

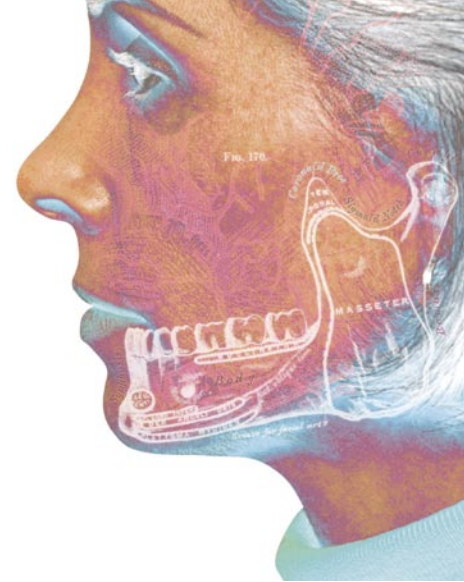
# Use of Osseointegrated Implants in the Restoration of Head and Neck Defects

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## ABSTRACT

Osseointegrated implants can be applied to facilitate retention, stability, and support for facial and intraoral prostheses used to restore head and neck defects.

At the University of California, Los Angeles, Maxillofacial Prosthetics Clinic, retrospective studies have indicated that in nonirradiated maxillectomy patients, implant survival rates are 82.6 percent. In mandibles reconstructed with fibula free flaps, survival rates are 94.6 percent. Similarly, high implant survival rates have been observed for most sites used to support facial prostheses. Cumulative six-year survival rates for auricular sites exceed 95 percent and for floor of nose sites, success rates exceed 87 percent. However, survival rates are low (53 percent) for implants placed in the frontal bone for retention of orbital prostheses and even lower for irradiated bone sites ranging from 63 percent in the maxilla to 27 percent in the orbit.



**S**urgical resection of head and neck tumors often create large defects accompanied by dysfunction and disfigurement, and radiation therapy produces significant morbidity and unique tissue management problems. Speech, swallowing, control of saliva, and mastication can be adversely affected. Prosthetic restorations may be necessary in the rehabilitation of these defects. However, appropriate retention, stability, and support must be provided for the prosthesis if successful results are to be achieved. Osseointegrated implants have been shown to be useful in the restoration of these patients. The purpose of this paper is to review the experience gained at University of California, Los Angeles, and compare these experiences with others.



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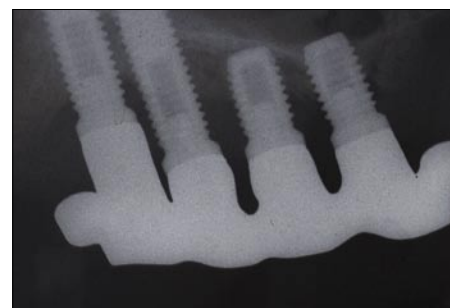
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**Figure 1.** Total maxillectomy defect in edentulous patient with implants placed in the remaining premaxilla.



**Figure 2.** Tissue surface of a maxillary obturator.



**Figure 3.** Implants demonstrating excessive bone loss.

### Maxillary Defects

Maxillectomy defects produce a variety of functional problems and cosmetic deformities. The loss of dental structures and/or denture-bearing tissue surfaces may make mastication difficult, particularly for edentulous patients. Swallowing is awkward since food and liquids may be forced up into the nasal cavity and out the nose. Hypernasality affects speech intelligibility, and facial disfigurement can result from lack of midface bony support. In some cases, tumor invasion superiorly requires exenteration of the orbital contents.

Maxillary obturators provide an effective means of rehabilitation of maxillary defect patients.<sup>1,2</sup> Although surgical reconstruction is an option, it is rather complex with a less predictable outcome.<sup>3</sup> Compromised retention, stability, and support are the main problems encountered when designing and fabricating an effective obturator prosthesis. The difficulty is dramatically accentuated when the residual maxillary segment is edentulous. Remaining teeth or properly positioned osseointegrated implants, or a combination of these two, therefore become important assets if a desirable outcome is to be achieved. In edentulous patients, implants provide retention, enhance support, and improve the stability of

the obturator prosthesis. Mastication is significantly improved, and speech and swallowing are made more efficient. However, the maxillectomy defect must be properly designed and prepared during tumor ablation so that the forces generated during oral function can be shared between the implants, the tissues of the defect, and residual denture bearing surfaces. Implants alone are not capable of providing total support for the obturator and excessive nonaxial loads result in severe bone loss.

The most desirable site for implants for most edentulous maxillectomy patients is the residual premaxillary segment<sup>4,5</sup> (Figure 1). This site is preferred because the anterior maxillary segment is diagonally opposite the most retentive portion of the defect, the skin-lined posterior lateral wall. In addition, satisfactory volume and density of bone can be found in the residual premaxilla in most patients. The maxillary tuberosity, posterior alveolar ridge, and the zygoma are considered secondary sites. In the maxillary tuberosity, the trabecular bone is not very dense, initial implant anchorage is difficult to achieve, and the bone-implant interface formed may not ensure a predictable long-term result. The edentulous posterior alveolar process may serve as an alternative site if there is at least 10 mm of bone available

between the crest of the alveolus and the maxillary sinus. In nonirradiated patients, if insufficient bone is present, the site may be augmented by elevating the sinus membrane and grafting the sinus with bone. This technique has become a popular option when treating conventional patients, but its predictability in maxillary defect patients has yet to be determined. Residual elements of the zygoma within the maxillectomy defect have also been used as implant sites. However, there are important disadvantages to be considered. First, the implants will be located high in the defect making oral hygiene very difficult for the patient. Second, because of angulation problems, the implants can only be used to facilitate retention. In defects lined with a skin graft with good posterior lateral wall undercuts, implants placed in the zygoma make only a limited contribution to retention on the defect side of the prosthesis. Zygomatic implants (Nobel Biocare USA, Yorba Linda, CA) placed into the unresected side of the maxilla have also been attempted in this group of patients, with some reported success.<sup>6</sup>

The authors' experience indicates that implants can be used successfully in total or partial maxillectomy patients in order to help retain obturator prostheses<sup>5</sup> (Figure 2). Initial results, however,

were disappointing. Implant failures can be grouped into two categories: 1) early, when implants are removed because they fail to achieve a state of osseointegration, and 2) late, when implants fail after being subjected to clinical function for a year or more. In the anterior maxilla most failures occurred “late” or after loading, secondary to progressive bone loss (Figure 3). In contrast, in the maxillary tuberosity where the bone quality is generally poorer, virtually all of the implant failures were “early” or prior to functional loading. In the tuberosities, once osseointegration was achieved and the implants were placed into function, bone levels did not appear to deteriorate over time.

In recent years, it has become increasingly clear that implant overload precipitates a resorptive remodeling response of bone around the implants.<sup>7</sup> Brunski has proposed the following mechanisms.<sup>8</sup> Application of excessive occlusal loads result in microdamage of the surrounding bone (fractures, cracks, delaminations). This microdamage elicits a response from osteocytes imbedded within bone precipitating a resorption remodeling response resulting in increased porosity of bone adjacent to the implant.<sup>9</sup> This vicious cycle proceeds — continued loading, causing more microdamage and more porosity — until implant failure.

In maxillectomy patients, the authors were frequently unable to place sufficient numbers of implants of sufficient length, with adequate anterior posterior spread to withstand the forces generated by large obturator prostheses. In retrospect, the early tissue bar designs were “implant-supported” i.e., most, if not all, of the forces generated during function were borne by the implants, particularly the implants adjacent to the defect. Designs used in association with implants placed in the maxillary

tuberosity tended to be implant assisted, i.e., forces generated during function were shared between the implants, the residual denture bearing surfaces and the maxillectomy defect. When the tissue bars were replaced with implant-assisted designs specifically tailored for maxillectomy defects based on a series of photoelastic analysis studies conducted in the lab, late implant failures were dramatically reduced.<sup>4</sup>

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### **Mandibular Defects**

Disabilities associated with tongue-mandible defects include impaired speech articulation, difficulty swallowing, deviation of the mandible during functional movements, malocclusion, poor control of salivary secretions and severe cosmetic disfigurement. In the past, these patients presented a far more difficult rehabilitation problem than did patients with maxillary surgical defects, particularly if significant portions of the tongue were involved in the resection. A number of factors affect the patient's functional status after resection.<sup>10</sup>

■ The impairment of motor and/or sensory control, in particular the integrated neuromuscular balance between the tongue, lips, and cheeks, limits the ability of the patient to control saliva, the food bolus, and dentures during function.

■ Loss of tongue bulk and immobility of the residual tongue element caused by surgical closure further inhibit the patient's ability to intelligibly articulate speech sounds, swallow, and manipulate saliva, the food bolus, and dentures.

■ Deviation of the mandible and the angular pathway of mandibular closure induces lateral forces upon removable prostheses that tend to dislodge them.

■ The deviation of the mandible at closure creates abnormal maxillomandibular relationships that may prevent proper occlusion of the residual dentition or ideal placement of the denture teeth over their supporting structures.

■ Frontal plane rotation and unilateral forces of occlusion tend to tip and dislodge both maxillary and mandibular dentures during function.

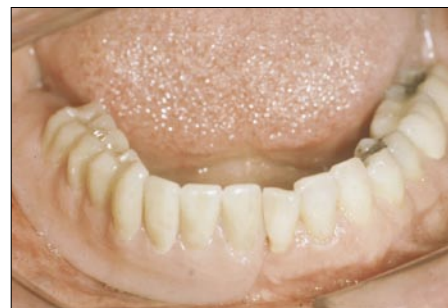
Two developments have reduced the severity of the disabilities associated with composite resection of tongue, floor of mouth, mandible and tonsillar neoplasms — microvascular free flaps and osseointegrated implants.<sup>11-16</sup> In the 1980s, pedicled myocutaneous flaps were used to replace the resected soft tissues and these flaps eliminated the need to approximate the tongue margin to the cheek margin for primary closure of the defect. The residual or reconstructed tongue had improved mobility and was better situated to control the air stream during articulation and manipulate the bolus during mastication. Free flaps (iliac crest, fibula, radial forearm, scapula, lateral thigh, etc.), introduced in the early 1990s improved the patient's post-resection function even more dramatically.<sup>13-16</sup> These flaps are particularly useful in replacing the bulk of the anterior two-thirds of the tongue because they demonstrate improved flexibility, resulting in less inhibition of tongue mobility. If the patient has dentition



**Figure 4.** Hypertrophic tissue around implant bar which emerges through skin in a fibula reconstructed mandible.



**Figure 5a.** Lateral mandibular defect with implants and milled tissue bar.



**Figure 5b.** Removable implant overdenture was used to restore lost dentition and alveolar ridge contour.

remaining in the unresected portion of the mandible or implants to retain a prosthesis, these patients may be able to masticate at a reasonable level dependent upon the amount of remaining tongue and innervation.<sup>17,18</sup>

The bone associated with free flaps, particularly the fibula, present with prominent cortical plates, which when properly engaged, provide excellent stabilization for the implants. The reported success rates of implants in fibula flaps are generally more than 95 percent.<sup>19-21</sup> Two major challenges are encountered when placing implants into these patients. The first is for the surgeon to properly position the implants. This is best accomplished with the use of a surgical template. Placement of implants at the time of tumor ablation is not recommended.<sup>22</sup> The second is to create thin, attached, keratinized peri-implant tissues around the implant. Bulky soft tissues overlying the bone of free flaps must be carefully thinned and attached to periosteum. Ideally, the thickness of the tissues adjacent to the implants should not exceed 4 mm. If the tissues are not thinned sufficiently, deep peri-implant pockets will result that predispose to infection. Peri-implant soft tissue hypertrophy is a common problem when implants emerge through skin in the oral cavity (**Figure 4**). This may

be the skin's reaction to environmental changes. The oral cavity presents a moist, warm environment with a variety of new microbial challenges. Use of highly polished metal bars or porcelain restorations, strict hygiene maintenance and daily use of chlorhexidine oral rinse appear to ameliorate the problems with hypertrophy. In severe cases, palatal mucosal grafts may be necessary.

The question is whether the placement of implants into bone grafts or flaps used to restore mandible defects of dentate or edentulous patients improves masticatory performance, the data is limited.<sup>18,23</sup> Masticatory performance may theoretically be improved with implants in these patients when motor and sensory innervation of the tongue is retained. However, the lingual nerve and hypoglossal nerves are frequently sacrificed during composite resection, particularly of lateral tongue and/or lateral floor of mouth tumors. These neurologic deficits prevent patients from detecting or manipulating the bolus on the defect side regardless of how effectively the bone, dentition, and soft tissue defects have been restored. So-called "sensate flaps" have not proven to be beneficial because the nature of the sensory feedback is not sufficient for the patient to detect, manipulate, or control the food bolus.

The objective of the prosthesis extension into the side of the defect is for lip support, esthetics, prevention of eruption of opposing dentition and speech. These objectives can be met with a conventional removable partial denture, providing the residual dentition on the nonresected side is in reasonable condition. If motor and sensory innervation on the reconstructed side is intact, the use of implants is justified and may enable efficient mastication on the reconstructed side.<sup>23</sup>

Removable overlay prostheses with tissue bars are preferred for restoring these defects (**Figures 5a and b**). Support for mastication is provided by the implants and by the denture bearing surfaces or dentition available posteriorly. Denture flanges can be contoured to correctly position and support the lower lip. In addition, access for oral hygiene is made easier for the patient.

Free bone grafts, such as iliac crest, are still used for mandibular reconstruction in patients with nonmalignant tumors or patients who are unlikely to undergo postoperative radiation therapy. Implants are placed into the bone six to nine months later to allow consolidation of the graft. Free bone grafts demonstrate a homogeneous calcification pattern, which also results in an excellent bone implant interface.



**Figure 6.** Craniofacial implants with flange design.



**Figure 7a.** Nasal implants with tissue bar designed for hygiene access. Vertical and horizontal Hader clips securely retain nasal prosthesis.



**Figure 7b.** Eyeglass frames effectively hide margins of nasal prosthesis.

Implants placed in free bone grafts used to reconstruct this region have a high success rate.<sup>24</sup>

### Facial Defects

Restoration of facial defects is a difficult challenge for both surgeons and prosthodontists. In the past, prosthodontic restorations had distinct limitations due to movable tissue beds, lack of retention of large prostheses, and the patient's acceptance of the prosthesis. The use of osseointegrated implants has eliminated some of these problems.<sup>25-27</sup> The retention provided by the implants makes it possible to use large prostheses resting on movable tissues. Patient acceptance is significantly enhanced because of the quality of the retention, and this enables the prosthodontist to fabricate thin margins in silicone which blend more effectively with peripheral tissues.<sup>28</sup>

Craniofacial implant fixtures were specifically designed to retain facial prostheses. They are available in 3 mm to 5 mm lengths, with or without a flange (**Figure 6**). The short lengths allow placement in areas with limited available bone. The flange, when present, facilitates initial stabilization of the implant and prevents accidental penetration into interior compartments of the cranium. In some locations (nasal floor, supraorbital rim, glabella) these

implants may be used in combination with longer dental-type implants consistent with CT scan data of the amount of available bone. The position and angulation of the implants must be compatible with the proposed facial prosthesis. In most patients it is desirable to sculpt a wax replica of the prosthesis, and to use this replica to fabricate a surgical template. This template is sterilized and used at surgery as a guide to ensure the proper positioning and angulation of implants.

Once the facial prosthesis has been designed, the number and arrangement of the implants necessary to retain and stabilize the prosthesis are determined and the possible bone sites evaluated. In routine surgical defects sophisticated radiographic studies usually are not necessary. In extensive acquired defects or in some congenital defects, a CT scan and 3-D model of the cranium are valuable aids in evaluating potential implant sites and key adjacent structures.<sup>29</sup>

The skin and soft tissues overlying the proposed implant sites require careful evaluation. The health of the soft tissues surrounding osseointegrated implants is easier to maintain if these tissues are thin (less than 4 mm in thickness) and attached to the underlying periosteum. If the skin and soft tissues overlying the implant sites contain

hair follicles or tissue remnants of past reconstructive procedures, these tissues should be considered for removal and replaced with a skin graft.

Success rates of osseointegrated implants used to restore craniofacial defects have been quite good, particularly for auricular sites. Success for the auricular sites have exceeded 95 percent in most studies and few complications have been encountered.<sup>25,30,31</sup> Minimizing the thickness of the peri-implant tissues will keep soft tissue complications to a minimum. Success rates for floor of nose sites are about the same as implants placed in the premaxillary segment. The authors' series indicates an 87 percent cumulative six-year survival rate.<sup>31</sup> All patients in the authors' series had undergone total or partial rhinectomy secondary to resection of malignant neoplasms. There have been few soft tissue complications associated with implants placed in the floor of nose site regardless of whether they penetrate mucosa or skin. However, the implants should not exit the mobile tissue of the lip and/or nasal labial-fold region. Design of the retention bar should allow sufficient space for hygiene maintenance (**Figures 7a and b**). Implants placed too far posteriorly into the nasal passage will compromise hygiene access and also lead to soft tissue problems.

The survival rates of implants placed in the frontal bone and around the orbit have been disappointing (Figures 8a and b). The authors' failure rates are three to four times greater than that seen with the auricular or floor of nose sites. The survival rate in nonirradiated orbital defects was 55 percent. The survival rates are particularly diminished if the implant sites have previously been irradiated. In the authors' series, the survival rate for implants placed in the irradiated frontal bone was 27 percent. The dosages delivered to the implant sites ranged from 45 to 60 Gy. Of particular interest is the fact that many of the remaining implants demonstrated signs of impending implant failure such as flange exposure, soft tissues reactions, and obvious bone loss.

There appears to be a direct correlation between the level of hygiene compliance and soft tissue reactions at all sites. In the authors' experience, the orbital implants are the most difficult for the patients to clean and have the highest rates of peri-implant tissue reactions. The floor of nose implants are the easiest to clean and have the lowest rate of soft tissue reactions. For all sites, when hygiene improved the inflammatory soft tissue, reactions subsided or were eliminated.<sup>32-34</sup>

### Implants in Irradiated Tissues

Irradiation of head and neck tumors predispose to vascular changes in bone, skin, and mucosa, which affect the predictability of osseointegrated implants. Long-term function of osseointegrated implants is dependent on the presence of viable bone that is capable of remodeling as the implant is subjected to stresses associated with supporting, retaining, and stabilizing prosthetic restorations. The viability of irradiated bone may not be sufficient to ensure a



**Figure 8a.** Craniofacial implants in irradiated frontal bone demonstrating bone loss, flange exposure, and soft tissue inflammation.



**Figure 8b.** Loss of integration of irradiated orbital implants.

predictable result, particularly in anatomical sites such as the supraorbital rim and the body of the mandible. Even in the maxilla remodeling and turnover of bone subjected to high-dose radiotherapy (above 50 Gy) may be adversely affected to the point where an implant subject to functional stresses cannot be sustained.

Reported results indicate that the success rates of osseointegrated implants in irradiated bone appear to be dependent upon the anatomical site selected, the dose to the site, and the use of hyperbaric oxygen. Animal experiments have shown that the quantity of the bone at the bone-implant interface (bone implant appositional index) is reduced in irradiated bone.<sup>35</sup> Other investigators have shown that the quality of bone in the implant appositional zone is compromised, particularly at high-radiation dose levels.<sup>36</sup> These studies reveal a steady decrease in cellular activity in bone, especially when the equivalent dosage exceeds 58 Gy.

Clinical reports appear to substantiate the concerns raised in the animal studies; namely, a high percentage of implants in irradiated tissues demonstrated advanced bone loss upon loading and appear to have significantly lower success rates than implants in nonirradiated tissues.<sup>5,31,37-40</sup> Because

of these results, some clinicians have attempted to improve the viability of bone with hyperbaric oxygen, HBO, treatments prior to implant placement. Granstron et al. treated 13 patients with hyperbaric oxygen who had previously been irradiated.<sup>41</sup> Each patient received 20 HBO treatments, implant surgery was performed, followed by 10 more HBO treatments. The follow-up period was short but only one implant fixture has been lost (2.0 percent of the total).

In summary, it is clear from the current data that osseointegration is impaired in bone that has received doses in excess of 50 Gy. Success rates, based on retrospective clinical reports, are reduced as compared to nonirradiated sites, particularly the orbit.<sup>31,40</sup> The success rates are lower even in the maxilla with its excellent blood supply. In addition, preliminary animal studies referred to previously appear to indicate that the bone — implant interface may be significantly compromised making the implant less able to tolerate functional loads. Hyperbaric oxygen appears to help revitalize the bone, leading to improved success rates, but long-term clinical follow-up data are still lacking. In addition, its high cost precludes its use in most patients.

**Table 1**

## Implants in the Irradiated Mandible

### Doses 55 Gy and below

- Implants can be inserted with little or no risk of osteoradionecrosis.
- Success rates will be approximately 10-15 percent lower than normal.

### Doses between 55 and 65 Gy

- Individual patient factors such as fractionation, tissue response, clinical findings, dental and medical history etc. impact the decision.
- Hyperbaric oxygen before implant placement should be considered.

### Doses above 6500 cGy

- The risk of osteoradionecrosis becomes significant.

## Risk of Osteoradionecrosis Secondary to Implants

The risk of osteoradionecrosis in the mandible is probably best determined by an analysis of the bone necrosis rate seen secondary to postradiation extractions.<sup>42</sup> Based on these data it should be relatively safe to place implants in irradiated mandibular sites if the dose is less than 55 Gy (Table 1). In patients with doses to bone sites between 55 to 65 Gy, individual patient factors such as the dose per fraction, a previous radical neck dissection, the quality of the overlying soft tissues and the presence of telangiectasia, are some of the important cofactors to consider when assessing the risk. In such patients, if implants are essential, the authors recommend a course of hyperbaric oxygen.<sup>39,41</sup> The risk could be quite high for doses above 65 Gy. In these patients, implants are not recommended, even in conjunction with HBO. It should be noted that when most oral cavity tumors are treated, most patients do not receive radiation to the symphyseal region. Therefore, implants can be placed with a high degree of predictability in these patients. In the maxilla, the risk of bone necrosis is probably negligible. The use of hyperbaric oxygen can be justified

only on the basis of improving implant success rates.

## Irradiation of Existing Implants

Irradiation of titanium implants already in place results in backscatter and, therefore, the tissues on the radiation source side of the implants receive a higher dose than the other tissues in the field. The dose is increased about 10-15 percent within 1 mm of the surface of the implant.<sup>43,44</sup> Because of backscatter and the increased numbers of elderly patients receiving implants, clinicians often ask if osseointegrated implants should be removed in patients about to be irradiated for head and neck tumors. In a report by Granstrom, 11 patients with 32 existing titanium implants were irradiated. Dosages ranged from 50 to 80 Gy delivered four to 60 months after the implants were placed. Based on their findings, the authors recommended that all abutments and superstructures be removed prior to radiation and skin and/or mucosa should be closed over the implant fixtures.<sup>39</sup> When healing is complete, radiation therapy can begin. Following the completion of radiation, abutments and the superstructure are reattached and the prosthesis is remade or readapted.

## Conclusions

The application of osseointegrated implants in this patient population significantly improves the retention and function of the various prostheses and hence the quality of life of the patient. Implants, however, are not uniformly successful. Implant failures appear to be site specific and radiation dependent. ■■■■

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