Maxillary reconstruction using zygomatic implants: a report of two cases


Introduction
Restoration of the atrophic maxilla or a maxillary defect following tumour resection presents a challenge to the surgeon and prosthodontist. The atrophic maxilla has an inadequate denture-bearing area and also a reduced bone volume, which may contraindicate the placement of endosseous implants. The International Research Group on Reconstructive Preprosthetic Surgery reported that bone loss in edentulous jaws is related to a number of factors, including adverse loading by a prosthesis, inflammation of the overlying mucosa, vascular changes and surgery that requires elevation of a mucoperiosteal flap. Maxillary atrophy occurs in both a vertical and anteroposterior dimension, with vertical resorption increasing the inter-arch distance, resulting in functional and aesthetic problems. Anteroposterior resorption alters the maxillomandibular relationship, often creating a pseudoprognathism. The atrophied edentulous maxilla also leads to collapse of mid-face soft tissues, impaired mastication and unbalanced diet, speech difficulties, and circum-oral hypotonia. Various surgical techniques, with or without bone grafting, have been advocated for reconstruction of the atrophic maxilla. The widespread use of endosseous implants has seen an increase in bone augmentation procedures prior to implant placement. Autogenous bone grafting is accepted as the gold standard in reconstruction. The most commonly harvested free bone graft sites include the iliac crest, tibia, rib and cranium. Intra-oral sites include the mental symphysis, mandibular ramus and tuberosity. The iliac crest is the recommended donor site in maxillary reconstruction, providing an adequate volume of corticocancellous bone for both sinus elevation procedures and onlay block grafts.

The placement of standard endosseous implants ideally requires bone volume in the maxillary alveolar crest of at least 10mm in height and 5mm in width. Multiple grafting procedures have been described for maxillary reconstruction, including onlay or alveolar split grafting, Le Fort I osteotomy with interpositional grafting, and sinus or nasal floor grafting. The most significant disadvantage related to iliac crest autogenous bone grafting is the second surgical site and donor site morbidity. Donor site sensory nerve deficit and scarring, gait disturbance and post-operative infection are some potential complications. Furthermore, maxillary
autogenous bone grafting usually requires a healing time of four months prior to implant placement, followed by a four- to six-month period of implant integration, resulting in a period of approximately 12 months from initial surgery to delivery of the prosthesis. During this time, the patient’s ability to use an existing removable prosthesis may be restricted. Iliac crest ‘horseshoe’ onlay grafts secured at the time of implant placement in a one-stage procedure have been used. However, Bell et al.15 highlighted the advantages of delaying implant placement, including more precise positioning of the implants. A number of other studies6,17,18 have reported improved results following a two-stage procedure. These potential complications and the delay from grafting to final restoration encouraged the development of non-grafting alternatives for prosthetic restoration of the atrophic maxilla. These include distraction osteogenesis,19,20 tilted implants,21,22 short implants,23 and zygomatic implants. First described by Branemark in 1988,24 the zygomatic implant was developed as an alternative to grafting procedures in the severely atrophic maxilla. Early reports described their use in conjunction with two to four standard implants in the anterior maxilla.25,26 This allows cross-arch stabilisation, provided that adequate anterior maxillary bone is present. Zygomatic implants are also used in the treatment of maxillary defects secondary to trauma, tumour resection, or congenital defects.27,28,29

There are a number of potential advantages of zygomatic implants when compared to bone graft augmentation with endosseous implant placement. Donor site morbidity is eliminated. The total treatment time is approximately six months shorter for zygomatic implants when compared to grafting with subsequent implant placement. Traditional sinus grafting requires six months of graft consolidation prior to implant placement. Simultaneous grafting and implant placement is possible, but is limited to patients with sufficient bone for immediate implant stabilisation.30 Furthermore, Misch and Dietsh31 reported an implant survival rate of 90% with implants placed simultaneously with the graft compared with 99% with those placed during a second procedure. Lundgren et al.32 showed, in a histological analysis of bone graft-titanium interface, that integration of implants placed six months post grafting was superior to implants placed at the time of bone grafting. The placement of zygomatic implants permits a shorter period between implant placement and permanent restoration. Zygomatic implants allow the patient to wear his or her existing denture as a temporary removable prosthesis until the final restoration is fitted. Also, while a number of authors have reported the successful use of four implants (with distal angulation of the posterior implants, the so-called ‘all on four technique’)32 to retain a prosthesis in the edentulous maxilla, the original protocol as described by Branemark26 recommended the placement of four standard implants in the anterior maxilla in combination with bilateral zygomatic implants.

This paper describes the use of zygomatic implants to restore the maxillae of two patients. The first is a patient with a severely atrophic edentulous maxilla, and the second is a patient who underwent a subtotal maxillectomy in the treatment of a maxillary adenocarcinoma.

**Surgical protocol**

Under general anaesthesia, a standard crestal incision, with releasing incisions in the midline and posteriorly, is used to expose the maxilla. Sub-periosteal dissection, starting at the lateral maxillary wall and extended in a posterior-superior direction, is used to expose the junction of the temporal and frontal processes of the zygoma. A channel retractor is placed to engage the zygoma at this angle. Care is taken to expose and protect both the infra-orbital nerve and rim. The curved end of the channel retractor should be palpable extra-orally, lateral to the orbit. The channel retractor serves to expose the zygomatic arch and also as a stop for the drill during preparation of the implant recipient site. A window is created in the lateral sinus wall to allow direct visualisation of the drill shaft while drilling. This window also allows irrigation of the drill and increases the accuracy of drill orientation. The sinus membrane is elevated to avoid trapping the membrane between implant and bone.

The implant site is developed as follows: a round bur is used to penetrate the alveolus extending into the sinus. In the atrophic maxilla, the initial bur hole is placed in the second premolar area slightly palatal to the alveolar crest. The zygoma is entered through the posterior-superior roof of the maxillary sinus. A twist drill (diameter 2.9mm) is used to continue the osteotomy through the zygoma, penetrating the outer cortex at the fronto-temporal angle (where the curved channel retractor is resting). The site is further widened with a 3.5mm twist drill. If required, a pilot drill (diameter 4mm) is used to enlarge the fixture entrance into the alveolar bone. The zygomatic implant is a self-tapping titanium screw and is available in different lengths, ranging from 30 to 52.5mm, with an apical diameter of 4mm and a crestal diameter of 4.5mm. Angled abutments (45 or 55°) are used to compensate for the angulation between the maxilla and zygoma. If two implants are placed bilaterally, the implants should be maximally separated without compromising engagement in the zygoma. Following placement of the cover screws, the incision is closed in a standard fashion. The implants are allowed to osseointegrate for four to six months. The surface characteristics of dental implant systems are designed to maximise implant integration. Rough surfaces improve bone contact and early integration. However, exposure of rough surface implant threads leads to increased difficulty with plaque control when compared to machined surface implants.33,34

The implants used in the case reports discussed here were Nobelpharma Branemark® Zygoma TiUnite® Implants. The TiUnite surface is anodised, i.e., it has been manufactured by electrochemical anodic oxidation in galvanostatic mode, using undisclosed electrolytes. This leads to an increase in the surface area available for osseointegration.35 Machined surface zygomatic implants are also available; however, given the limited bone available for implant placement (particularly in Case 2), TiUnite implants were chosen to improve the implant osseointegration,36,37 being aware of the need for plaque control measures in the event of thread exposure.
Case reports

Case 1 - Restoration of an atrophic edentulous maxilla

A 57-year-old male presented with a significantly resorbed maxilla and inability to tolerate a maxillary denture. There was one remaining maxillary molar. The maxilla was opposed by lower anterior natural teeth (Figure 1). Previously, the patient had been treated by conventional maxillary dental implants, which had failed. The mandibular anterior teeth displaced the existing conventional maxillary denture. At consultation, the following radiographic investigations were carried out: panoramic radiograph and computed tomography (CT) scan. These assessed the available bone levels for implant placement and for the presence of sinus disease. The CT scan showed that there was inadequate bone to permit conventional implant placement without bone grafting. Following this, the patient intimated that he wished to avoid bone grafting and therefore elected to have zygomatic implants placed.

Due to the lack of soft tissue support anteriorly and to increase stability (as no endosseous implants would be placed anteriorly), a maxillary overdenture was chosen as the planned final prosthesis. Four zygomatic implants were placed, two on each side (Figure 2). After a two-week post-surgical period of healing, the maxillary denture was modified to fit over the four fixtures and the healing abutments. The palatal location of the fixtures (Figure 3) created a palatal ‘bump’ on the interim denture. After four months, fixture level impressions were made (Figure 4) and a tissue bar fabricated. The design of the bar (Figure 5) was an attempt to minimise the vertical profile and adapt to the existing ridge contour. The fit of the tissue bar was confirmed (Figure 6), and the final prosthesis was processed to incorporate the retentive clips (Figure 7). The denture acrylic was thinned to reduce encroachment on the tongue (Figure 8). Follow-up included dental hygiene support and home care techniques for the care of the tissue bar. Initially the palatal tissue was reactive but it gradually normalised. Clinical outcome has been successful (Figure 9) for the patient in terms of sense of confidence, security and improved function. The follow-up, since implant placement, is 18 months.
FIGURE 5: The design of the bar was an attempt to minimise the vertical profile and adapt to the existing ridge contour.

FIGURE 6: The fit of the tissue bar was confirmed.

FIGURE 7: The final prosthesis was processed to incorporate the retentive clips.

FIGURE 8: The denture acrylic was thinned to reduce encroachment on the tongue.

FIGURE 9: Clinical outcome for the patient has been successful.
Case 2 – Restoration of a defect following maxillectomy

A 68-year-old male with a previous history of maxillectomy was considered for zygomatic implant placement. Two remaining maxillary molars were present in the left maxilla. The mandibular anterior teeth were present (Figure 10). His past surgical history was complex. He underwent a subtotal maxillectomy for removal of a low-grade palatal adenocarcinoma eight years previously. The defect was initially reconstructed with a radial forearm free flap and subsequently with a fibular free flap. The reconstruction was not ideal and a large maxillary defect remained (Figure 11). Clinical examination revealed a loose maxillary obturator (Figure 12) occupying the maxillary defect. The only remnants of the maxilla were the tuberosities bilaterally. Retention for the existing obturator was gained from the remaining molars, the soft palate and the internal aspect of the nares. The lack of palatal support and the lever arm of the obturator created instability of the prosthesis, especially in function. The pre-operative assessment included a panoramic radiograph and CT scan to assess remaining available bone and to identify the position of previously placed plates and screws. A treatment approach of bilateral zygomatic implants was considered to create a source of vertical resistance and retention. The proposed prosthetic design was for a bar-retained obturator prosthesis.

At the time of surgery, three zygomatic implants were placed, two on the left and one on the right (Figure 13). One of the implants on the left failed and was subsequently removed prior to definitive prosthetic restoration. Because of the surgical defect resulting from the maxillectomy, the implant on the left side, although integrated, ‘exists in space’, and the exposed threads require close attention to plaque control. The implant on the right has a better emergence tissue cuff permitting easier maintenance of oral hygiene.

A fixture level impression was made and, based on the prosthetic setup, an angulated multi-unit abutment and a straight multi-unit abutment were selected to improve orientation and the level of the prosthetic bar. (Figure 14). The prosthesis was subsequently adapted to incorporate the retentive clip (Figure 15).
prosthetic bar (Figure 14). The bar was tried in for passivity. Subsequently, the prosthesis was adapted to incorporate the retentive clip (Figure 15). Clinical outcome demonstrates improved vertical support and retention for the obturator prosthesis (Figures 16 and 17). Utilisation of just two zygomatic fixtures is not ideal, and conventional obturator retentive points and support points from the remaining maxillary molars are essential in this case. The future longevity is not predictable in this case. Vigorous hygiene support and home care is also needed for the exposed implant. The follow-up for this patient, since implant placement, is 18 months.
Discussion

Prosthetic aspects of zygomatic implants

The clinical outcome of prosthetic restoration is determined by the available supporting tissue. If the supporting tissue is limited due to long-term tooth loss and associated resorption, anatomical anomalies, or a forceful opposing occlusion, the utilisation of dental implants provides significant advantage for prosthetic restoration in terms of support, retention and stability.

The proposed prosthetic restoration and the available bone determine the location of the dental implants. In the maxilla, there are advantageous positions for the placement of dental implants in terms of prosthetic outcome relating to force distribution, antero-posterior spread and location within the arch.

Conventional dental implant treatment is ideal in cases of optimal available bone, both in the anterior and posterior maxilla. As a guideline, good outcome in terms of longevity is expected when four to six implants are utilised in overdenture cases, and six to eight implants in cases of fixed restoration. The advent of the zygomatic implant has facilitated restoration in cases where the normal guidelines of available bone are not fulfilled.

Zygomatic implants have applications in both fixed and removable prosthetic rehabilitation. As with conventional implant treatment, numerous factors influence treatment planning decisions related to the role of fixed or removable prostheses as follows: the number and location of implants placed; the need for lip support; patient preference; and, ability to maintain adequate hygiene measures and mechanical demands related to the occlusion. The classic zygomatic protocol involves rigid splinting of the fixtures. Depending on the available zygomatic bone, one or two fixtures may be placed in the zygoma. The potential long lever arm of the zygomatic implant demands the rigid splinting.

Removable prostheses were provided in both cases reported. In Case 1, the absence of lip support, tooth position requirements, the absence of alveolar bone in the anterior maxilla and the opposing natural dentition dictated the choice of a removable prosthesis. In Case 2, the need for obturation of the extensive maxillary defect and requirement for access for adequate hygiene procedures also dictated the need for a removable prosthesis.

The prosthetic set-up is fabricated in terms of tooth position, lip support and occlusion. Using this set-up a radiographic template and surgical guide may be generated. However, in the cases reported here, a surgical guide was not utilised.

The palatal emergence location of the zygomatic fixture, seen in Case 1, has implications in terms of palatal contour of the prosthesis. The extent of maxillary alveolar resorption was in fact beneficial in providing adequate prosthetic space.

The prosthetic components for impression making and restoration are specific to the zygomatic implant and are not interchangeable with conventional components. This difference is related to the angulation of the neck of the zygomatic fixture, which demands a shorter abutment screw for full engagement. A conventional impression coping screw or a conventional abutment screw will “bottom out” prior to full engagement. Access for connection of components may be more difficult in light of the disto-palatal orientation of the zygomatic fixture.

Surgical aspects

Numerous techniques, involving differing surgical procedures, graft materials and endosseous implant systems, have been described for reconstruction of patients with an edentulous severely atrophic maxilla, and also patients who have undergone maxillary resection for neoplastic disease. Various restorative techniques, including microvascular free flaps, local flaps, and prosthetic obturators have been advocated.

However, significant obturator retention and stability problems occur when extensive defects remain following a maxillectomy. Schmidt et al. reviewed the clinical outcome of patients reconstructed with zygomatic implants after maxillary tumour ablation. This article describes the use of zygomatic implants to restore both the atrophic maxilla and the maxilla post tumour ablation.

The first patient had a Class V (<10mm in vertical height and 4mm in the horizontal dimension) maxillary alveolar crest. The reported success rate of zygomatic implants placed in atrophic edentulous maxillae is 90-100%. Kahnberg et al., in a three-year review of 145 zygomatic implants, reported a 96.3% success rate. Branemark et al., in a long-term follow-up of 52 zygomatic implants placed in 28 consecutive patients, reported a 94% success rate. Penarrocha et al., in a review of 40 zygomatic implants placed in 21 patients, reported no failures after a mean follow-up of 29 months. A number of authors have reported on the placement of zygomatic implants in smokers, with no increase in failure rates. Zygomatic implants may be loaded immediately or six months following placement. Chow et al. reported no failures in the preliminary results of 30 zygomatic implants immediately loaded. Duarte et al. placed 48 zygomatic implants in 12 patients. All were immediately loaded with a prosthesis supported solely by the zygomatic implants. At 30 months, two of the 48 zygomatic implants had failed.

The second patient in this report had two zygomatic implants placed on the left side and one on the right. One implant placed on the left failed and was removed; the remaining implants are functioning successfully at present.

Reconstruction following a maxillectomy is challenging, as engagement of the alveolar bone and the use of standard implants anteriorly is not possible. The volume and quality of the remaining bone available for osseointegration is compromised. Also, the lever arm placed on zygomatic implants is significantly greater than the lever arm placed on standard endosseous implants. This places the zygomatic implants at a significant biomechanical disadvantage. Schmidt recommends the placement of two zygomatic implants bilaterally, not only to allow for distribution of occlusal and retentive forces, but also to retain the ability to use one implant should another...
fail. If two zygomatic implants are placed bilaterally, the implants should be maximally separated without compromising engagement of the zygoma. Landes\cite{60} reported a significant quality of life improvement, comparable to maxillary reconstruction with autogenous bone, in patients restored with zygomatic implants following maxillectomy.

Although zygomatic implants have a number of advantages when compared to other grafting or non-grafting restorative techniques, the procedure is demanding and, in the authors' opinion, requires a surgeon experienced in maxillofacial procedures. The risk for orbital injuries demands particular attention. The reported complications include post-operative sinusitis, oro-antral fistula formation, peri-oral haematoma, orbital injury, lip lacerations, epistaxis, and temporary sensory nerve deficits.\textsuperscript{22,26,29,51} The reported incidence of sinusitis is 2.3-13.6%.\textsuperscript{22,30,61,62} However, Petruson\textsuperscript{63} studied the surgery. Also, it retains the ability to wear an existing denture immediately after maxillectomy. Zygomatic implants allow patients to avoid bone grafting and non-grafting procedures to predictably and safely restore improvement, comparable to maxillary reconstruction with autogenous bone grafts and immediate endosseous implants.\textsuperscript{14: 571-578} Concerns related to speech and hygiene problems caused by the palatal emergence of the zygomatic implant have been raised. However, a number of reports show minimal long-term speech problems associated with the prosthesis.\textsuperscript{26,60} Also, modification of implant head angulation design and new placement techniques\textsuperscript{66} have been suggested to further decrease this potential problem. While not utilised in the pre-operative planning of the two cases highlighted here, pre-operative CT planning may be used, with or without radiographic stents, to plan placement of zygomatic implants. Three-dimensional images and planning software programmes are used to plan implant placement and restoration, create surgical stents, and subsequently fabricate provisional or final restorations before implant placement surgery.\textsuperscript{67,68} Prefabricated surgical guides rigidly fixed at the time of surgery offer the ability to transfer the software planning to the surgical field to assist in ideal implant location; however, due to the absence of suitable alveolar fixation sites, the use of surgical stents in the cases presented here would provide no significant advantage.

Conclusion

Zygomatic implants may be used as an alternative to traditional grafting and non-grafting procedures to predictably and safely restore the severely atrophied maxilla. In addition, they also offer a reliable method to retain and support a maxillary obturator following maxillectomy. Zygomatic implants allow patients to avoid bone grafting procedures and associated donor site morbidity. The patient also retains the ability to wear an existing denture immediately after surgery.

References


