

## **Chapter 80: Maxillofacial Prosthetic Rehabilitation of Acquired Defects**

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*"It is the God given right of every human being to appear human".*

Since the sixteenth century acquired surgical defects have been restored by prosthetic replacements constructed from a variety of materials and techniques (Chalian et al, 1972). The cosmetic and functional disabilities following radical surgery for oral and paraoral cancer are significant and disabling. Definitive reconstruction should be performed wherever possible as part of the ablative procedure. Specific techniques and indications include, among many modalities, an increase in regional myocutaneous flaps (Beumer et al, 1978). When definitive reconstruction is coordinated and combined with maxillofacial prosthetic rehabilitation, head and neck defects can be restored to near-normal function and appearance in many cases.

Maxillofacial prosthetic therapy for acquired defects has become more complex and sophisticated with advances in surgical, physical, and rehabilitative medicine. Acquired defects of the orofacial structures must be analyzed as to the specific cause and the consequent objectives of rehabilitation (Adisman, 1990).

The traditional concept of a one-time prosthesis that supplies the patient's requirements through the course of life is no longer realistic or valid. If the prosthesis is fabricated in an acceptable fashion to meet the physiologic, anatomic, functional, and cosmetic requirements of the patient, there is no predictable method of calculating its longevity (Adisman, 1990).

Identification of the variable factors that influence the serviceability of prostheses for the treatment of jaw defects is important and useful information for the patient, the family of the patient, the rehabilitative team, and third-party payers. Jaw defects affect many vital functions (that is, respiration, mastication, deglutition, speech, and aesthetics). Ideally, any anatomic defect should be surgically reconstructed. However, when surgical reconstruction is contraindicated, prosthetic reconstruction must be employed to restore anatomy, function, and aesthetics (Adisman, 1990).

Conventional and traditional prostheses were designed to be inserted after fabrication as single-unit structures. Extensive anatomic defects and the patient's diminished neuromuscular adaptability may preclude acceptance of this type of design. Sectional and sequential prosthetic design offers an acceptable solution for the restoration of large, complex maxillofacial defects.

### **Evaluation and Treatment Planning**

A thorough dental examination, radiographs, and impressions are completed routinely. A good oral hygiene protocol is mandatory for dentulous patients. Preservation and restoration of such teeth may provide a much better fitting prosthesis.

Effective communication between the surgeon and the maxillofacial prosthodontist is essential for developing a realistic treatment plan or rehabilitation of patients undergoing palatal resection (Figs. 80-1 and 80-2). Preoperative consultations allow the prosthodontist to

make recommendations to the surgeon to achieve better prosthetic results (Ackerman, 1956). Good communication is particularly important in determining the extent of resection and in the initial design of the surgical prosthesis.

The major goal of cancer therapy is not only to eradicate the disease but also to restore patients to a reasonably normal quality of life. The team concept, in which the head and neck surgeon, speech pathologist, radiation oncologist, maxillofacial prosthodontist, and other members of the health profession function together in planning the rehabilitation and primary modes of therapy, ensures the patient's early and successful rehabilitation (Aramany et al, 1988).

Surgical resection of head and neck tumors affords the opportunity to examine resection margins for adequate excision, and if necessary, a wider resection can be performed at the time of the initial surgery. The treatment plan should focus on first eradicating the tumor with resection margins greater than the extent of the tumor. The extent of resection should be influenced by anatomic site as well as, consideration of the best possible functional and cosmetic repair.

The use of surgical obturators reduces both postsurgical morbidity and the length of the patient's hospitalization. The initial oral health of each patient affects the potential or postsurgical complications. The maxillofacial prosthodontist is responsible for evaluating the oral health of each patient. The appropriate dental treatment is then initiated as quickly as possible to prepare the patient for surgery. The extent of dental treatment provided before surgery or irradiation varies with the time available. At this stage, treatment is generally limited to providing oral prophylaxis and presurgical impressions (Fig. 80-3). Extractikon of nonsalvageable teeth is often performed in conjunction with the resection of the tumor while the patient is under general anesthesia. If time permits, carious teeth are restored with temporary or permanent restorations (Aramany et al, 1988).

In treatment planning, efforts are made to preserve as many teeth as possible, particularly on the contralateral arch. In some patients the anterior teeth may be saved on the side of the resection of the tumor (Figs. 80-4 and 80-5). Frequently the central and lateral incisors can be preserved, and occasionally the canine can be saved. This salvaging enables the prosthodontist to utilize cross-arch stabilization and indirect retention in the obturator design (Fig. 80-6), thereby improving obturator stability (DaBreo, 1990a).

The prognosis should be discussed with the patient and limited treatment objectives clearly defined with the patient giving informed consent. In addition, patients should be informed of the many variables that influence the course of treatment and treatment outcome. Care should be taken in preparing the patient for a realistic treatment result, emphasizing the limitations of prosthetic treatment in simulating the natural missing structures (Adisman, 1990). With proper patient preparation, orofacial prostheses may prove to be a significant and positive factor in the physiologic and psychologic rehabilitation for the patient with acquired defects (Bailey and Edward, 1975).

## **Diagnostic imaging**

Computed tomography (CT) is currently the best diagnostic modality for evaluating head and neck pathologic conditions and is particularly useful in distinguishing tumors from other diseases. By using both axial and coronal scans, the location and shape of a lesion can be ascertained, and its relation to important nerves, vessels, and muscles can be delineated. This is vital in planning tumor exposure and anticipating neuromuscular structures involved in the dissection (Greenburg et al, 1985).

Ultrasonography can broadly classify lesions as solid, cystic, angiomatous, or infiltrative. The enlargement of soft tissue, the inflammation and scleritis of false tumors, and the cellulitis of infections are differentiated from primary neoplasms. Ultrasonography cannot distinguish one solid tumor from another, and the detail is inferior to CT scanning near the bony walls because of sound reflection (Dallow and Coleman, 1979).

Magnetic resonance imaging (MRI) is considered a non-invasive modality and holds great potential in tumor discrimination. Advantages compared to CT include the lack of ionizing radiation exposure to the patient and the production of coronal or sagittal sections. However, time required to perform an examination is lengthy compared with time required for CT (Sassani and Osbakken, 1984).

## **Materials Used in Maxillofacial Reconstruction**

Materials used in maxillofacial prosthetics encompass a wide range of chemical structures. Physical properties range from hard, stiff alloys, ceramics, and polymers to soft, flexible polymers and elastomers, including formulations of latex and plastisols. Polymers and elastomers are the mainstay of modern maxillofacial prosthetic reconstruction. Poly(methyl)methacrylate, polydimethylsiloxane, and polyetherurethanes have been tested and used in meeting the demand for materials that will be biocompatible, durable, color stable, and easily manipulated. An ideal material has yet to be formulated. Improvements toward the ideal will result from molecular modifications of functional units of the polymers and elastomers (Lontz, 1990).

Desirable properties of a maxillofacial prosthetic material include biologic and mechanical compatibility, a light weight, flexibility, translucence, color stability, ease of fabrication, minimal conductivity, lack of irritation, ready availability, hygiene sterilizability, and cost-effectiveness. To attain or approach an ideal state, each specific property must be assessed with regard to alteration of other important properties. For example, a formulative change to provide improved flexibility may compromise biocompatibility and durability. To achieve the balance needed synthetic structural research should be directed toward defined property improvement to meet clinical performance standards presently lacking.

Acrylic polymers, particularly poly(methyl)methacrylate and copolymers of methyl methacrylate, are used extensively in the fabrication of intraoral prostheses. Clear-autopolymerizing or heat-polymerizing acrylic polymers are used for immediate surgical obturators; characterized autopolymerizing, heat-polymerizing or visible light-activated acrylic polymers are used to construct interim obturators; and characterized definitive obturators are made of heat or light polymerized acrylic polymers. Selective immediate facial prostheses can

also be constructed from any of these acrylic polymers. Soft, flexible autopolymerizing copolymers are used in chair-side refitting and relining procedures, when tissue changes take place during healing.

Some formulations of room temperature vulcanizing (RTV) silicone elastomers are difficult to color intrinsically, tend to have reduced tear strength, and trap air during mixing of colorant and catalyst. MDX 4-4210 (Dow Corning, Midland, Mich) has improved tear resistance and edge strength, but air entrapment and a prolonged curing time are drawbacks (Fig. 80-7). Curing time is extended well beyond 12 hours at room temperature. Curing time can be accelerated by curing in a dry heat oven in metal molds at 85° to 150°C. If stone molds are used, curing temperature within the dry heat oven must be kept below the hydration temperature of the stone used (Chalian et al, 1972).

Heat temperature vulcanizing (HTV) silicone elastomers exhibit higher tear strength, but require a mechanical milling machine to intrinsically incorporate colorants (Fig. 80-8). The HTV silicone elastomer may come in a two-part base-catalyst system or a one-part system. Both materials require milling and a dry heat oven for curing. HTV MDX 4-4514 and MDX 4-4515 are one-part systems that release a byproduct (benzoyl peroxide) during the curing cycle. Metal molds are preferable with the HTV elastomer because of the high viscosity and compression molding technique used in packing the material. High-density stone contained-in-metal molds may also be used with a compression molded technique. Adequate color stability, controlled intrinsic coloration, and satisfactory edge strength are a few of the clinically important qualities obtainable with the HTV silicone elastomer (Bell et al, 1985).

### **Coloration**

Realistic coloration of extraoral prostheses is an important feature for patient satisfaction and acceptability. An accurate color match is the final determinant in creating an acceptable prosthesis. Cosmetic realism involves the correct application of colorant formulations within the base material before polymerization (intrinsic) and after polymerization (extrinsic). Additionally, the finished prosthesis requires subtle characterization in order to approximate the texture of the adjacent tissue. The spectral values in natural skin (Fig. 80-9) must be matched by corresponding pigments to accommodate environmental changes, seasonal changes, and varying light conditions. The ultimate in realistic cosmetic matching depends on the combination of in-depth intrinsic and extrinsic colorations (Lontz, 1990).

#### ***Intrinsic coloration***

Intrinsic coloration is the first step in incorporating indepth coloration reflected internally by discrete pigment particles spectrally equivalent or approximating those of the physiologic colorant and color centers, namely arterial red, venous red-purple, carotenoid yellow, melanoid brown, and opaque dispersed cellular lipids. Intrinsic coloration involves incorporating precise proportions of pigments (Fig. 80-10) by mixing (RTV) or milling (HTV) into the base elastomer before to packing in the mold and curing in a dry heat oven.

### ***Extrinsic coloration***

In general, the extrinsic coloration uses a medical-grade adhesive combined with xylene and earth pigments, which are applied to the external surface of the prosthesis (Fig. 80-11). The prosthesis is then postcured in a dry heat oven to evaporate the xylene. Finishing the margins of the facial prosthesis by direct extrinsic application of the colorant has been performed by Ary Udagama at University of Texas MD Anderson Cancer Center (Chalian, 1989) with very realistic results.

### **Retention of maxillofacial prostheses**

Retention of facial prostheses has been primarily by way of medical adhesives (Fig. 80-12). An ideal adhesive should be one that provides firm functional retention under flexure or extension during speech, facial expressions, and moisture or perspiration contact. Adhesives for extraoral maxillofacial prostheses require a substantial amount of supportive ingredients properly formulated to provide lasting visco-elasticity with a high degree of retention. Numerous proprietary brand names of adhesives have been introduced over the years in maxillofacial prosthetics (Lontz, 1990).

Other methods of retention include discretionary engagement of anatomic tissue undercuts (Rouse and Chalian, 1985), thereby minimizing dependence on adhesives. The potential for tissue irritation exists with this technique, and therefore it must be used prudently (Figs. 80-13 and 80-14). Areas that have been irradiated contraindicate the use of this technique (DaBreo and Ghalichebaf, 1990).

Finally, with the increased use of osseointegrated implants, dependence on adhesive and anatomic methods of retention has diminished. Magnets (Javid, 1971) and clips (Parel et al, 1986) can be used to minimize force transfer to the implant and supporting bone. The resultant decrease in dependence on chemical (adhesives) and anatomic (tissue undercuts) sources of retention is beneficial to both the patient and the prosthetic rehabilitation.

### **Intraoral Maxillofacial Prosthetics**

The ablation of malignant tumors of the oral cavity often requires the resection of structures essential to the functions of speech, mastication, and deglutition. When surgery affects the function of the palatopharyngeal complex, the resulting loss of oronasal separation may result in changes in the speech patterns, resonance characteristics, and ability to develop oropharyngeal pressures for both speech and swallowing (Baredes et al, 1985).

At the present time, conventional or rigid obturation involves extending the prosthesis to the level of greatest muscular activity tolerated by the residual palatopharyngeal and nasopharyngeal complex. Retention of the obturator in the edentulous patient is not always possible. The weight of the maxillary prosthetic obturator is often a factor in retention because the prosthesis may act as a cantilever, resulting in dislodgement (DaBreo, 1990b).

Resection of oral tumors of the tongue, floor of the mouth, and mandible result in functional disability and cosmetic disfigurement. The degree of disability depends on the location, extent, and differentiation of the lesion. Disabilities include impaired speech

articulation, difficulty in swallowing, severe cosmetic disfigurement, poor control of salivary secretions, and deviation of the mandible during functional movements (Cantor and Curtis, 1971). Mandibular discontinuity defects present a major challenge to the rehabilitative team and to the maxillofacial prosthodontist.

### **Maxillary resections**

In maxillary resections (Aramany et al, 1988) bone cuts should be made through the sockets of the extracted anterior teeth close to the segment to be removed rather than next to the remaining tooth. This approach preserves the alveolar bone adjacent to the tooth abutting the maxillary defect, thereby providing greater stability for this tooth, which can be used safely in supporting the obturator (Fig. 80-15). In the completely edentulous maxilla, the preservation of bone anteriorly or posteriorly on the resection side improves the stability and retention of the obturator (Fig. 80-16).

A local pedicle flap of mucosa from the hard palate of the maxilla to be resected is raised before making the bone cut on the palatal aspect of the maxilla. This is possible only if the tumor does not involve the palatal mucosa. The bone cut is made, and the maxillectomy is completed. The palatal flap is reflected up onto the medial aspect of the defect and sutured to the nasal septum with through and through sutures, after a small area of the mucosa has been elevated from the inferior aspect of the nasal septum (Fig. 80-17). In edentulous patients an undercut is created on the medial wall of the defect at the base of the nasal septum. This undercut is then covered with the palatal flap. Surveying the dental cast is essential to avoid the presence of an antagonistic undercut on the buccal surface of the alveolar ridge on the nonresected side (Aramany et al, 1988; Beumer et al, 1978).

The coronoid process may be resected in extensive maxillectomy tumors. As the mandible moves forward, the coronoid tends to dislodge the obturator. The mucosa covering this area tends to be irritated by posterosuperior extension of the prosthesis (Aramany et al, 1988; Beumer et al, 1978).

After resection of the soft palate, if the posterior residual tissue is anticipated to be a nonfunctional tissue band, a decision should be made to either preserve or remove it. Such a band is useful in supporting the prosthesis against gravity in a large palatal defect when the patient is edentulous (Fig. 80-18). On the other hand, if the patient has natural teeth, the nonfunctional band may interfere with the proper placement of the pharyngeal extension of the speech aid obturator. In the latter situation, it is preferable to perform a total palatal resection (Aramany and Matalon, 1970).

If the tumor is located posteriorly on the palate, the resection should be carried further anteriorly to the static tissue in the region of the fibrous aponeurosis. When a mobile section of the soft palate remains, the prosthesis has to cover this section to reach the oropharynx. The mobile section tends to displace the prosthesis and causes discomfort for the patient (Fig. 80-19).

Resection of the coronoid process is also recommended in extensive lateral soft palate resection. These recommendations do not apply in small lateral defects of the palate since these patients tend to regain oral function without the aid of the prosthesis. Patients who lose

25% or less of the soft palate exhibit initial oral incompetence. They may, however, gain effective oronasal separation after using a prosthesis for a period of time and eventually may be able to function well without the prosthesis (Aramany and Myers, 1978).

### ***Classification of maxillary defects***

The palatal aponeurosis may be considered the structure differentiating two types of residual palatal defects (Aramany, 1978a; Aramany et al, 1988). Defects anterior to this structure are hard palate defects. The prosthetic replacement is supported by the residual static structures. Prostheses for defects originating posterior to the aponeurosis are more difficult to design and adapt to patient comfort because they are related to a functionally dynamic area.

Aramany (1978a) used the classification of hard palate defects as a base for specific design considerations. The classification was based on the frequency of maxillary defect occurrence in 123 patients (Fig. 80-20). The location of the defect is in relationship to the remaining dentition. Class sequence reflects the frequency of the occurrence of the defect in the patient population. The design of the obturator for each class was selected to maximize the utilization of the remaining teeth and hard and soft tissue structures within the limits of the physiologic tolerance of these tissues.

Preservation of teeth adds to the stability of the prosthesis and enables an equal distribution of force to the teeth and adjacent structures. However, lack of remaining dentition or the removal of the teeth because of pathologic conditions presents a different design principle of the obturator and the necessity to maximize extensions of the prosthesis. Retention of the obturator is therefore greatly improved.

Contact of the nasal extension of the obturator prosthesis against the regions of the skin graft helps to promote healing, maintains hemostasis, and prevents hematomas and graft failure. Postsurgical infection is minimized, and uneventful healing ensures early discharge from the hospital. Normal speech is restored immediately, and the morale and psychologic attitude of the patient are enhanced with the realization that the surgical experience will not cause a permanent handicap.

The residual defect may involve an isolated anatomic site or may extend into adjacent structures. When the defect is small and limited to one site, the results of rehabilitation are predictably good. However, in larger defects involving more structures the prognosis for rehabilitation must be guarded.

### ***Classification of soft palate defects***

Classification of soft palate defects (Aramany et al, 1988; Cantor and Curtis, 1971) is based on the location of the defect and on the structures involved (Fig. 80-21). The soft palate and the lateral and posterior pharyngeal walls act as a physiologic valve in the control of oronasal air pressure and the air pressure, air flow, and fluid flow that are vital to swallowing, speaking, and hearing.

Postsurgical defects of the soft palate are classified by location, size, and tumor type. The residual physiologic activity in the remaining muscles of the oropharyngeal region

determines the degree of success of prosthetic rehabilitative efforts.

Although resection of the soft palate varies greatly, the resultant defects may be grouped into three categories based on frequency of occurrence. The categories are lateral, total, and medial soft palate defects. Lateral defects result from tumors that occur laterally in the soft palate. Resection of tumors of the retromolar trigone region, base of tongue, and lateral mandible frequently involves the lateral portion of the soft palate. Resection of tumors of the soft palate interrupts the bilateral arrangement of the musculature. Oronasal separation is interrupted also. Lateral defects occurred in about 61% of acquired soft palate defects seen in a study (Cantor and Curtis, 1971) of 102 patients (59 males and 43 females), who underwent surgical excision for a palatal neoplasm. The extent of the defect ranges from a simple palatectomy to a composite resection including the neck, partial mandibulectomy, and partial glossectomy (Figs. 80-22 and 80-23). In the former the function of speech and swallowing can be rehabilitated very effectively; in the latter the results are less than optimal. The second category, total or near total resection of the soft palate occurred in 37% of the patients seen (Figs. 80-24 and 80-25). The third category, medial resection of the soft palate with preservation of an active posterior neuromuscular band, was seen in 6% of the patients. In the medial resection group the defects in two patients included resection of the horizontal plate of the palatine bone and the aponeurosis. However, the prosthesis was designed similar to a soft palate speech aid obturator.

### *Palatal prostheses*

Generally, the size of the prosthesis (Aramany et al, 1988) is determined by the surgical boundaries of the resection. Restorations of extensive deformities are naturally quite bulky and in some instances are constructed in more than one section to minimize the size. By constructing the prosthesis in more than one section, as in the hollow bulb technique, the weight of the obturator can be reduced. By reducing the weight and making the bulb extension self-retentive, the retentive qualities of the prosthesis can be greatly enhanced (Chalian and Barnett, 1972).

Three distinctly different types of prostheses are constructed for patients with palatal defects. The type of prosthesis constructed in a given situation is based on its intended use. The surgical obturator is constructed before the surgery and is inserted in the operating room. The interim obturator is used during the healing stage. The definitive obturator is constructed and inserted when the tissue heals, if minimal changes are expected in the defect area.

The three types of prostheses are constructed for both edentulous and dentulous patients. Surgical obturators are not practical in conjunction with soft palate resections. Conversely, they are vital in maxillary resection patients. The interim and definitive obturators, with some modifications, are used for both hard and soft palate resection patients. When the obturator prosthesis is constructed for soft palate defects, it is generally referred to as a speech aid prosthesis.

**Surgical obturator.** Resection of the palate affects the individual's ability to speak and swallow. The skeletal support of the cheek is lost after maxillary resection, leading to a midfacial asymmetry. Resection of the orbital floor, causing enophthalmos and excision of the skin when infiltrated by tumor, further undermines the facial appearance. Resection of the



soft palate results in loss of oronasal separation (Aramany, 1978b).

The immediate postoperative period is difficult for the patient who has experienced a maxillary resection. The patient is acutely aware of the unintelligible speech and altered eating habits. Contraction of the operative site occurs dramatically with resultant collapse of the soft tissue around the resected site (Fig. 80-26).

The advantage of a presurgical maxillary obturator prosthesis (DaBreo, 1990b) is the restoration of normal speech and eating habits. Collapse of the soft tissues on the affected side may also be prevented. Facial symmetry will be preserved, and retention of the interim and definitive prostheses will be facilitated. Above all, the mental well-being of the patient is improved considerably. A sponge may be used approximately 10 days after the operation. The sponge is removed by the patient and cleansed after each meal. An immediate presurgical obturator prosthesis obviates the need for a sponge after the operation.

When a maxillary resection is planned, an immediate surgical obturator prosthesis is fabricated from presurgical impressions. The surgical prosthesis is inserted at the time of surgery or immediately after surgery, with modifications to the prosthesis for accurate fitting by the use of autopolymerizing soft denture liners. The immediate surgical obturator prosthesis is effective in providing an artificial palate separating the oral and nasal cavities. The patient is then able to take food parenterally as opposed to enteral feeding when an oronasal communication exists.

**Interim obturator.** When the surgical dressing is removed (7 to 10 days after the operation), the immediate presurgical prosthesis can be relined with a provisional denture liner. As healing progresses, an interim obturator prosthesis (DaBreo, 1990b) is constructed and extended further into the defect, with subsequent soft liner additions improving seal and retention. Teeth may be added to the interim obturator prosthesis if aesthetics are of primary importance (Fig. 80-27). However, it is advantageous to omit the placement of teeth to prevent occlusal loading in the region of resection during the early stage of healing. This delay reduces the chances of irritation that could affect healing of the surgical site.

The prosthodontist should not hurry the provision of artificial teeth for the interim obturator prosthesis. If radiation therapy is applied, the tenderness of tissue afterward usually allows use of only the simplest type of prosthesis. At this stage, the mucous membrane is particularly fragile and subject to ulceration by a prosthesis.

The interim prosthesis may be inserted 1 to 3 weeks after maxillary resection. Although reepithelialization of the wound is minimal, interrupted sensory innervation limits discomfort to the patient. However, diminished salivation and mucosal secretions, psychologic deterioration, and limited nutrition add to the patient's discomfort and concern. When needed, interim prosthodontic management by artificial replacement of the teeth and palate will aid speech, mastication, esthetics, and morale (Beumer et al, 1982).

**Definitive obturator.** The provision of an obturator prosthesis (DaBreo et al, 1990a) after resection of the maxilla serves three purposes: (1) it creates an oral seal that makes swallowing and speech effective; (2) it contributes support, retention, and stability for the intraoral prosthesis; and (3) it restores contour after partial loss of the facial skeleton. These

improvements are of considerable psychologic benefit to the patient.

Defects of the hard palate are restored effectively with a prosthesis. Surgical reconstruction is usually neither possible nor desirable after maxillary resections. If teeth are present, they greatly improve obturator retention and stability. One of the forces to be counteracted in the dentulous maxillary obturator is rotational stress on the abutment teeth caused by occlusion and gravity. Thus the weight of the nasal bulb section of the obturator should be as light as possible. The buccal flange of the obturator should also be constructed to engage the lateral scar band superiorly (Brown, 1986; Chalian et al, 1972). This design helps to restore the facial contour as well as prevent dislodging forces from unseating the obturator.

The obturator prosthesis should extend minimally along the lateral wall of the defect. The high lateral extension improves retention and lateral stability and provides support for the lip and cheek (Fig. 80-28). The anterior movement of the coronoid process into the posterolateral region of the defect must be accommodated during muscle molding and final impression procedures.

The extension superiorly along the medial margin of the defect should not exceed the level of the repositioned palatal mucosa. In selected patients, extension across the nasal surface of the soft palate or into the nasal aperture may improve retention.

Following definitive obturation, speech and swallowing are restored within normal limits and appearance is greatly enhanced. The patient should be seen for postinsertion adjustments within 24 to 48 hours and then seen periodically for adjustments, evaluation, and examination for recurrences.

Most prostheses require relining or refitting within the first 6 months to 1 year because of slow and continuous tissue changes about the surgical defect and normal alveolar bone changes. Most patients can be rehabilitated successfully with restoration of aesthetics, mastication, and deglutition to near-normal limits.

### **Mandibular resection**

Tumors in and around the mandible usually require surgical removal of the lesions and extensive resection of the bone (Aramany et al, 1988). Smaller lesions that are removed without discontinuity of the bone are relatively simple to treat by prostheses (Fig. 80-20). Larger lesions that extend into the floor of the mouth may be more difficult to treat by prosthesis even though the continuity of the mandible is maintained.

Mandibular surgery generally has the least effect on the speech and swallowing function, as long as the activity of the tongue and the competence of the palate are not impaired. Resection of the tongue produces the greatest effect on speech since it is the primary organ for vowel and consonant articulation. Extensive resections involving the tongue, palate, and pharynx create the greatest handicap for speech and swallowing and require direct intervention by the maxillofacial prosthodontist.

### ***Classification of mandibular defects***

Chalian (1985a) has arranged mandibular defects in a classification system as follows (Fig. 80-30):

Class I	Resection of the ipsilateral condyle
Class II	Resection of the ipsilateral condyle and ascending ramus
Class III	Resection of the ipsilateral condyle and body to midsymphysis
Class IV	Resection of the ipsilateral condyle to the contralateral body
Class V	Total mandibulectomy
Class VI	Resection of the midsymphysis
Class VII	Segmental resection of the body
Class VIII	Marginal or coronal resection of the body.

Mandibular discontinuity following traumatic accidents or tumor resection can create restorative difficulties. If mandibular continuity is reestablished by grafting procedures, the grafted bone is subject to rapid resorption once loaded by occlusal force through a denture base. If grafted bone is allowed to heal undisturbed, however, it may serve as a site for implant placement. The grafted and implanted bone will be internally loaded and resorption can be slowed dramatically.

### ***Resection prosthesis***

Patients have functioned with resected mandibles for many years using their proprioceptive feedback on the nonresected side to compensate for deviation toward the resected side. Partially edentulous patients are able to compensate for the lack of continuity. However, completely edentulous patients (Fig. 80-31) do not function well with dentures because of a lack of cross-arch stabilization (Adisman, 1990). An equally disturbing functional loss often associated with mandibular resection is the loss of speech intelligibility found in the partial or subtotal glossectomy patient.

A common site for an oral carcinoma is the lower posterior lateral aspect of the tongue. Malignant tumors in this region may lead to removal of part or all of the tongue. Invasive lesions require extensive surgical resection, which may involve part of the bone of the mandible. As in other lesions, the functional effect is directly related to the size, location, and extent of the tumor.

### ***Functions of the tongue***

The tongue plays a major role in the processes of mastication, deglutition, and phonation. In mastication it serves to keep food on the occlusal plane and provides the motion necessary to rotate and shape the food into a bolus. Once the bolus is prepared, the tongue and the muscles of the floor of the mouth rise to place the bolus of food against the palate and walls of the pharynx. With a continuous, sweeping motion, the tongue presses the food posteriorly into the oropharynx. Subsequent pressure of the tongue against the palate propels the bolus into the pharynx and through the cricoesophageal segment.

The tongue is the primary articulator in speech production. It modifies the size and shape of the oral cavity, a function required for the production of vowel and consonant sounds and in the production of resonance, an articulatory feature that gives an individual a characteristic voice quality. In addition, the tongue functions to restrict air flow or to close the airway entirely to produce consonant sounds during speech. Understanding this relatively broad range of functions provided by the tongue is critical to proper preparation of the glossectomy patient facing challenge of rehabilitation.

### ***Glossectomy defects***

When a patient has a partial or total glossectomy, the ability to masticate, swallow, and formulate vowels and consonants for speech sounds is dramatically altered. The size, location, and extent of the defect affect the degree of disability to swallow or speak. Other factors, such as age, motivation, prior speaking habits, and prior surgery or other modalities of treatment, also play a role in the patient's overall rehabilitation of swallowing and speaking.

The areas of surgical resection that affects tongue function includes removal of the anterior tongue tip, lateral (partial) glossectomy, removal of the base of the tongue, and total glossectomy.

When only the tongue tip is removed (Fig. 80-32), the patient cannot control the food before bolus formation, and drooling may be a problem. If teeth are not present, particularly in the lower dental arch, the tongue is unable to control the escape of the oral liquids. Placing the food posterior to the horizontal wall created by the remaining tongue is often difficult. In speech, the sounds requiring tongue tip elevation are lost. The patient with an extensive lateral glossectomy (Fig. 80-33) also loses the ability to control the bolus, has excessive drooling, and has reduced speech articulation skills because of difficulty in controlling tongue tip placement.

Surgery to the base of the tongue (Fig. 80-34) is of limited extent, may not affect speech or swallowing skill once the recovery period has passed. However, if the tumor is extensive and includes part of the lateral wall and palate, the effects on speech and swallowing are severe. These effects are caused by the heightened loss of function, since the ability to maintain the tight velopharyngeal seal necessary for swallowing and speech has changed. While swallowing, the patient may be unable to control the bolus in the oral phase. In the pharyngeal phase the food may be pressed into the nasal cavity because of loss of the oronasal seal. Thus pressing the food posteriorly into the esophageal segment may be difficult. Aspiration and coughing may also occur following such resections. Speech may become

hypernasal because of the lack of velopharyngeal seal. The fricative sounds, such as /s/, /z/, and /sh/, and the plosive sounds, such as /p/, /b/, and /t/, may be distorted or omitted because of the inability to impound and maintain intraoral pressure.

In the glossectomy patients, speech is generally more affected than swallowing is. Precise articulation of consonants and vowels is lost and speech may be unintelligible. With removal of the tongue the oral cavity becomes one large resonator without the ability of being modified in shape, which is required for adequate speech. The patient may learn compensatory movements for articulation of some consonants. Without prosthetic help, the speech prognosis is poor.

The total glossectomy patient is able to take liquids and soft foods readily after healing; however, the ability to mash, chew, and formulate a bolus is lost, so the patient requires prosthodontic intervention.

### ***Mandibular tongue prosthesis***

The treatment for a total glossectomy involves construction of a two-part mandibular prosthesis, or artificial tongue (Aramany et al, 1982). Because the floor of the mouth is concave, a maxillary edentulous tray is used to make the mandibular impression with an irreversible hydrocolloid material. Modifications in the impression procedure, including the use of soft wax posteriorly to prevent spillage into the pharynx and warm water to shorten setting time, are necessary. From this impression a permanent acrylic base is made. A mushroomlike button is added to the acrylic base to hold the prosthetic tongue (Fig. 80-35). A silicone tongue is molded with a concavity on its undersurface designed to fit over the button. The button eventually allows for easy placement and removal of the silicone prosthetic tongue.

Two types of tongues are constructed: one for speaking and one for swallowing. Both tongues are flat, rising to the occlusal plane and elevated anteriorly above it. This elevation aids in appearance, in shaping the oral cavity for vowel production, and in providing extension of surface for the contact required for articulation of linguoalveolar sounds, such as /t/ and /d/. The tongue is also broad to allow for approximation of the tip to the contour of the alveolar ridge, thus making possible the constriction required for production of the fricative sounds, such as /s/ and /sh/. The tongue for swallowing differs from the speech tongue in that it is not as high anteriorly and is grooved posteriorly to aid in the movement of the food bolus.

### ***Palatal augmentation prosthesis***

The treatment for a partial glossectomy may require the construction of a palatal augmentation prosthesis. This prosthesis is designed to take advantage of the residual movements of the tongue and to fill spaces where tongue-palate contact needs to be made. For the edentulous patient a removable partial dental framework is constructed. Soft modeling compound material is added to the prosthesis so that it closely forms to the contour of the tongue. Then with the aid of a speech pathologist the patient produces various sounds requiring tongue tip elevation, including the linguoalveolar and linguovelar sounds. When contact is not achieved, the modeling compound is added and pressure-indicating paste is used

to aid in outlining pressure areas. Once the contact areas have been improved and the best articulation of sounds achieved, functional wax is used as a working model, and the final prosthesis is processed in clear acrylic resin.

The shape of the augmentation prosthesis depends on the tissue and the location and flexibility of the residual tongue. In some cases treatment has stabilized much of the movement of the tongue. If tongue-palatal contact is achieved via the prosthesis, it may be possible to shape the prosthesis so that speech sounds requiring fine adjustment can be produced. For example, a small groove can be placed on the midline of the prosthesis so that air flow through the groove helps approximate the high-frequency sounds required by the fricative sounds, particularly /s/ and /z/ (Fig. 80-36).

In more severe cases in which part of the mandible is removed, a combination of a palatal-augmentation prosthesis and a guiding-flange prosthesis may be required to maintain symmetry of the face and to keep the oral cavity in proper alignment so that speech can be produced most effectively.

Perhaps the most difficult patient to treat functionally is the patient with a tumor in the base of the tongue who receives a partial glossectomy, partial mandibulectomy, and partial palatectomy. Problems may include effecting and controlling swallowing, drooling, nasal regurgitation of foods, aspiration, poor articulation, loss of speech intelligibility, loss of facial symmetry, and depression. Prosthodontic intervention, along with support from the speech pathologist, is necessary to provide oronasal separation (through a palatal-speech prosthesis), to improve swallowing and speech articulation (through a palatal-augmentation prosthesis), and to stabilize lateral forces (through a guiding-flange prosthesis).

### **Extraoral Maxillofacial Prosthetics**

Preoperative evaluation of the patient, as with any head and neck cancer patient provides for optimal preparation of the patient and planning of the treatment. This can greatly enhance the patients' postsurgical adjustment to the prosthesis (Bailey and Edward, 1975). The type of tumor often dictates the prosthetic prognosis and therefore the approach to prosthetic rehabilitation. The extent of surgical treatment is directly related to tumor size, extension, and type. Immediate or delayed prosthetic treatment depends not only on the timing of healing of the patient but also on the knowledge that the tumor has been completely eradicated. The postoperative pathology report and type of tumor will reveal the necessity for adjunctive or combined therapy via chemotherapy or irradiation (DaBreo and Schuller, 1990).

Squamous cell carcinomas are the most common malignancies of the sinonasal tract. Among the sinuses, the antrum is the most prevalent site. The disease usually manifests at an advanced stage with orbital invasion in almost two thirds of the patients, resulting in some degree of facial disfigurement (Fig. 80-37) when resected (Johnson et al, 1984). Adenocarcinomas are more numerous in the ethmoid sinus, whereas adenocystic carcinomas cluster in the maxillary sinus. Resection of these tumors often leads to external manifestation of the defects (Clifford, 1980).

## **Extraoral resections**

With the exception of basal cell carcinoma, the most common neoplasms affecting the facial structures originate in the paranasal sinuses. Malignant tumors such as adenocystic carcinoma and adenocarcinoma tend to be poorly defined and may cause destructive bony changes. Neoplastic processes originating in the paranasal sinus thus have ready access to external infiltration. The lacrimal fossa empties into the nasolacrimal duct (Fig. 80-38), and hence extension of tumors along this structure will permit orbital invasion and resultant facial involvement (Hesselingk and Weber, 1982).

Tissue healing and tissue tolerance to a prosthesis and to adhesives used in retention are adversely affected by both chemotherapy and irradiation. In general, a malignancy that does not penetrate a bony wall can be resected with an adequate margin by inclusion of the adjacent wall and a small perimeter of tissue (Grove, 1979).

## **Auricular defects**

The ear or pinna is made up of (1) a cartilaginous framework, (2) fatty tissues, and (3) an external covering of skin, all of which impart to the ear its characteristic shape, color, and texture. Examination of the major features in the pinna reveals eight anatomic structures critical in obtaining a natural-appearing auricular prosthesis. These are the concha, tragus, antitragus, incisura intertragica, antihelix, helix, lobe, and scapha. Of these the concha and tragus play the most important roles in creating the illusion of nature.

The concha is the central depressed portion leading into the auditory canal. A small prominent elevation situated anterior to the external auditory meatus and the tragus if intact, along with a normal concha depression have a camouflaging value that gives the prosthesis a natural emergence profile from the face. When feasible it is essential to preserve the tragus or eliminate bulky scar formation in the conchal region.

In general the best surface or base on which to construct an auricular prosthesis consists of maintaining the existing tragus or surgically contouring a traguslike structure and using the cavum conchae or some similar depression just posterior to the tragus. This provides a natural landmark and creates a shadow into the concha, which gives an illusion of depth to this region and is instrumental in creating a natural effect.

Joint efforts of the surgeon and the maxillofacial prosthodontist should first include surgical reshaping of existing unfavourable contours to provide a foundation over which a prosthesis may be constructed. Unfortunately, neither a partial prosthesis nor a prosthesis that fits over an existing ear remnant will be satisfactory.

## **Nasal defects**

Centrally located on the face, the nose draws obvious attention when it is greatly altered in any form. Losing all or a portion of the nose because of trauma or pathologic or resultant surgical reasons is a devastating and debilitating circumstance. Hence there is every indication for the design and fabrication of a nasal prosthesis.

The various types include partial nasal replacement, complete replacement, and even replacement of involved adjacent areas. Because it is a single entity (that is, there is no contralateral equivalent as with eyes and ears), the nose is the easiest and technically simplest prosthesis to fabricate.

When possible, make presurgical photographs and moulage. If these are not feasible or useful, obtain some of the patient's portraits or home pictures. These will allow a more accurate replication of the patient's original nose. Record any peculiar pigmentation or topographic features.

As with any facial prosthesis there is an attempt to hide the margins and match the texture, color, and translucency of the skin. This becomes a most challenging task, but with the use of eyeglasses, subtle pigmentation, and placement of the margins in anatomic grooves or sulci, the maxillofacial prosthodontist attempts to conceal and blend the prosthesis into the facial topography.

### **Orbital defects**

It is essentially impossible to reconstruct an exenterated orbit with autogenous material in an anatomic situation in which there is a total loss of upper and lower eyelids, along with the eye (Stanley and Beumer, 1988). Thus the treatment of choice is an orbital prosthesis to restore lost structures (Fig. 80-39).

The decision to save or sacrifice a globe when a malignancy penetrates the bone but not the periorbital should be based on such factors as the tumor histology, contralateral vision, the probability of permanent diplopia, and the need for irradiation in doses that would destroy vision. Because of the complications involved with irradiation of orbital tumors, surgical resection has been the treatment of choice (Dortzbach and Woog, 1985).

Depending on the surgical procedure used to remove the tumor, orbital defects may include an evisceration, enucleation, or an exenteration (Baylis and Shor, 1981), each of which involves a different prosthetic approach. An evisceration procedure wherein only the intraocular contents of the globe are removed will generally require minimal prosthetic treatment (DaBreo and Schuller, 1990).

With an enucleation defect (Fig. 80-40), prosthetic treatment begins with the use of a spherical implant behind the posterior layer of Tenon's capsule to preserve greater volume in the orbit following globe removal (Allen, 1983). Various materials such as silicone, methyl methacrylate, or glass may be used for this purpose. A conformer is also placed to maintain the fornices (Gass, 1985). An ocular prosthesis can then be initiated approximately 10 to 14 days after surgery.

Orbital exenteration involves the complete removal of the orbital contents, including the eyelids. Surgical prognosis and prosthetic prognosis is directly related to the tumor type. Skin grafting with split-thickness skin grafts (Fig. 80-41) offers an advantage in tolerance of the eventual prosthesis. A prosthesis is constructed after complete healing (usually 2 to 4 months).



In addition, orbital exenteration presents a unique challenge to the maxillofacial prosthodontist. Prosthetic restoration of the orbit is often complicated by the extent of resection, tissue response, and method of retention.

### **Cranial defects**

Trauma and pathologic diseases account for most cranial defects (Beumer et al, 1979). During the repair of compound skull fractures, penetrating wounds, or cranial tumors, removal of significant portions of the skull may be required. Successful management of these fractures and tumors necessitate repair of the scalp and dura but not necessarily restoration of cranial integrity. Also, in some patients, a bone flap reimplanted during elective craniotomy may become infected and require removal.

The major indications for cranioplasty are disfigurement and mechanical vulnerability. Small defects (2 to 3 cm in diameter) located immediately above the orbital rim or at the nasion may require repair entirely for cosmetic reasons (Fig. 80-42). Some large defects (8 to 10 cm in diameter) at the posterior parietooccipital junction or in the frontal region may require repair almost entirely for the purpose of brain protection. However, most cranial defects will have some variable proportion of cosmetic and mechanical aspects, and the decision regarding cranioplasty must be influenced by the patient's age, prognosis and activity level and by the specific conditions of the scalp and calvarium. In some patients who may be poor candidates for surgery, an external prosthesis can be fabricated for protection.

### **Radiation Effects on Maxillofacial Reconstruction**

Surgery and radiation therapy (Fig. 80-43) may be delayed to carry out dental restorations and extractions on the existing dentition. Patients with poor oral hygiene, rampant decay, or advanced periodontal disease may have radiation therapy postponed to correct these problems. Healing of large intraoral wounds is improved by good oral hygiene. Dentulous patients who have postoperative radiation therapy planned should have fluoride treatment on a continuous basis (Aramany et al, 1988).

### **Oral complications from radiation therapy**

Radiation changes have a direct effect on rehabilitation of both intraoral and extraoral defects found in the maxillofacial prosthetic patient. Radiation changes include erythema and tissue sensitivity (mucositis), ulcers in the mouth and on the lips, fungal infections, dryness (xerostomia) of the mouth from salivary gland destruction, dental decay from decreased salivary flow and pH changes, and possibility of infections in the jaws or the potential for osteoradionecrosis from infection or trauma to irradiated bone.

Hypersensitivity of the teeth, dental pulp changes, taste loss, oral bacterial shift, and periodontal breakdown are other problems of concern to the maxillofacial prosthodontist in treating the patient undergoing radiation therapy.

## Prosthetic care during radiation therapy

Intraoral prostheses are generally kept out of the mouth during radiation therapy, and prostheses are generally not recommended to be constructed for up to 1 year following radiation therapy (Chalian et al, 1972). This recommendation stems from concern about potential irritation to the already compromised oral mucosa and the exacerbation of infection with subsequent osteoradionecrosis. Because the healing capacity of the irradiated patient is compromised, denture irritation must be monitored closely and kept to a minimum. Keeping the prosthesis out of the mouth is not always possible or practical for patients who have undergone a maxillectomy procedure. The necessity for adequate nutritional intake and intelligible communication often precludes this recommendation.

Mucositis can be controlled by selective use of viscous lidocaine and glucerin-Kaopectate-Benadryl oral rinses. Other medicaments may include benzocaine ointment, alkaline-saline rinse (sodium bicarbonate, sodium chloride, and water), or sodium bicarbonate-milk of magnesia rinse. Because of the transient nature of mucositis, treatment is palliative through the period of greatest intensity. Meticulous oral hygiene can also help to limit the duration of mucositis (Chalian, 1985b).

If a fungal infection is precipitated during prosthetic treatment, adequate measures should be taken to prevent reinfection while the patient is medicated for this problem. The prosthesis should be relined, rebased, or remade depending on the severity of the infection and the medical history of the patient. Interim soft liners have been known to harbor *Candida albicans* and therefore should be eliminated from the treatment regimen as early as possible (Fig. 80-44). If definitive procedures (that is, remake of the prosthesis) are not possible, the prosthesis may be soaked in nystatin or chlorhexidine rinse to reduce the floral contamination.

Xerostomia often results in loss of retention in the prosthesis and tissue soreness during service. To avoid unrealistic expectations at the time of delivery of the completed prosthesis, this problem needs to be identified and discussed with the patient before instituting treatment. The mouth may be lubricated with constant water intake or with artificial saliva substitutes to help relieve some of the discomfort. A sound oral hygiene regimen of brushing the prosthesis and mouth (with a soft toothbrush), meticulous adjustment to minimize irritation, and possible use of a permanent soft liner (when fungal infections are not a concern) are helpful aids in working around the problem of xerostomia.

Radiation caries occurs as a result of xerostomia, oral bacterial shift, and pH changes in the oral cavity. By treating xerostomia directly with fluid intake and a good oral hygiene regimen, caries progression can be offset. Stringent oral hygiene, antibacterial agents, buffering rinses, and topical fluorides are helpful in correcting bacterial shift and pH changes.

Trismus can potentially eliminate the possibility of prosthetic treatment if the oral opening is dramatically reduced. Impression making and placement of the prosthesis following construction will be impossible in some situations of minimal opening. The patient can play a major role in the treatment of trismus during prosthetic care. Continual jaw-opening/muscle-stretching exercises and the use of tongue blades to pry the jaws open manually are very helpful. In very severe cases dynamic jaw appliances and surgical intervention may be necessary. A lack of patient motivation and effort in the early phase of trismus treatment

ultimately predicts an inability to wear the prosthesis. Therefore all members of the rehabilitative team should provide positive and continual reinforcement.

Although the incidence of osteoradionecrosis is a rare occurrence from a prosthetic point of view, the elimination of irritation early in the treatment phase is necessary, and avoidance of early prosthetic loading of irradiated tissues is warranted. Irritation that shows signs of ulceration necessitates the immediate removal of the prosthesis from the mouth. Small localized bone exposure can be treated with a zinc peroxide-neomycin-triamcinolone-lidocaine salve, zinc oxide-neosporin dressing, or Benadryl-glycerin-lidocaine rinse (Shidnea, 1985). A stent is needed to keep the medicament closely adapted to the exposed area.

Dermatitis and dehydration may result in external skin surfaces being intolerant to the use of medical adhesives for extraoral prostheses (Fig. 80-45). The use of skin lotions and moisteners, minimization of physical exertion, and increased fluid intake will help to restore balance to the tissues.

### **Osseointegration in irradiated bone**

Experimental and clinical findings indicate previous irradiation in therapeutic doses is not an absolute contraindication for implant insertion. It is recommended that some time elapse (minimally 1 year) before implant placement in irradiated bone. A multicenter study reported three failures of 80 implants placed over 1 to 5 years follow-up (Albrektsson et al, 1988a). Another study (Jacobsson et al, 1988) evaluated 35 extraoral titanium implants and reported an 85% success rate from 0 to 5 years. An animal study (Albrektsson et al, 1988b) found hyperbaric oxygen to be potentially useful in stimulating bone formation around implants placed in rabbits. This finding may be potentially beneficial to patients who have received radiation therapy before implant consideration.

Patients with mandibular resection present a more difficult rehabilitation problem than those with maxillary resection. Efforts to restore mandibular function are often complicated by loss of mandibular bone as well as adjacent soft tissue. The administration of radiation therapy as a part of the treatment protocol often precludes certain implant and prosthetic restorations. Mandibular implant procedures that may be successful in nonirradiated patients are contraindicated in irradiated bone (Aramany et al, 1988).

### **Implant Reconstruction in Maxillofacial Prosthetics**

The ideal biomaterial for use as a surgical implant should have certain characteristics.

1. Sterilizability
2. Ease of fabrication into an implant device
3. Absence of toxic, immunologic, or carcinogenic effects
4. Minimum inflammatory response
5. Durability over lifetime of implant.

Because every foreign material generates some tissue response, reduction of this response to an acceptable level is the goal, and it is postulated that *biologic performance* or *acceptance* may be a preferred term to *biocompatibility*. The site and mode of use of the implantable device are important in determining the requirements in mechanical properties. For instance, a cranial or facial implant would require different properties than an oral implant that supports the forces of mastication.

### **Implant reconstruction of mandibular discontinuity**

Hemimandibulectomy patients normally present less of a rehabilitative problem than patients in whom the anterior third of the mandible has been removed. By use of intraoral fixation at the time of surgery and intraoral guide planes postsurgically, the hemimandibulectomy patient can be returned to a functional state (Chalian et al, 1972).

The prime requisite surgically is adequate tissue with a good blood supply so that coverage of the implant can be accomplished without tension. If it is possible to fixate the mandibular segments in the most ideal relationship to the maxilla, this should be done before insertion of the implant. This can be accomplished by arch bars and a bite wafer if enough teeth remain to establish occlusion. If teeth are not present but enough of the body of the mandible remains, a splint may be constructed to maintain the desired relationship of the arches (Chalian et al, 1972).

Titanium, tantalum, and chrome-cobalt-molybdenum alloys and acrylic polymers are the materials most used to restore mandibular continuity defects. Perforated tantalum implants are often used for reconstructing facial defects, such as the infraorbital bone, the zygomatic-orbital-malar bone, the symphysis, and associated structures.

### **Implant reconstruction of facial defects**

Polymeric materials have the distinct advantage of allowing complex shapes to be constructed. In the processed state they have much lower tensile strength than metals. But their low modulus and higher compliance characteristics often allow them to serve in an energy absorbing capacity between a metallic implant and bone or in an anatomic recontouring role.

Silicone elastomers, particularly polydimethylsiloxane and polyvinylsiloxane, are the forerunners in fabrication of facial prostheses and implant augmentation procedures, particularly where flexible tissue anatomic recontouring is indicated. Although new formulations have been introduced consistently over the years for industrial and medical implant use, HTB and RTV silicone elastomers remain popular in facial implant recontouring procedures.

Silicone implants are used for reconstruction of the dorsum of the nose, floor of the orbit, the malar bone, and the forehead and in recontouring the retrognathic chin. When a polymeric implant, especially one fabricated from silicone, is used, contact with powder from surgical gloves should be avoided. Perforations should be placed on the silicone implant surface to provide tissue ingrowth for stabilization and retention of the implant.

### ***Osseointegration in maxillofacial prostheses***

Branemark and coworkers (1969) became the first researchers to indicate the possibility of a bony anchorage of oral implants, which was regarded as impossible by most authorities. Osseointegrated implants have been used to provide a source of retention for facial prostheses after the loss of the pinna, nose, or orbital contents following trauma or cancer surgery.

### **Implant reconstruction of cranial defects**

Numerous metals and alloys have been employed for the restoration of cranial defects. The most popular metal employed has been tantalum. Tantalum is inert and malleable. It is available in 0.015-inch perforated sheets that can be shaped to the desired contour and cut with shears to the appropriate dimension. For small defects tantalum can be easily shaped during surgery with the aid of a mallet and a wood block.

For larger defects an impression of the defect and the surrounding surface is obtained and a working model prepared. The model is then contoured and used as the positive side of a die. It is lubricated, and a negative die or counter-die is poured in dental stone directly over the positive half. Titanium has been used recently in fashioning cranial prostheses. This metal is a strong but light material that is soft enough to be swaged in a counter-die system, and its radiodensity permits most radiographic studies. After the metal prosthesis is shaped, trimmed, and polished, tissue acceptance of the implant is enhanced by anodizing it in a solution of 80% phosphoric acid, 10% sulfuric acid, and 10% water (Beumer et al, 1979).

There are a number of disadvantages associated with metal cranial implants. Their high thermal conductivity may precipitate headaches and other neurologic symptoms. Their electrical conductivity precludes accurate interpretation of electroencephalograms. Some metals, particularly tantalum, are radiopaque and may prevent interpretation of routine radiographic studies. Infection and perforation are other complications attributable to metal implants.

The use of heat-polymerizing acrylic resin requires presurgical fabrication of the implant (Fig. 80-46). Heat-processed acrylic resin enjoys many of the favorable properties of autopolymerizing acrylic resin given below and, when appropriately fabricated, facilitates reproduction of contours. In addition, the tissue bed is not exposed to the heat of polymerization or to free monomer.

### **Future Clinical Developments and Applications**

Many advances in the field of maxillofacial prosthetics have resulted from interdisciplinary research and clinical applications of research findings in the head and neck cancer patient in particular. Collaborative endeavors have provided some success in patient rehabilitation where failure existed previously.

### **Cranial implants from CT scan-generated casts**

Recently, with the evolution of acrylic resins, polyethylene, and silicone, metals have been used less than in previous years. The use of autopolymerizing acrylic resin has become increasingly popular among neurosurgeons because of its tissue compatibility and the ease with which it is manipulated at surgery. And an alternative to the direct method of using autopolymerizing acrylic resin has been developed, whereby a three-dimensional model of the cranial defect is created through CT (Fig. 80-47) and computer-aided CAD/CAM re-formation (Van Putten, 1990a, 1990b).

A new technique utilizing CAD/CAM video imaging to construct a working model and cranial implant from polyethylene blocks and acrylic resin, respectively, has been developed; it has increased the accuracy of fit and has reduced operating room time for cranial implants considerably (Fig. 80-48).

### **Prosthetic rehabilitation of partial and total glossectomies**

DaBreo and Schuller in conjunction with principal investigator Osamu Fujimura, DSc (Professor of Speech and Hearing Science, Ohio State University) and others have applied for a National Institute of Health research grant to investigate "Articulation of Glossectomies with Intraoral Prostheses". The goals of the study are as follows:

1. To investigate articulatory gestures involved in speech production of postglossectomy individuals, using the X-ray Microbeam Facility at the University of Wisconsin, Madison.
2. To design movable and partially deformable tongue prostheses primarily but not exclusively for each of many total glossectomies with myocutaneous flap reconstructions and intact laryngeal and mandibular control, based on their articulatory performance at stages of improvement and on prediction and interpretation of controlled and uncontrolled movement patterns of the prostheses and their acoustic consequences using computational tongue models.
3. To assess phonetic capabilities at each stage of improvement both in terms of patients' practice and improvements of the prostheses, using articulatory and acoustic signal analyses and listening tests.
4. To use existing computational algorithms of three-dimensional static finite-element methods and new three-dimensional dynamic finite-element methods, particularly their simpler versions at an earlier stage of development, to help in designing new prostheses and interpreting observed performance of the patients.
5. To identify, test, and characterize most suitable families of materials for the prostheses, in particular among hybrid acrylic-siloxane copolymers and polyphosphazenes.

## **Computer-video image processors in maxillofacial prosthetics**

One of the problems faced by the maxillofacial prosthodontist is sculpting a facial prosthesis without adequate visual aids. These aids usually include any presurgical photographs along with presurgical and postsurgical moulage. Surgical and radiation therapy may result in facial changes that may reduce the value of presurgical photographs. Therefore the prosthodontist must try to create a prosthesis by trial and error, attempting to create a prosthesis that adequately covers the acquired defect and restores facial features.

A new solution is the use of a computer-video system (Van Putten, 1990b) to "capture", store, and alter video images of the patient at predetermined times during the treatment sequence. A relatively inexpensive computer-video image processor along with a standard composite video camera and standard VHS unit to record and modify patient images can be used to assist in the diagnostic and fabrication phase of maxillofacial prosthetic therapy.

The patient's image is recorded with the video camera at the initial appointment and at various stages of the treatment sequence. The video camera is transferred and connected to a Macintosh II computer or the video tape is removed and placed in the VHS unit. The ColorCapture or PhotoMac Edit program is open and the tape is previewed via the second monitor to determine the best possible image to use. The images are captured in real time in 1/30 second via the frame-grabber board. Once captured, the image is saved in the 8-bit PICT-r format. The PICT-2 format saves a custom 256-color plate along with the image allowing the image to be transferred to any other PICT-2 wise application. The image can then be reopened in the color graphic software where the contralateral structure, for example, the orbit, could be copied, flipped horizontally, cut, and superimposed over the defect. The result is the production of an accurate copy of the patient's normal orbit superimposed over the surgical defect.