Zygoma implant-supported prosthetic rehabilitation after partial maxillectomy using surgical navigation: a clinical report

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Abstract

The rehabilitation of patients with acquired defects of the maxilla is a challenge in terms of reestablishing oronasal separation. In most patients these goals are met by means of prosthetic rehabilitation with an obturator prosthesis. If the remaining dentition does not offer sufficient retention and support, the placement of zygoma implants can enhance the stability of the prosthesis. Due to the anatomic intricacies of the zygomatic bone and the implant length, computer-supported navigated implant placement can be advantageous. In the following clinical report, a diabetic patient with a status of posthemimaxillectomy secondary to aspergillus infection is presented, in whom a zygoma implant was placed using a CT scan-based navigation system. A special retentive anchoring abutment was used to integrate the zygoma implant into a telescopic crown-retained denture on the residual dentition. This tooth-implant-supported obturator prosthesis restored function and phonetics, as well as esthetics, for this young patient.
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ABSTRACT

The rehabilitation of patients with acquired defects of the maxilla is a challenge in terms of re-establishing oronasal separation. In most patients these goals are met by means of prosthetic rehabilitation with an obturator prosthesis. If the remaining dentition does not offer sufficient retention and support, the placement of zygoma implants can enhance the stability of the prosthesis. Due to the anatomic intricacies of the zygomatic bone and the implant length, computer-supported navigated implant placement can be advantageous. In the following clinical report a diabetic patient status post hemimaxillectomy secondary to aspergillus infection is presented, where a zygoma implant was placed using a CT-scan-based navigation system. A special retentive anchoring abutment was used to integrate the zygoma implant into a telescopic-crown retained denture on the residual dentition. This tooth-implant-supported obturator prosthesis restored function, phonetics as well as esthetics for this young patient.

INTRODUCTION

Defects of the maxilla may result from trauma, disease, pathological changes or follow surgical resection of oral neoplasms. Maxillectomy defects result in the formation of a communication from the oral cavity into the antrum and/or the nasopharynx. This inevitably results in problems with speech, mastication, swallowing and impaired facial esthetics. Rehabilitation is important as such functional impairments have a detrimental effect on quality of
There are several reconstructive options including prosthetic obturation, non-vascularized grafts, local flaps, regional flaps and microvascular free tissue transfer. Although there have been advances in plastic surgery, surgical reconstruction of maxillectomy defects continues to be challenging, unpredictable, and not always possible, either due to local or systemic reasons. Additionally, some patients may prefer to avoid secondary morbidity from reconstructive procedures. In these patients an obturator prosthesis can reestablish the separation of the oral cavity from the sino-nasal cavities, restoring speech and swallowing function. In dentate patients, support, stability and retention of such an obturating removable prosthesis relies on the remaining hard and soft tissues. The larger the surgical resection, the greater the loss of mucogingival support, which in turn results in increased unfavorable forces acting on the remaining abutment teeth. Since the advent of osseointegration the combination of implants and prosthetic obturators has proven to be beneficial, especially in the rehabilitation of the edentulous maxillectomy patient. Because of the limited amount of remaining maxillary bone following maxillectomy, implant placement for anchoring a prosthesis has also been performed in more remote sites such as the zygomatic bone. The zygoma implant (Zygomaticus fixture; Nobel Biocare, Göteborg, Sweden) developed by Branemark was specifically designed to offer maximum bone anchorage while simplifying access to the implant head, facilitating the abutment connection. The zygoma implant is available in 8 lengths ranging from 30 to 52.5 mm. The head of the zygoma implant is engineered to allow prosthesis attachment at a 45-degree angle to the long axis of the implant. With this specific design these implants have been successfully used to support prostheses in the atrophic edentulous maxilla, as well as in patients which have undergone maxillectomy. This clinical report demonstrates the use of a zygoma implant to improve stability and
retention of a telescopic-crown retained \textsuperscript{48-51} obturator prosthesis and highlights the benefits of computer-supported navigation when placing such an implant.

**CLINICAL REPORT**

A 23-year-old white woman presented at the dental school in the University Hospital of the Albert-Ludwigs University (Freiburg, Germany) seeking definitive rehabilitation 18 months following hemimaxillectomy. The medical history revealed a rare example of a fulminant infection in a type I diabetic patient. Following extraction of the lower left second molar the patient was treated for a paramandibular abscess and the postoperative course was further complicated by sepsis. Microbiological tests revealed a suprainfection with *candida albicans* and *aspergillus*. The bacterial and fungal infections proved to be therapy-resistant and disseminated systemically. A poorly controlled diabetes control can be a risk factor for fungal infection after tissue damage.\textsuperscript{52} The patient developed pneumonia which resulted in complete collapse of the respiratory system (ARDS; acute respiratory decompensation syndrome). Aspergillus has a propensity for invading blood vessels causing thrombosis and infarction.\textsuperscript{52} In the presented patient a blocking of the internal carotid artery and the maxillary artery was diagnosed which was supposedly caused by such an infarction of these vessels. The consequent necrosis of the left maxilla made hemimaxillectomy inevitable. From the sinuses, the infection spread into the brain resulting in multiple cerebral insults, which lead to a palsy of the oculomotor and abducens muscle. The Magnetic Resonance Imaging (MRI) verified abscess-foci located in the frontal lobe and temporobasal near the cavernous sinus. As a side effect to the antimycotic therapy the patient suffered from toxic hepatitis.
At the time of the first appointment, the resection site was free of inflammation and completely covered by respiratory mucosa. The defect extended from the palatal midline to the distal surface of the left incisor and posteriorly onto the soft palate (Fig. 1 and 2), resulting in an opening to the nasal as well as the antral cavity (Fig. 3). Examination of the remaining maxillary dentition revealed extensive restorative treatment and root canal therapy of the right central incisor. A provisional obturator inserted following the surgical resection allowed the patient to speak and swallow. The patient desired a definitive rehabilitation to improve function and at the same time provide a more esthetic result.

In this patient, there was no alternative to prosthetic obturation as microsurgical rehabilitation was not considered a viable option due to the compromised vascular supply of the defect site. Considering stability, retention, load distribution and suprastructure longevity, the decision was made to rehabilitate the patient with a telescopic crown-retained obturator prosthesis additionally supported by one or two zygoma implants (Zygomaticus fixture; Nobel Biocare, Göteborg, Sweden) on the defect side. To ensure a proper position and bone anchorage it was planned to navigate the implant placement. After preliminary impressions with alginate (Alginat Super; Pluradent, Offenbach, Germany) artificial teeth (Physiodens; Vita Zahnfabrik, Bad Säckingen, Germany) were diagnostically arranged on trial bases of the maxillary prosthesis. Using this arrangement, an acrylic resin (Probase; Ivoclar, Schaan, Liechtenstein) template for the computerized tomography (CT) was generated and radiopaque marker (5 mm titanium drilling sleeve, Straumann, Freiburg, Germany) was positioned where the implant-prothesis-connection would ideally be located. The marker was positioned so it would not interfere with the palatal contours of the prosthesis nor with the buccal flange which was necessary for a good seal. This information was transferred into the CT and enabled to generate a CT-based virtual
model with the ideal position of implant head being visible. Using a special navigation system (VoXim, IVS Solutions AG, Chemnitz, Germany) it was possible to preoperatively simulate and predetermine the ideal implant position in a 3-D-reconstruction. It became evident that it would not be possible to properly place two zygomas side by side as the zygomatic bone was very thin in the caudal part, thus allowing the placement of only one implant in the thicker cranial part. During surgery, there was constant visualization of the drill trajectory in the 3-dimensionally reconstructed CT-image and in sagittal, coronal and axial views (Fig. 4). Deviation from the planned position was immediately detected and precise implant placement was achieved. An implant with the connecting external hexagon of the implant head facing towards the occlusal plane was used. A postoperative CT-scan verified placement and angulation of the implant in the remaining zygomatic bone (Fig. 5). During the 3 month-healing period, all remaining teeth were prepared for a telescopic-crown retained prosthesis. The abutments were prepared with a chamfer margin and definitive impressions were made (polyether material; Impregum Penta Soft, 3M Espe, Neuss, Germany), the inner telescopic-crown copings were cast with a precious alloy (Bio MSG, Heraeus Kulzer, Hanau, Germany). A transfer impression over these telescopic copings and the implant was made and (Nobel Biocare, Göteborg, Sweden) a definitive cast model was manufactured (Fig. 6) for the framework design. Wax occlusal rims formed on the acrylic resin record base were used to make an interocclusal record to transfer the interarch relationship into the articulator and a face-bow registration was performed. The trial arrangement of the teeth was completed and evaluated intraorally to verify tooth position, esthetics and proper occlusion. At the time of insertion of the completed prosthesis (Fig. 7-9), a retentive attachment (Locator; Zest Anchors Inc., Escondido CA, USA; see Fig. 8) was connected to the implant. The matrix of the retentive abutment was attached to the obturator prosthesis intraorally using
autopolymerizing acrylic resin (Ufi Gel Hard, Voco, Cuxhaven, Germany) to ensure passive fit. As the obturator had been processed on the definitive cast without any functional border molding, a reline impression using a silicone impression material (Epiform Flex, Dreve-Dentamid, Unna, Germany) was prepared simultaneously. After wearing the obturator for 3 weeks, nasal leakage reoccurred because of an imperfect seal in the soft palate area. Modelling plastic impression compound (Ex-3-N, Schopfloch, Germany), was used to mold the borders during functional movements. The patient was instructed to take a sip of warm water and to perform functional movements including speaking and swallowing. After the relining, all surfaces were polished to facilitate cleaning of the prosthesis. As there was no horizontal support inside of the defect except lower orbita floor (see CT-reconstruction fig. 3) it was decided not to extend the obturator bulb into the defect for additional support. However it can be expected that the abutment teeth and the implant offer enough stability and retention. As the main function of the obturating portion of the prosthesis was to guarantee oral-antral separation and seal, it was possible to create a light-weight, flat and therefore easy to incorporate obturator bulb. Further recall appointments were performed at 1 month, 3 months, 6 months and 1 year following prosthesis insertion. No complications such as sinusitis, periimplant mucositis or implant mobility were detected. There was no loss of sensitivity noted at the abutment teeth. Excellent oral hygiene was maintained and the patient was instructed and repeatedly motivated to use an electric tooth brush and floss the angulated abutment head. The patient was also encouraged to keep her diabetes under control. The patient is satisfied with the treatment result (Fig. 9 and 11) and happy to resume normal life.

DISCUSSION
Prosthetic obturation was the treatment of choice for this young patient. Recent investigations have confirmed the effectiveness of obturator protheses in terms of speech, masticatory function, swallowing and appearance, especially for small defects. There is evidence that speech can be restored to a preoperative level with a maxillary obturator prosthesis. Nasalance values are markedly influenced by the extent of resection respectively and particularly by the degree of soft palate involvement.

The presented patient corresponds to a class I (resection performed along the palatal midline) according to the Aramany classification of defects, with the left central incisor being preserved. Evaluating the remaining dentition without the supporting implant, a triangle is formed by the fulcrum line of the prospective framework and the tooth farthest away from the defect, the canine. Loading of the defect portion of a conventional obturator prosthesis would have induced considerable non-axial forces on the anchoring dentition. Through placement of the implant, a more favorable quadripodal support was achieved (see Fig. 7), and leverage was reduced for the teeth adjacent to the defect.

The presented solution of using a telescopic-crown system offers maximum support and stability, while offering acceptable esthetics without visible clasps. Because the telescopic copings are completely embraced and incorporated into the rigid prosthesis framework these anchoring teeth are loaded axially and are rigidly splinted by the prosthesis. Loading forces are thereby evenly distributed among the anchoring teeth and the implant and tilting and tipping forces are minimized. Moreover the teeth and prosthesis are easy to clean and in case of loss of 1 or more abutment teeth, the secondary crowns can be filled with relining material without compromising function and esthetics. The disadvantages of this type of attachment are the loss of tooth substance during preparation, a possible overcontouring of the crown and the unesthetic
aspect of the uncovered inner golden copings when the prosthesis is not in position. Despite these disadvantages, the telescopic-crown technique is well established and has good long-term performance, with the reported loss of abutment teeth averaging approximately 10% at 10 years. \cite{48, 49} A study comparing clasp-retained RPDs to telescopic-crown retained dentures showed a higher rate of abutment tooth loss and failure for clasp-retained dentures. \cite{49} Technical problems associated with telescopic-crowns are primarily related to loss of cementation of the inner crowns and fracture or chipping of the veneering resin. \cite{48} As the residual dentition had a substantial number of restorations the amount of required tooth preparation was considered acceptable. The traditional alternative would have been to use conventional clasps and rests to retain the obturator in place and to neutralize adverse cantilever forces. Such a design would have been much more plaque retentive, thus increasing the risk of caries and gingival inflammation. The telescopic-crown prosthesis might be more costly to manufacture, but more cost-effective in the long term.

Due to the quadripodal support provided by remaining dentition and implant it was possible to avoid complete palatal coverage. The narrow palatal bar connector was less compromising speech, taste and sensitivity.

The report on the use of zygoma implants penetrating the nasal and antral cavity was published by Branemark. \cite{36} Since then several reports have been published on the clinical performance of zygoma implants. \cite{28, 29, 31, 35, 37-46} The 2 primary indications for the use of zygoma implants are atrophic edentulous maxillae and defects after maxillary resection. \cite{28, 29, 40} Zygoma implants are generally placed at a 30 to 60-degree angle relative to the occlusal plane. \cite{35} To minimize the large lever arm detailed preoperative planning is mandatory. However, no implant fractures because of the long lever arm have been reported to date. In the edentulous maxilla a
“Quad” approach is recommended, supporting a denture with at least 2 implants in the anterior maxilla in conjunction with one zygoma implant on each side. However, unilateral anatomic conditions unique to the maxillary defect patient might allow the placement of only 1 zygoma implant in combination with 2 to 6 conventional implants, which was reported to be successful. In the presented situation, it was assumed that the stability of the remaining dentition on the non-defect side is equivalent to what could be achieved with 2 conventional implants and 1 zygoma implant. Hence, a single zygoma splinted rigidly but secondarily to the remaining dentition should not be prone to overload. Two zygoma implants on the defect side would have become a compromise in terms of bone anchorage as the bone quantity was very limited. In the literature, a primary splinting of 1 or more zygoma implants by a rigid bar assembly has been described to accomplish cross-arch stabilization, especially in the edentulous maxilla. In the presented patient, the benefits of splinting the zygoma implant to the remaining dentition are questionable. In the event of failure of a single tooth of such a design or the implant, repair would be much more complicated than with the telescopic crowns, where single units are splinted rigidly but secondarily. In addition, the retentive abutment and the telescopic-crown copings provide improved hygiene access and are more cost-effective when compared to use of a bar crossing the defect. This concept has been shown to perform well in the 4-year follow-up study by Landes. The majority of patients were rehabilitated with prostheses supported by unsplinted zygoma implants connected either by telescopes or ball attachments. Cumulative zygoma implant survival was 82% after a follow-up period of 4 years. Four factors for failure were identified and included: overloading leverage in extensive maxillectomies, overgrowth of local soft tissue preventing abutment connection, recurrent infection and tumour recurrence.
Another factor described as crucial for the prognosis of the zygoma implant is soft tissue management. Thick soft tissue overlapping the implant head can create problems when it comes to the prosthetic phase of rehabilitation. The situation is worse if the implants extend through soft tissue flaps after palatal reconstruction, creating deep peri-implant pockets which are predisposed sites for infections. In the presented patient, no signs of inflammation were visible during the follow-up period. In event of implant failure the double-crown retained obturator will have enough support and retention to function until a new implant can be placed. In the worst case scenario of a second implantation not being possible, the patient could function with the prosthesis without any implant at all. An extension of the major connector onto the remaining hard palate might then be considered to increase support.

There is agreement that the placement of a zygoma implant is more complex and difficult than conventional oral implant placement. Not only the dimensions of the implants, but also the anatomical intricacies of the curved zygomatic bone, such as the orbital floor and the limited intraoperative visibility make this type of surgery a demanding procedure. The surgical procedure can be simplified and facilitated by making use of computer-assisted planning and surgery. A computer-based transfer of preplanned positioning can be achieved by using drilling guides. However when applying this technique the precision depends largely on the ability to position the drill guide accurately on the underlying tissue. In contrast to the approach with drilling-templates, a computer-aided surgical navigation approach offers constant intraoperative visualization of the tip of the drilling bur. This enables the surgeon to precisely guide the drill to control the implant axis and ensure optimum bone utilization. A cadaver study revealed an accuracy of 1.3 mm (±0.8mm) of the implant
position compared to the planned position.\textsuperscript{47} This result is better than the accuracy reportedly achieved by using drilling templates.\textsuperscript{46}

**SUMMARY**

The presented situation demonstrates the interdisciplinary treatment of a patient with a maxillary defect using conventional prosthetics as well as computer-supported implant surgery. Although there is scarce data on the long-term performance of zygoma implants, the literature provides evidence that zygoma implants can reliably anchor maxillary prostheses. This treatment option provides additional support and retention to a conventional obturator and renders such a procedure beneficial to the patient.
REFERENCES


LEGENDS

Fig. 1. Preoperative situation.

Fig. 2. Preoperative situation.
Fig. 3. CT reconstruction showing extent of resection.

Fig. 4. Intraoperative navigation program. The drilling direction is made visible in the CT in three different planes (upper left figure: frontal plane, lower left figure: coronal plane, upper right figure: sagittal plane) and a three-dimensional reconstruction (lower right figure) by using a special pointing device (green). This enables adjustment to the preoperatively simulated zygoma position (red). The red marker represents the radiopaque marker of acrylic resin template and indicates the ideal position of implant head.
Fig. 5. Postoperative CT-scan with acrylic resin template in position. Implant head is ideally situated above the marker (yellow) of template. Position and angulation of implant in zygoma bone provide sufficient anchorage.

Fig. 6. Primary crowns on definitive cast.

Fig. 7. Completed prosthesis.
Fig. 8. Inner telescopic crown copings after cementation

Fig. 9. Completed prosthesis in place.
Fig. 10. OPT after insertion of the primary crowns

Fig. 11. Facial harmony with definitive prosthesis