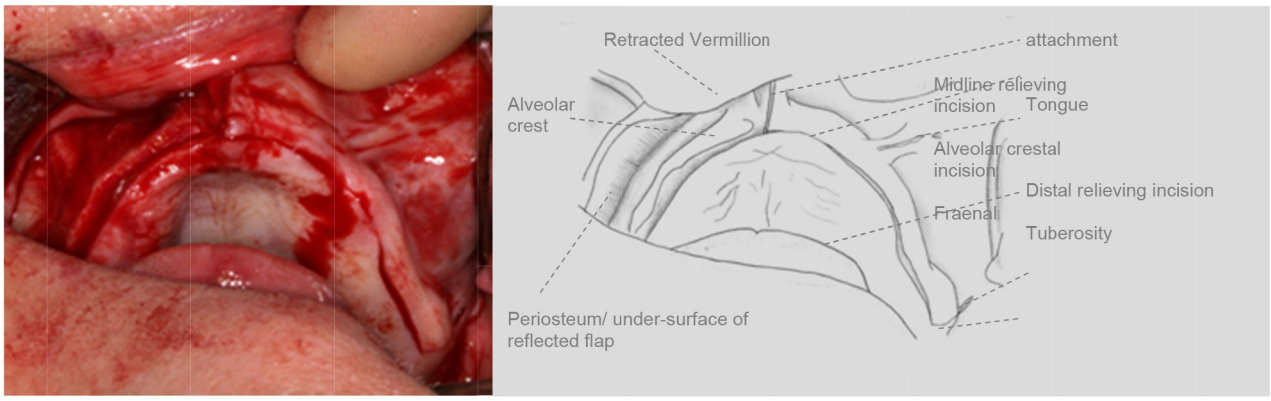
All patients were deemed American Society of Anesthesiologists (ASA) grade 1 (healthy) or 2 (with only mild systemic disease).[8] Inclusion criteria (Table 1) were the presence of inadequate bone for conventional implants in the posterior maxilla and where augmentation procedures were considered either inappropriate or contraindicated, or had previously failed. For the cases in this study, the minimum sized implant considered suitable for conventional treatment would be a regular platform, 4–4.5 mm diameter × 8 mm length. Thus patients who did not have minimum bone dimensions of 5–6 mm width and 8 mm height were eligible for treatment in this study. Implants placed subsequent to 2006 were not included in the study due to the lack of complete 5-year follow-up data. Furthermore, textured-surface zygomatic implants were used increasingly from this date.

Although this study presents combined data relating to implants placed by two different surgeons, the technique used by each surgeon was comparable and consistent. Full access to the alveolar crest and zygomatic region was gained using a crestal incision with both anterior and distal vertical relieving incisions (Fig. 1A). Full exposure of the alveolar crest and associated zygoma was achieved so as to allow access for the creation of a modified sinus slot (Fig. 1B) using the methods described by Stella and Warner.[9] Briefly, this modified sinus slot technique is a variant of the original Brånemark protocol in which dissection is minimized and the need for a window in the maxillary sinus is avoided, substituting a narrow sinus slot. The sinus slot technique positions the implant in a more vertical plane over the crest of the alveolar ridge in the first molar region, and results in a greater bone-to-implant interface along the posterior aspect of the

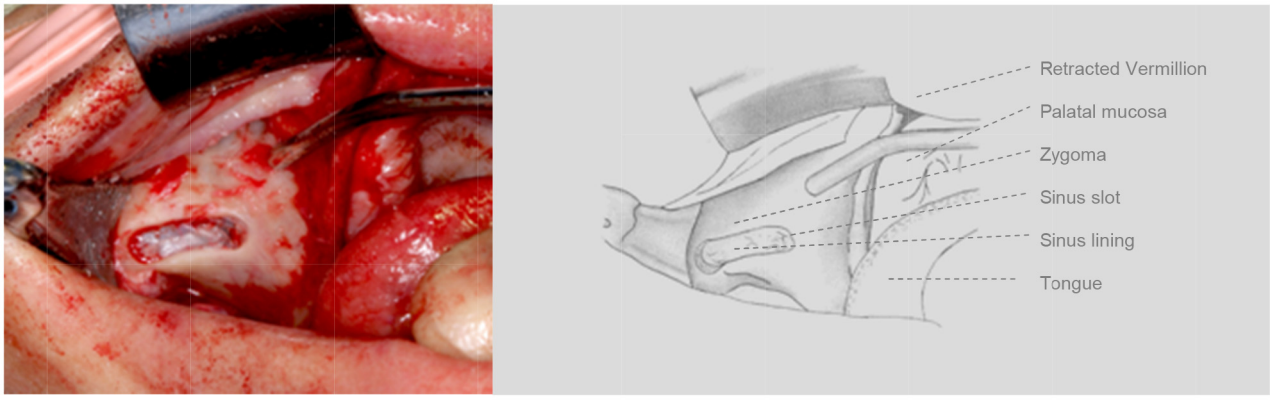
Table 1. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
ASA grade I or II	ASA grade > II
No medical condition linked to implant failure (e.g. diabetes mellitus)	Presence of a medical condition linked to increased incidence of implant failure
Inadequate bone for restoration with conventional implants	Adequate bone for implant-retained prosthesis without need for progression to augmentation procedure/zygomatic implants
Alternative augmentation procedures considered either inappropriate or contraindicated, or previously failed	Alternative augmentation procedure feasible
Patient able and willing to give valid consent	Unable to provide valid consent
Age > 18 years	Age < 18 years
Suitability of zygomatic implants agreed by both surgical and restorative team at MDT meeting	Patient judged not suitable for zygomatic implants at MDT meeting

ASA, American Society of Anesthesiologists; MDT, multidisciplinary team.



A



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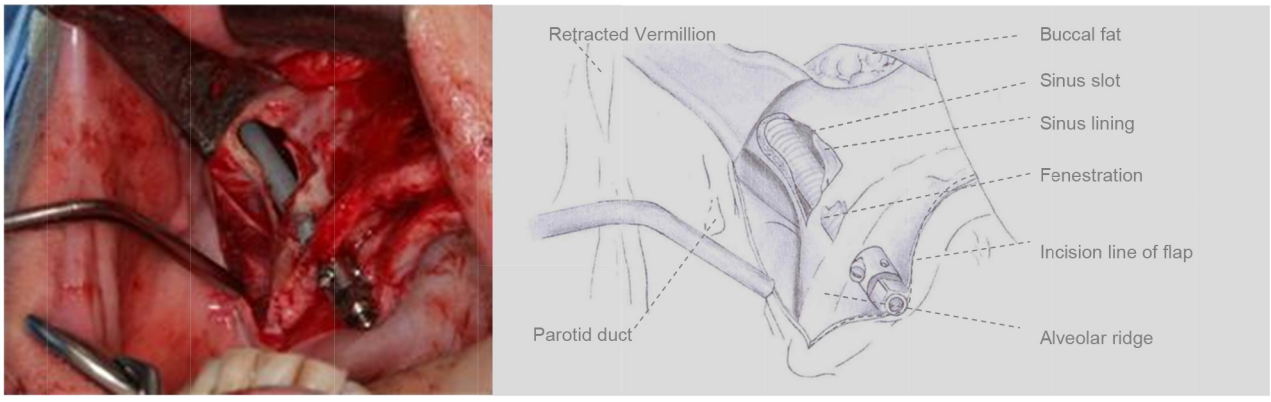

C

Fig. 1. Modified sinus slot technique. (A) Access: crestal incision with distal and mesial relieving incisions; mucoperiosteal flap retracted on the right side exposing alveolar bone. (B) Sinus slot: full exposure of the associated zygomatic buttress with subsequent creation of a slot using saline-cooled burs. (C) Placement of the implant fixture: orientation achieved under direct vision; note exposure of the lateral wall of the orbit to allow confirmation of no impingement. Note that the images show a textured implant rather than a machined-surface implant for the purposes of illustration, however the technique is identical.

maxillary sinus. Saline-cooled burs were used throughout the slot preparation to avoid thermal trauma to the surrounding bone. In addition to providing direct implant visualization during placement, the methods of access also achieved visualization of the infero-lateral aspect of the neighbouring orbit to ensure inadvertent trauma to this region was avoided (Fig. 1C).

Osteotomy preparation was undertaken using appropriate saline-cooled drills, as recommended by Nobel Biocare (Gothenburg, Sweden). Drill orientation was achieved under direct vision, with an

initial osteotomy placed through alveolar bone in the region of the absent first molar, directed towards the zygomatic prominence. Supero-lateral drill inclination under careful observation of the infero-lateral aspect of the orbit allowed a more vertical (and therefore more desirable) orientation of the final fixture. Following successful placement of the planned number of zygomatic implants along with anteriorly placed conventional implants where needed, fixtures were buried using cover screws and then all incisions closed with 4-0 resorbable sutures.

Postoperative plain films were taken (OPG and occipitomental views) the day after surgery to ensure acceptable implant orientation prior to ward discharge. Outpatient follow-up was then undertaken at 1 week, 1 month, and then 3 months to assess for acceptable healing and screen for postoperative complications. All patients were provided with conventional partial or complete removable prostheses that were adjusted at first- and second-stage surgery in order not to traumatize or inadvertently 'load' the implants. Second-stage surgery was then performed under local anaesthetic 6 months after initial placement. Second-stage surgery allowed further assessment of osseointegration through the manual torquing of transmucosal healing abutments – attempted clockwise rotation of the cover screw under approximately 15 N·cm pressure with a unigrip driver prior to unscrewing the abutment.

All prostheses were subsequently delivered within 6–12 weeks of second-stage surgery. Reassessment of implant stability was performed at each subsequent restorative appointment prior to discharge with the final prosthesis. All prostheses were screw-retained, either indirectly or directly. Where prostheses were indirectly screw-retained, they consisted of a screw-retained cast/milled bar with a removable prosthesis. In the case of directly screw-retained prostheses, the prosthesis was in the form of a bridge screwed directly onto the implants.

Thereafter, all patients were provided an annual review in a restorative clinic to monitor treatment success clinically and radiographically, and were followed up for at least 5 years. Only two drop-outs to follow-up were noted, which may be explained by the high motivation of patients engaging in complex treatments, in addition to the consensus view of all treating clinicians to keep all patients under close long-term review.

The success criteria for this study were consistent with those previously described by Buser et al.,[10] namely that implants were osseointegrated (radiographic suggestion of direct apposition between implant and bone, with no clinical evidence of infection including pus discharge or implant mobility), functional, and restorable. Subjective assessment of any problems the patient may have been experiencing with the implants was also part of the success criteria.

Implant failure was defined as the clinical point at which an implant was judged to have lost functional stability, having failed to achieve integration following placement, losing integration with bone following successful initial integration, or where patient symptoms necessitated its removal.

Results

A total of 43 zygomatic implants were placed in 25 consecutive patients over a period of 6 years (Table 2). Twenty-three of the 25 patients were followed up for the entire 6 years. Unfortunately the two remaining patients were unable to be reviewed after 4 and 5 years, respectively, as they were lost to follow-up. Six implants failed during follow-up, leading to a 5–10-year overall survival rate of 86%. All failures occurred within the first

Table 2. Summary of all zygomatic implants placed over the period 2000–2006. Details of specific clinical points are also included.

Year	Age, years	Sex	Restoration	No. of implants placed	No. of implants failed	Comments
2000	54	F	Full	2	1	
2000	56	M	Partial	1	0	Semi-dentate. Right partial maxillectomy
2000	66	F	Full	2	0	
2001	84	M	Full	2	0	
2001	65	M	Full	1	0	
2001	66	F	Full	2	0	
2001	74	F	Full	1	0	Edentulous maxilla with cleft palate
2001	73	M	Full	2	1	
2001	64	F	Partial	1	0	Semi-dentate. Resection of alveolar bone due to pathology
2002	62	M	Full	2	0	
2002	42	M	Partial	1	0	Semi-dentate. Traumatic tooth/bone loss in posterior maxilla
2002	73	F	Full	2	0	Previous failed augmentation anterior maxilla
2003	49	F	Full	2	1	
2003	63	F	Full	2	0	
2003	69	M	Full	2	0	
2004	79	F	Partial	1	0	Semi-dentate. Resection of alveolar bone due to pathology
2004	54	M	Full	2	1	
2004	68	M	Full	2	1	
2004	61	F	Full	2	0	
2004	50	M	Full	2	0	
2005	71	F	Full	2	0	
2005	75	F	Full	2	0	
2005	73	M	Full	1	0	Edentulous maxilla with cleft palate
2005	50	M	Full	2	1	
2005	62	F	Full	2	0	

F, female; M, male.

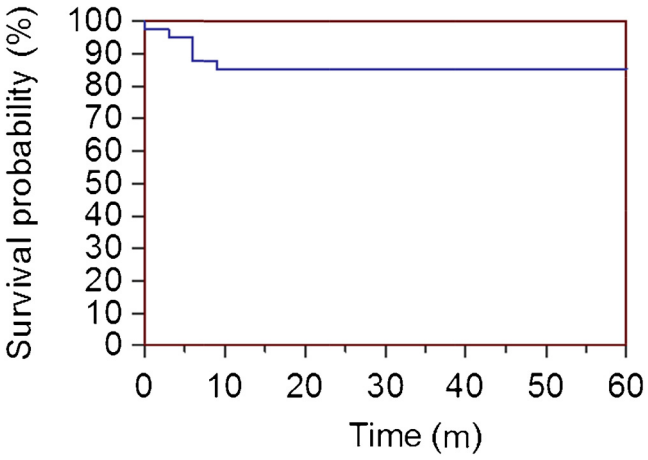

Fig. 2. Kaplan–Meier curve of implant survival over follow-up of 5 years.

year following placement, as depicted in Fig. 2 (Kaplan–Meier survival curve). Multiple zygomatic implant failures in the same individual were not observed. In the case of the two patients who were lost to follow-up, their implants were deemed successes at their last review; therefore we made the assumption they did not contribute to the failure rate. There was no difference in outcomes between the two surgeons. The vast majority of patients (18/25) underwent bilateral procedures, although seven cases underwent surgery for unilateral arch reconstruction (details summarized in Table 2). Unilateral zygomatic implants were placed in a further two edentulous cases, with the contralateral sides carrying adequate bone for the final prostheses to be supported with conventional implants.

No relationship was noted between sex, medical history, or smoking status and implant failure (χ^2 $P > 0.05$ for all data; Fisher's exact test also used on smoking data, $P > 0.05$). Causes of implant failure are listed in Table 3. The most common reason for failure was lack or loss of osseointegration (4/6 failures). No identifiable cause for this lack of osseointegration could be identified. This was determined clinically by percussion of the implant and by using a manual prosthetic screwdriver with torque wrench.

Eventual complications included those relating to the implants and those associated with the prostheses. In the case of implant-related complications, some ($n = 6$) demonstrated evidence of gingival recession around the implant/fixture heads and thus showed 2–4 mm of exposed implant threads; however, there was no further pocketing with time. With regards to prosthetic implications, when a zygomatic implant failed, the distal extension of the planned prosthesis had to be reduced to reflect the reduction in support/retention.

Discussion

Zygomatic implants offer a relatively measured approach to restoring the missing upper dentition when direct alveolar support for conventional implants is lacking. The 86% 5–10-year survival rate observed in this study compares favourably to alternative, augmentation-based methods of managing the atrophic maxilla, which have reported survival rates of 81–96%.[2] Moreover, the lack of failures seen beyond 9 months suggests that zygomatic implants offer a highly predictable long-term solution to those patients who have no other alternative than to undergo additional augmentation procedures. A number of patients have also been reviewed beyond the reported 5-year follow-up period and have shown no additional failures beyond those presented in Table 3.

Interestingly, no relationship was noted between medical history (although a potential confounder relates to the inclusion criteria, whereby all patients treated were ASA 1/2), age (mean 58 years in the failure group, 64 years for all cases), or smoking status and implant failure. Although these variables have been implicated in increased failure rates in conventional dental implants,[10–13] their influence on the success of zygomatic implants is unclear. The authors do accept that due to the relatively small number of implant failures within the series presented, definitive conclusions cannot be drawn. Furthermore, the presence of clinically important medical conditions known to have a bearing on healing, including diabetes and high-dose bisphosphonates, may act as a deterrent for both the clinician and patient to engage in complicated surgical treatment, thereby biasing the medical status of patients enrolled in the study.

The benefits of avoiding multiple general anaesthetics, in addition to avoiding the potential for inducing morbidity at anatomical sites remote from the jaws, are not insignificant given the patient demographic presenting with edentulous, heavily resorbed maxillae. Although some authors have placed zygomatic implants under local anaesthesia, which may be considered the ideal approach to the

Table 3. Details of implant failures.

	Age, years	Sex	Smoking status	Period to failure, months	Reason for failure	Final prosthesis salvageable
2000	54	F	Non-smoker	6	Failure to integrate	Yes
2001	73	M	Non-smoker	6	Failure to integrate	Yes
2003	49	F	Non-smoker	6	Failure to integrate and exposed threads	Yes
2004	54	M	Non-smoker	0	Incorrect positioning[a]	Yes
2004	68	M	Smoker	3	Chronic discharging sinus with symptoms[b]	Yes
2005	50	M	Non-smoker	9	Exposed threads leading to symptoms[c]	Yes

F, female; M, male.

[a] The initial osteotomy site within the zygomatic bone was not in an ideal position and an alternative site could not be successfully undertaken without drilling into either the infra-temporal fossa or orbit.

[b] Implant was associated with a chronic infection around the portion of the implant in the zygomatic bone and thus symptoms of chronic sinusitis. The patient did not have symptoms before treatment.

[c] Implant was associated with chronic irritation around the exposed threads, enough for the patient to request its removal.

surgical management of the medically compromised patient, all cases in our series undertook a single general anaesthetic procedure due to the small, yet significant risk of surgical complications resulting from vascular damage or orbital trauma.

Following recent advancements in CT-based planning, the authors have now adopted cone beam CT scanning and the use of Nobel Clinician software (Nobel Biocare UK, Ltd.) as standard for planning purposes. All implants were sited by means of a two-stage surgical procedure, with the use of cover screws and primary flap closure following initial placement. Although there appears to be a trend towards early loading of zygomatic implants,[14,15,16] our series undertook a more conservative postoperative healing phase of 6 months prior to second-stage surgery. Although early/immediate loading of zygomatic implants may be a viable approach, it may lead to failure rates contrary to those suggested by our data, and caution should be taken in extrapolating our results beyond the context of the methods described.

With regards to the prosthetic outcome, as outlined in Table 2, all cases in which zygomatic implants were used and failed were ultimately restorable to the planned prosthesis through modification of the final prosthetic design. The combined use of concomitantly placed, conventional dental implants in the anterior maxilla, in combination with contralateral, integrated zygomatic implants, allowed acceptable support in all cases and this appears to support previously published work[14,17]; the authors feel this outcome reflects the versatility of the technique rather than unnecessary use of advanced measures from the outset. Finally, although we present a relatively small case series, zygomatic implants appear to offer a predictable alternative to augmentation procedures in the management of the atrophic maxilla.

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Competing interests

None.

Ethical approval

Not required.

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