Endosseous implants in Maxillofacial Prosthetics

Limitations of prosthetic intervention

Alterations in maxillofacial anatomy result in diverse physical and emotional responses from the patient.[1] [2] The reasons for these responses are varied, but cosmetic changes, loss of function and discomfort are usually the major sources of concern.

It is unlikely that any prosthetic replacement can duplicate what nature provides from both a cosmetic and a physiologic standpoint. Cosmetically there must be matches in hue, chroma and value of the lost tissue while also considering tissue texture, size, shape and contour. Placement of a prosthesis in an area that is the focal point for most human contact, the face, serves to complicate the matching process even more. When the societal emphasis on physical appearance is considered, it is evident that maxillofacial defects may have the potential to be emotionally traumatizing.

The physiologic function of natural structures cannot be totally duplicated. In some instances, such as in the prosthetic replacement of an eye, all function is lost while in other instances, such as the replacement of a single missing tooth, there is little functional deficit. Prediction of the functional deficit prior to surgical excision of a diseased structure is complicated by the presence of a disease process that, in and of itself, creates a functional deficit. Pre-existing disease limits function because it is anatomically compromised. Removal of diseased structure will normally result in further functional loss but such a loss is not always the case. The exception occurs when the normal

anatomy is so altered by disease that it cannot function naturally. In such situations the removal of diseased structure may be regarded as a relief to the patient rather than a distinct disadvantage.

The human body is remarkably complex. Every tissue is dependent upon another tissue if physiologic function is anticipated. The skeleton, without ligaments, muscles and cartilage, will not remain erect. Musculature, without a controlling nervous system, is unable to perform purposeful activity. When considering the maxillofacial complex as an integrated system, it is clear that disruption of any of the components of this system has an effect on all of the remaining components. Physiologic deficits are easily understood since there are outward signs of the deficit but patient comfort is not easily perceived by an observer. When treating patients with maxillofacial defects, it is prudent for the clinician to anticipate altered sensations that may be difficult to overcome with conventional prosthetic methods. Patients should be provided with prostheses that avoid tissue irritation and are comfortable. Tissue irritation should be avoided. Retention that is dependent upon frictional contact can result in irritation that may cause alteration in the residual anatomy.

The prosthodontist assumes responsibility for the fabrication of prostheses that provide function, esthetics and comfort. As defects increase in size, or as the number of involved structures increase, the task of the prosthodontist increases in complexity. [3] [4] Optimal care is provided if residual anatomy is used appropriately.

Primary factors that affect prosthetic success

All prostheses must resist a variety of forces that may displace the prosthesis and generate stress to the residual structures of the orofacial complex. Forces may be directed towards, away from or at an angle to the supporting structure. Prosthesis success is often dependent upon methods of compensation for diminished anatomic capacity for support, retention and stability of a prosthesis.

In order to achieve a favorable level of **retention**, remaining teeth and the remaining soft and hard tissues must be used to the optimal degree. It is prudent to extend impressions as much as possible without interfering with movable tissue. Border molding is performed whenever a prosthesis depends on tissue support whether that tissue is located within the defect or is part of the remaining structures. In addition, close adaptation to the underlying tissue results in a thin fluid film between the prosthesis and the tissue. According to the Stanitz equation,[5] the thinner the intervening fluid, the greater the prosthetic retention.

Support is the ability to resist displacement of the prosthesis towards the supporting structures. Remaining teeth, remaining edentulous areas and the postsurgical defect are the supporting tissues for prostheses and prosthesis loads are generated through these tissues to the underlying supporting bone. Since the tissue has limited capacity for displacement, the greater the surface area of tissue contact, the less the displacement of

the prosthesis towards the tissue. In this situation, maximum peripheral extension combined with an accurate adaptation to the remaining teeth, the residual ridges and the postsurgical site will provide the most favorable support for prosthesis.

Resistance to forces that are neither directed towards the tissue nor directed away from the tissue is provided by the remaining teeth, the residual ridges and the surgical site itself. This characteristic of a prosthesis is called **stability** and it is the physical force that is called upon most frequently in maxillofacial prosthetics because alteration in the normal structures results in diminished potential for support and retention. Since the majority of forces are not directed towards or away from the tissue, but generated at an angle to the tissue, it is stability that is tested most frequently in function.

Residual anatomy, in the form of teeth, residual ridges or the contours of the defect may provide retention, support and stability to maxillofacial prostheses. With distortion or loss of normal anatomic structures, the ability to maximize these goals is diminished. When teeth are lost, prostheses generally lose capacity to fulfill the stated objectives of comfort, function, esthetics and preservation of the residual anatomy. As functional demands are placed on the residual anatomy, the response is one of further deterioration of the underlying foundation. Atwood [6] described this chronic, progressive and relentless deterioration of the underlying structures relative to the use of complete dentures but this structural loss may be even more evident when maxillofacial prostheses are needed.

Historically, the continuing loss of supporting structures left patients with increasing levels of physiologic and cosmetic deficiency. Compensation for unfavorable anatomy generally requires surgical alteration of the defect area, alternative methods of external fixation, mechanical engagement of tissue undercuts or the use of denture or skin adhesives. Although these methods have been beneficial when alternatives do not exist, none of them have been absolutely predictable. [7]

An alternative method of prosthetic retention has been developed. [8 9] Endosseous implants may be used to address the concerns of diminished support, retention and stability (Fig.1). Implants are placed into the residual bone and are then used for retention and stability of a prosthesis. Efficacy of implant support has been established in the restoration of the edentulous and partially edentulous jaws and it appears that similar responses are possible in congenital, developmental and acquired maxillofacial defects. [10] [11] Use of similar implants in extraoral sites is growing in popularity especially for the retention of auricular prostheses and for bone anchored hearing aids (Fig. 2). [12 13 14]

Unfortunately, the use of endosseous implant support in maxillofacial defects can be complex. As seen in most maxillofacial prosthetic patients, alterations in normal anatomy reduce the opportunities for the clinician to place and restore endosseous implants. This situation occurs when supporting bone is lost due to surgical resection or when tissue is altered due to therapeutic modalities such as radiation.

Since endosseous implants lack clinical mobility, force equalization and compensation for prosthesis displacement, use of these implants clinically may be difficult. Prosthetic designs and strategic implant placement must anticipate the functional demands of the prosthesis while also recognizing the dislodging forces applied to the prosthesis. Excessive force application to the implants is possible since the masticatory forces are generally applied to nondefect areas of the jaw which may also be the only possible location for implant placement. With localized implant placement only there is a risk of lateral force application. Such forces have been implicated in bone loss, implant loss, and prosthetic retaining screw complications. [15] [16] [17] [18]

When considering maxillary defects, implants are of great benefit in providing retention but their use for support and stability may be risky. Because dislodging forces can be anticipated the design of the prosthesis is modified to resist these forces. Since the fracture strength of the implant components should be known to the clinician, it is reasonable to design the prosthesis to provide retention that is below the level of component breakage and to disengage before breakage is likely. Unfortunately it is more difficult to anticipate the biting forces of the patients, especially when these forces may not be generated in the long axis of the implant. [19] [20] Mastication could provide forces that exceed the physical properties of the implant or the prosthetic components.

With extraoral defects, support and stability of the prosthesis is unlikely to overstress the implants. Similarly, retention of the extraoral prosthesis is limited to the resistance of gravitational forces. [21] [22] The weight of the prosthesis must be resisted but the weight is

quite limited. Movement of the head, jaws and facial musculature must also be considered but none of these forces approach the levels of force encountered with intraoral prostheses. Therefore, extraoral prostheses supported by endosseous implants should require a reduced number of implants relative to prosthesis size when compared to intraoral prostheses.

Auricular Prostheses

Prosthetic replacement of the missing or altered ear can provide excellent cosmetic results. Unfortunately, the presence of hair and the absence of anatomic irregularities often result in unfavorable adhesive retention of an auricular prosthesis. Endosseous implants, specifically designed to be placed in the temporal bone, permit positive retention of auricular prostheses (Fig. 3). Patients also benefit from the positive seating of the prosthesis over the implants. The main complication in this area is related to the difficulty in maintaining adequate hygiene around the skin penetrating implants (Fig.4). Holgers [23]reports adverse tissue reactions in approximately 11% of the patients receiving these implants. Although soft tissue reactions rarely jeopardize the long-term survival of the implants, it can create an uncomfortable situation which may require surgical intervention and, at the least, increased hygiene needs. [24]

Endosseous implants may also be used to secure bone conduction hearing aids. The BAHA (Bone Anchored Hearing Aid) has demonstrated efficacy in patients with intact middle ear components but with damaged external ear structures. [25 26]

Nasal Prostheses

Nasal resection is a highly variable treatment. Surgical margin extension is different for every patient, making general statements regarding the use of implants in this area difficult. Clearly the total or near total resection of the nose creates difficulties for the maxillofacial prosthodontist. Prostheses must be extended to surrounding areas to provide for skin adhesive retention thus making these prostheses large with dislodgment possible dependent upon the level of physical activity of the patient. Engagement of the defect itself may be possible only if highly resilient materials are used for this purpose.

Implant success is highest when implants are placed into the superior surface of the maxilla and are used to retain the inferior aspect of the nasal prosthesis (Fig. 5). [27] Unfortunately the bone quantity and quality in the glabellar region of the frontal bone is limited and implants at the superior aspect of a nasal defect usually cannot be placed. Because implant retention is possible at the inferior aspect of the prosthesis only, it is critical that the design of the retentive elements of the prosthesis incorporate two planes of retention. Generally a "U" shaped retentive bar, connected to the implants at the base of the "U," will provide three points for retention, the two vertical struts and the horizontal crossbar.[27] Retentive clips are most often used to secure the prosthesis.

Orbital prosthesis

Small orbital defects may not be suitable for implant supported restorations (Fig. 6). In smaller defects adhesive retention of the prosthesis may be satisfactory and the limited

size of the defect may prevent implant placement without interference with the prosthesis margins. [28 29 30]

As orbital defects increase in size, the need for implant support becomes greater (Fig. 7). This need is particularly true when orbital defects are confluent with facial and nasal defects. In those situations the implants are generally located in the supraorbital rim or in the lateral rim of the residual orbit. Medial placement of the implants is discouraged due to diminished bone quantity and quality in this area and the associated lowered implant survival rates in bone of low quality. [31 32]

Mandibular defects

Mandibular discontinuity subsequent to tumor ablative surgery is effectively managed by immediate (Fig. 8) or delayed (Fig. 9) surgical reconstruction to re-establish continuity. The reconstructed mandible will be edentulous in the graft site. Endosseous implants in this grafted bone will allow the placement of a dental prosthesis that does not create deleterious compressive forces on the graft (Fig. 10). [33] Internal loading of the graft results in bone preservation, a situation that would otherwise not occur if transmucosal loading of the underlying bone were to occur.

If mandibular continuity is not re-established the functional capacity of the patient is diminished. [20] The mandible will deviate towards the side of the resection because of cicitricial changes in the surgical site and because of absent musculature on that side. This treatment group also shows a high level of functional variability but it can be said

that patients with good control of the residual mandible generally perform better than patients who lack such control. As patients experience tooth loss, management of removable prostheses in conjunction with manipulation of the residual mandible may prove difficult. In these situations the use of endosseous implants is quite effective since dental prostheses will gain retention, support and stability from the implants. Force application to the implants must however be considered carefully.

The resected mandible which has not been reconstructed will have a deviated opening and closing arc (Fig. 11). The angle of mandibular closure will place forces on the implants that are not in line with the long axis of the implants. This situation is offset somewhat by the fact that maximum biting force with the resected mandible is diminished from normal. Clinical experience with fixed implant supported mandibular resection prostheses has shown promising results despite the concerns over the angular force application.

Hard and soft palate defects

Surgical resection of tumors in the maxilla often results in communication between the oral and nasal cavities. These communications must be closed if the patient is to experience normal or near normal functions of phonation, deglutition and mastication. Obturator prostheses supported and retained by the residual natural dentition have a long history of successful clinical application. Loss of supporting teeth however results in compromises in prosthetic retention and support. Relatively large obturator prostheses place substantial forces on the residual structures. When implants are used to retain such

prostheses it is essential that the different forces be considered (Fig. 1,12). These prostheses will have a tendency to rotate into the defect area when occlusal loads are placed on the defect side and they will have the tendency to rotate out of the defect area as gravity exerts its pull on the prosthesis. [34] Although it is possible to gain support and retention within the defect, it is often less satisfactory than might be hoped.

Endosseous implants in residual maxilla must be of sufficient number, length and distribution to resist the anticipated complex forces from mastication and dislodgment. The use of four implants in the intact maxilla has been suggested as the minimum number for the support of overdenture prosthesis. [35] The force distribution in the hard palate defect patient is likely to be less favorable than in the edentulous maxilla, consequently it is prudent to consider four or more implants when an obturator prosthesis is to be retained and supported by endosseous implants. If the implants can be distributed bilaterally, more acceptable forces will be generated to the implants and there will be better retention and stability of the prosthesis (Fig.13).

Soft palate defects are normally associated with bilateral maxillary support. Once again, as natural teeth are lost implants may improve prosthesis prognosis. Since occlusion is not a consideration in soft palate defects, the primary function of implants is to retain the prosthesis and to support the occlusion that is more directly placed above the implants themselves. Implant placement should consider retention and indirect retention of the prosthesis with broad distribution of implants providing more favorable long-term prognosis.

Conclusions

Patients with facial or intraoral defects will seek treatment to address the loss of comfort, function or natural appearance. It is maxillofacial prosthodontist's responsibility to provide prostheses that do not injure the remaining structures. As anatomy is altered, demands on residual structures increase. Endosseous implants may be used to provide retention, support and stability for maxillofacial prostheses when the residual anatomy is not longer capable of fulfilling these functions.

Legends

Figure 1. Endosseous implants in place in edentulous maxilla with left surgical defect.

Figure 2. Endosseous implants in place in the orbital region in addition to the maxilla and mandible.

Figure 3. (A)Endosseous implants and bar splint in place to retain an auricular prosthesis. (B)Internal surface of auricular prosthesis. Note retentive clips in place in an acrylic resin superstructure which is included within the auricular prosthesis. (C)Auricular prosthesis in place.

Figure 4. Localized skin inflammation around endosseous implant abutments.

Figure 5. (A)Endosseous implants in place in superior surface of maxilla for retention of a nasal prosthesis. (B)Internal surface of nasal prosthesis with bar splint with associated magnet pods. (C)Internal surface of prosthesis with magnets in place.

Figure 6. Orbital defect is too small to accommodate implant abutments and retentive bar without compromising position of the ocular portion of the prosthesis.

Figure 7. (A)Lateral orbital and nasal implants in place with bar splint with magnet pods. (B)Internal aspect of prosthesis with magnets in place. (C)Combined orbital/nasal prosthesis in place.

Figure 8. Immediate reconstruction of the mandible with fibula graft with subsequent placement of dental implants.

Figure 9. (A)Delayed reconstruction of the mandible with subsequent placement of dental implants. (B)Prosthesis in place.

Figure 10. (A)Two implants in mandible with discontinuous defect. Note deviation of mandible towards defect. (B)Overdenture in place.

Figure 11. (A)Abutments and bar splint in place on endosseous implants shown in Fig. 1. (B)Internal surface of obturator prosthesis with retentive clips in place and additional sites availabel for ERA attachments if needed. (C)Prosthesis in place.

Figure 12. (A)Bilaterally placed implants in maxillary defect with bar splint in place. (B)Internal surface of obturator prosthesis with retentive clips in place. (C)Obturator prosthesis in place.

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