

Textbook of Oral and Maxillofacial Surgery

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Chapter 8

Preprosthetic surgery

Louis H Guernsey

In a *Time* magazine essay, it was noted that 20 million people in America are older than 65 years of age and that the aged have grown to represent approximately 10% of the total population. Actuaries have emphasized that the American life-span can be expected to increase as a result of public health measures, research, and the high quality of medical care that are the earmarks of our nation. Already the US population of persons older than 75 years of age is increasing at two and one-half times the rate of the general population. This large, superaged citizenry, living in an era of social consciousness in which health and health care are believed to be rights that are to be guaranteed and even underwritten by government, will certainly create a colossal prosthetic restorative problem.

Prosthodontics aims to restore the functional and esthetic portions of the gnathological system that have been lost or are congenitally absent. Since a denture can be no better than its foundation of basilar bone with its proper tissue cover, it is axiomatic that every effort should be made by the dentist to prepare, improve, preserve, and reconstruct the jaws for prolonged denture wearing.

Many dentures that are worn with discomfort, annoyance, and embarrassment could be made comfortably functional if surgical alterations were accomplished to improve denture wearing.

Edentulous Ridge Criteria

Goodsell outlined the criteria for prosthesis in an ideal edentulous mouth. Following are the criteria of an ideal edentulous ridge:

1. Adequate bony support for dentures.
2. Bone covered by adequate soft tissue.
3. No undercuts or overhanging protuberances.
4. No sharp ridges.
5. Adequate buccal and lingual sulci.
6. No scar bands to prevent normal seating of a denture at its periphery.
7. No muscle fibers or frenums to mobilize the periphery of the prosthesis.
8. Satisfactory relationship of the maxillary and mandibular alveolar ridges.
9. No soft tissue folds, redundancies, or hypertrophies of the ridges or in the sulci.
10. Freedom from neoplastic disease.

Corrective Surgical Procedures

A large number of oral surgical procedures have been advocated to achieve the previously listed prerequisites. Recently a great amount of emphasis has been placed on ridge extension procedures. However, little attention has been given to surgical attempts to alter, improve, or replace faulty ridge-covering tissues with a functioning masticatory mucosa or skin. The principles of oral plastic surgery - gentle handling of tissues, preservation of blood supply, and prevention of infection - are particularly applicable to this type of surgery.

Corrective procedures necessary to prepare the edentulous ridge for prosthesis can be divided into two basic groups with respect to time of surgery: *initial preparations* and *secondary preparations*. *Initial preparations* of the edentulous ridge occur at the time of tooth extraction or at the time of the first denture insertion. This group can be further subdivided into preparations to correct soft tissue and hard tissue deformities. Soft tissue preparation includes procedures to eliminate frena, scars, and high muscle attachments and to resurface the basilar bone with a new tissue covering; hard tissue preparation includes procedures for alveoloplasty, tori removal, and sharp ridge removal, which includes lingual shelf reduction. Correction for combined soft and hard deformities includes procedures for tuberosity alteration and reduction. These procedures are mostly supportive in nature.

Secondary preparations of the ridge occur after a period of protracted denture wearing during which excessive atrophy, scarring, or injury have caused a marked change in the basilar bone and its covering tissues, thus negating successful denture wearing. This group can also be further subdivided into soft tissue and hard tissue preparation. This preparation includes elimination of epulis fissuratum and scars, correction of reactive inflammatory papillary hyperplasia of the palate, ridge extension, and ridge augmentation in the maxilla and mandible. Special attention will be given to ridge extension and ridge augmentation procedures.

Initial preparations

Soft tissue deformities and corrective procedures

Soft tissue preparation of the edentulous ridge involves correction of soft tissue deformities. Deformities such as high muscle attachments and frena can occur normally, but they are usually found when excessive atrophy has decreased alveolar height. Scars can be residuals of previous periodontic, endodontic, or trauma surgery.

Correction is begun by transverse incision across and a supraperiosteal dissection of the attachment, followed by downward displacement and suturing of the muscle to the periosteum with No 3-0 Dexon (polyglycolic sutures) in the new position. Additional stabilization is obtained by overextending the denture periphery with dental compound and guttaform or zinc oxide impression paste to support the attachment in this new position. Obwegeser states that if there are three or more high muscle attachments or frena, consideration should be given to submucosal vestibuloplasty in the maxilla or to vestibuloplasty with skin graft in the mandible.

Other useful corrective methods include Z-plasty, V-Y-plasty for lengthening tissue, Y-V-plasty for shortening tissue, and cross-diamond excision of frena.

Hard tissue deformities and corrective procedures

Alveoloplasty. With alveoloplasty only the protuberances that prevent insertion of the denture or retard healing are removed.

Conservatism should be the paramount guide. Minimal raising of attached gingiva is accomplished (whether labially, lingually, or palatally) so that a minimum of the underlying bone is exposed. Wide retraction of tissues increases bony resorption and obliterates sulci.

In single tooth extraction with early loss of adjacent teeth, the collar of bone around the tooth must be reduced at the time of extraction. Labial, lingual, and palatal sharp edges should be reduced to provide a U-shaped ridge. Bone should not be sacrificed for primary tissue closure.

During the procedure, inflamed or excessive interdental and interradicular tissue should be trimmed and removed. Copious irrigation with normal saline and final palpation and inspection should accompany the procedure to assure removal of debris and to ascertain smoothness of the bony base. Suturing with No 3-0 silk or Dexon should be done across the interseptal bone while the assistant supports the sulcus superiorly with a retractor.

Radical alveolectomy has a minimal role in special preparations of the mouth for specific conditions. Correction of severe overbite and overjet can best be obtained by extensive labial removal of the buccal and interseptal bone or by interseptal alveolectomy.

Radical alveoloplasty is performed in patients with oral cancer who are to undergo radiation therapy as a part of the preoperative therapy for their cancer. In these patients periodontally involved, devitalized, and extensively restored teeth and teeth that are going to be in direct path of the radiation are removed. Radical alveoloplasty of bone is accomplished at surgery to contour the bone to the level achieved by subsequent normal healing and atrophy. It has been noted that interseptal and alveolar bone that has been irradiated will not remodel itself, which expose a nonrecontoured ridge, can predispose the ridge to radio-osteomyelitis of the jaws.

Torus removal. Tori have no pathological significance, but occasionally they are misdiagnosed as tumors, thereby alarming patients. Tori that are impinged on by a prosthesis are sources of painful chronic irritation that can invite infection or denture failure or both or even become an etiological factor in oral malignancy.

Maxillary Tori. Maxillary tori should be studied by a true lateral radiograph to rule out the possibility of pneumatization of the tori. Removal of such tori could lead to an iatrogenic oral-nasal opening (traumatic cleft palate).

Indications for removal include a large, lobulated torus with a thin mucoperiosteal cover extending posteriorly to the vibrating line of the palate that prevents seating of the denture over the mass and prevents posterior seal at the fovea palatini.

The technique for removal of the torus is as follows: The maxillary torus should not be excised en masse to prevent entry into the nose but should be subdivided into segments by a bur. The segments are then removed with an osteotome, and protuberances are finished down smooth with a bone file or a Hall Surgairtome under a constant stream of coolant. The flap is trimmed and loosely sutured.

The palate should be covered to prevent hematoma formation and to support the flap and is best covered by a palatal splint fastened to the teeth by clasps or by ligation with stainless steel wire. The splint remains in place for 48 hours at which time it is removed to clean and inspect the wound. It is then worn as a bandage over the operative site until healing is satisfactory. The splint is removed, however, after each meal for cleansing and oral hygiene measures.

Mandibular Tori. Mandibular tori occur primarily in the area lingual to the bicuspid. They are usually bulbar, can be single or multiple, and occasionally coalesce to form a thick lingual exostosis extending from the cuspid posteriorly to the second molar.

The removal technique of mandibular tori is described. Placement of the incision over the crest of the edentulous ridge or around the necks of the teeth is important to afford proper closure. The incision should be long enough to encompass the entire torus and then extended beyond this to avoid tearing of the usually thin flap. Only the full thickness of the mucoperiosteum on the lingual side is reflected. The labial tissues are not freed, providing a stable labial tissue for closure and preventing loss of sulcus depth.

A trough is cut by bur in the exposed torus to develop a plane from which the torus should split. A single-beveled osteotome with the bevel directed away from the cortex is placed in the cut, and the torus is split off by a sharp blow with a mallet. Bony smoothing is accomplished with a bone file or, if space permits, a rotating bone bur or both. The area is irrigated with normal saline. Closure is accomplished with interrupted No 3-0 silk or Dexon sutures, and a clear acrylic splint is placed lingual to the teeth to prevent hematoma formation. Splint care is the same as for maxillary tori.

Sharp ridge removal. Sharp, sawlike edentulous ridges are a common cause of denture discomfort. The ridge is usually obscured by movable redundant tissue overlying the crest. Heavy finger palpation or underexposed x-ray films or both will reveal the sharp excrescences.

Removal is initiated by placing the incision through periosteum labially to the crest of the flabby ridge and reflecting the mucoperiosteum minimally to preserve the vestibule. Bony trim is accomplished with rongeur, files, or surgical burs and involves only the sharp spines and knifelike bone. A maximum of 1 or 2 mm need be removed, since resorption during healing accounts for further loss. The flabby excess tissue is resected and sent to the pathologist. Closure is done with No 3-0 silk or Dexon sutures. Additional tissue support is afforded by relining the patient's denture with periodontal pack or soft acrylic.

Shelf Reduction. Shelf reduction involves the sharp mandibular lingual shelf that houses the third molar and the mylohyoid ridge, which, although normal anatomy, becomes relatively more pronounced with extreme atrophy of an edentulous mandible. Increasingly prosthodontists are extending the flanges of mandibular dentures lingually to increase stability and decrease lateral stresses. This requires the elimination of the naturally occurring undercut in the lingual shelf area. Significant ridge extension in this area can also be obtained by using techniques suggested by Trauner, Obwegeser, and Caldwell.

The reduction of the shelf is predicated on the fact that mandibular bone contains a grain similar to wood and that the grain direction is known. This permits the surgeon to split bone off predictably for removal of the shelf.

The procedure for shelf reduction is as follows. A special bite block with a self-retaining tongue retractor is used. Incision is made through the periosteum from the ridge crest laterally and superiorly onto the external oblique ridge. The periosteum is first detached buccally; a No 4 Molt curet is then inserted into the lingual space under the retromolar pad. At this point, care is exercised to not damage the lingual nerve. The lingual shelf is widely exposed by stripping the periosteum anteriorly. The lingual nerve and Wharton's duct are protected with a Lane retractor.

The shelf is chiseled free by placing a 1 cm, single-beveled osteotome parallel to the anterior border of the ascending ramus and driving the chisel downward and lingual to split off the bone shelf. Significant bleeding can be encountered as the mylohyoid muscle is detached from the bone. Further trimming and smoothing is done with a bone bur or file to eliminate sharp spicules in the pterygomandibular space.

The wound is irrigated copiously with saline, followed by a loose closure of the tissues using No 3-0 silk or Dexon. Downward repositioning of the tissue can be maintained by placing a rubber No 14 French catheter in the floor of the mouth and passing over it a No 2-0 Tevdek suture that has been passed through to the skin with an awl. The sutures emerging on the skin are tied over a cotton roll or buttons and allowed to remain in position for 5 days.

Pain on swallowing and edema of the floor of the mouth are the exposed postoperative sequelae. This expected edema poses no significant threat to the airway. In more extensive procedures, edema can be controlled about the floor of the mouth and medial aspect of the mandible by using preoperative, interoperative, and postoperative dexamethasone (Decadron).

Mylohyoid Muscle Release. As noted previously, mylohyoid muscle release is commonly a part of lingual shelf reduction since the posterior portion of the insertion of the muscle extends distally to the lingual shelf. Mylohyoid muscle release per se is indicated as part of preprosthetic surgery in two instances: (1) when the mandible is atrophic and the floor of the mouth tissues protrude above the crest of the ridge and (2) as surgical preparation for the insertion of the mandibular bone plate prosthetic fastener system. The surgical technique for the muscle release procedure will be detailed later in this chapter under floor of the mouth lowering with skin graft vestibuloplasty.

Combined soft and hard tissue deformities and corrective procedures

Tuberosities. Enlarged tuberosities of the maxilla can accompany submucosal fibrous hyperplasia or be the result of true bony enlargements that interfere with denture seating because of excessive undercut or impingement on the intermaxillary space. Correction is accomplished by wedge resection of the fibrotic tissue down to bone over the crest portion of the ridge, followed by submucous resection of this tissue from beneath both the buccal and palatal flaps. In this palatal undermining, care should be taken to avoid the palatine artery. Excess or undercut areas in bone are removed with rongeurs or surgical burs, irrigated, and smoothed with files. When the desired bony base contour is achieved, excess tissues are trimmed to afford closure without tension. Closure is made with No 3-0 silk sutures left in place for 5 days.

Tuberosity Reduction, Lateral Approach. A modification of tuberosity reduction using a lateral rather than crest-of-the-ridge incision has been designed to conserve the limited amount of keratinizing mucosa overlying a narrow tuberosity, thus saving it for local advancement vestibuloplasty at the end of the operation. An incision to bone is made on the

lateral side of the maxillary ridge from the tuberosity anteriorly but inferiorly enough to pass below the malar buttress. A relaxing incision is extended down onto the crest of the ridge anteriorly and posteriorly as needed to obtain tissue relaxation. The thickened fibrotic tissue overlying the bony tuberosity is elevated with periosteal retractors, and a submucosal excision of the fibrotic tissue is accomplished. The sulcus is extended superiorly from the height of the lateral incision by submucosal dissection as needed to deepen the sulcus. The palatally based keratinizing mucosa flap can now be advanced to cover the bone and line the new sulcus where it is sutured to periosteum with No 3-0 Dexon. A maxillary denture splint with extended periphery is immediately introduced to stabilize the tissue in the new position.

Tuberoplasty. This procedure, advocated by Obwegeser, is specifically designed to increase the depth between the hamular notch and the distal aspect of the maxilla. It is particularly useful for creating a space in a flat maxilla when extreme atrophy has caused complete loss of the tuberosity for the denture flange to rest on.

This is usually a general anesthesia, operating room procedure, since hemorrhage from the pterygoid venous plexus can be significant. The operative technique is as follows. The area is infiltrated with 2% lidocaine with a 1:100,000 solution of epinephrine for hemostasis. An incision is made over the hamular notch, and the mucosa of the soft palate is undermined and mobilized. The tissue overlying the hamular notch is dissected down to the bone with curved scissors. A 1 cm osteotome is introduced into the area until it encounters bone; then it is driven into the bone, fracturing the pterygoid plate loose to a depth of approximately 1 cm. Bleeding is usually profuse at this time and can be controlled by saturating a 1-inch selva gauze with a 1:50,000 epinephrine solution and packing it, under pressure, into the wound. Once hemostasis is obtained, the undermined mucosa is sutured at the depth of the tuberosity with a fishhook needle and No 3-0 chromic gut or No 3-0 Dexon to the remnants of the pterygoid muscle. The exposed bone of the distal aspect of the maxilla can be covered by secondary epithelization or, if desired, by a split-thickness skin graft. Should difficulty be encountered with the suturing method just described, an awl carrying a No 3-0 Dexon suture can be passed through the sinus, exiting at the level of the posterior tuberoplasty. This will afford an excellent means for pulling the tissue downward into the newly created space. Healing continues for at least 1 week before a temporary denture can be worn.

Secondary preparations

Epulis fissuratum and corrective procedures. Soft tissue trapped between an ill-fitting denture flange and the underlying bone will lead to tissue fibrosis and scarring of the sulcus, which is known as epulis fissuratum. Traumatic occlusion of natural teeth opposing an artificial denture is also a cause. Severe scarring of the sulci is also seen in acute trauma injuries incurred in auto accidents and gunshot and mortar fragment avulsive injuries.

Correction of epulis fissuratum is accomplished by excising the fold, if small, or by sharp submucosal dissection to develop a flap and then by sharp submucosal excision of the scarred tissues. The flap is sutured to the periosteum so as not to lose vestibular height.

In severe scarring or avulsive wound cases or both, the method just described frequently fails because of extensive contracture relapse, which further decreases the vestibule height. In these cases the epulis is excised, the vestibule is extended supraperiosteally, and a free mucosal palatal graft is placed in a manner similar to that described for ridge extension procedures. If a small graft is placed, it can be protected and stabilized with isobutyl cyanoacrylate or a special denture splint to protect the graft site.

Reactive inflammatory papillary hyperplasia of the palate. Reactive inflammatory papillary hyperplasia of the palate is commonly associated with prolonged wearing of an ill-fitting, maxillary, full or partial denture or with relining or remaking the denture over a preexisting papillomatosis, which perpetuates the condition. Day and night wearing of a denture and poor or ill-timed oral hygiene measures (such as allowing food to remain for long periods in the denture), are important contributing causes. The condition is recognized as reddened, nodular, or papillary excrescences arising from the palatal mucosa. It is occasionally found over the ridge and in labial or buccal sulci.

Removal can best be accomplished with the patient under sedation or nitrous oxide-oxygen analgesia and local anesthesia, using a fully rectified electrosurgery unit and a loop electrode. Depth of removal is to the submucosa. The proper depth is determined by the absence of the "wheathfield-in-the-wind" effect when the tissues are subjected to a stream of compressed air. The yellow-gray color of the submucosa is a useful guide to adequate depth of removal. Penetration of the periosteum must be avoided to prevent a bony slough, resulting in delayed healing. A biopsy of the affected tissue is performed toward the end of the procedure, and the tissue is sent to the pathologist to confirm the diagnosis.

A palatal splint lined with special periodontal pack is used to minimize postoperative bleeding and pain. The splint is allowed to remain in place (except for oral irrigations for hygiene purposes) to allow for a good start of granulation to occur. The dressing is changed weekly under a topical anesthetic to allow for healing by granulation and secondary epithelization.

Postoperatively, pain lasting for 1 week can be severe. A narcotic analgesic is prescribed. Hemorrhage can occur for 5 to 7 days postoperatively when eschars soften and break loose during eating or oral hygiene measures. This is controlled by pressure on the splint, a sponge saturated in sodium hypochlorite solution, or anesthetizing the palate adjacent to the bleeding site to achieve vessel pressure and vasoconstrictor effect. Between 3 and 5 weeks is required for healing prior to the new denture construction period.

Ridge Extension Procedures

The goal of ridge extension is to uncover existing basal bone of the jaws surgically by repositioning the overlying mucosa, muscle attachments, and muscle to a lowered position in the mandible or to a superior position in the maxilla. The resultant advantage is that a larger denture flange can be accommodated, thus contributing to greater denture stability and retention.

Not all cases of maxillary or mandibular basal bone atrophy can be surgically treated by sulcus extension. There must be adequate alveolar bone with sufficient height remaining to allow for repositioning of the mental nerves and the buccinator and mylohyoid muscles in the mandible. In the maxilla the anterior nasal spine, the nasal cartilage, and the malar buttresses may interfere with repositioning the sulcus superiorly.

Conversely not all cases require a full skin or mucosa graft vestibuloplasty with floor of the mouth lowering. Many cases have success with a vestibular extension anterior to the mental foramina or a lingual procedure to reduce the genial tubercles or release the mylohyoid muscle posteriorly in the floor of the mouth, which may well solve the problem of lack of denture stability and retention.

Principles of plastic revision of tissues

Many basic and well-known procedures have been recommended to correct the many oral abnormalities encountered. However, the principles of plastic revision of tissue must be understood before these procedures are discussed. According to Ashley, these principles are as follows:

1. Bare soft tissue should be covered surgically with epithelium to prevent subsequent contracture.
2. Whenever local tissue is not available to obtain the anticipated final result or to cover the defect without tension, distant tissue should be used.
3. In creating a new cavity, allowance should be made for contracture whenever the cavity is lined with remote grafted tissues or local flaps. Contracture is usually prevented by overcorrection of the cavity defect without tension on the lining tissues.
4. The greater the thickness of split-skin grafts, the lesser the tendency for contracture.

Review of the literature

Kruger in an excellent review article in 1958 evaluated the Kazanjian, Clark, and Collett vestibular extension techniques and the lingual approaches of Trauner and Caldwell. He found that the main differences in techniques lie in the location of the incision, which was either over the crest of the ridge or in the lip and buccal mucosa, and in whether the periosteum was incised and retracted. The techniques of Clark and Kazanjian were more difficult to accomplish than Collett's full-thickness pushback of the mucoperiosteum, supported in its new position by an appropriately extended denture periphery. In comparing the techniques of Clark and Kazanjian, Kruger concluded that placement of the incision made little difference in the result. There was in all cases an obliteration of the artificially created new sulcus by contracture from the bottom, which occurred early, usually before placement of the final denture. This was also confirmed in a study by Spengler and Hayward who used these techniques on dogs.

The location of the surgical scar in the sulcus in the Kazanjian technique was considered helpful or detrimental to denture retention by various prosthodontists.

The following outline lists ridge extension procedures with appropriate references to publications containing detailed reviews. Only those operations that have given the best results will be described in more detail later in the chapter.

I. Maxillary procedures

A. Buccal approach

1. Secondary epithelization vestibuloplasty
 - a. Full thickness mucoperiosteum dissection - Collett
 - b. Submucosal dissection, periosteum intact - Szaba
2. Submucosal vestibuloplasty - Obwegeser, Yrastorza
3. Ridge skin grafting vestibuloplasty - Weiser, Schuchardt
4. Buccal sulcus skin grafting - Esser, Gillies
5. Ridge mucosa grafting vestibuloplasty - Obwegeser, Steinhäuser, Maloney and associates

II. Mandibular procedures

A. Buccal approach

1. Submucosal dissection, periosteum intact
 - a. Secondary epithelization vestibuloplasty
 - (1) Incision in lip mucosa - Kazanjian
 - (2) Incision over the crest of ridge - Clark
 - b. Ridge skin grafting vestibuloplasty - Obwegeser, McIntosh and Obwegeser
 - c. Mucosa grafting vestibuloplasty - Propper, Nabers, Hall and O'Steen, Maloney and associates, Shepherd and associates, Guernsey
2. Full thickness mucoperiosteum dissection
 - a. Incision in lip mucosa - Godwin
 - b. Incision on crest of ridge with mental nerve lowering and lingual frenotomy with genioglossus transplant - Cooley
 - c. Incision in lip mucosa and incision of periosteum over the crest of the ridge - Edlan
 - d. Ridge skin grafting and incision on crest of ridge, with genial tubercle removal and repositioning of genioglossus and geniohyoid muscles - Anderson

B. Lingual approach

1. Submucosal dissection, periosteum intact
 - a. Secondary epithelization
 - (1) Lingual sulcus extension with resection of mylohyoid muscle and with or without lingual skin graft - Trauner
 - (2) Floor of mouth lowering - Trauner, Obwegeser
 - (3) Sublingual ridge extension with free mucosa graft - Lewis
2. Full thickness mucoperiosteum dissection
 - a. Lingual sulcus extension with resection of mylohyoid ridge, mylohyoid muscle, and lingual flap cover of bone - Obwegeser
 - b. Lingual ridge extension - Caldwell
 - c. Lingual sulcus extension with free skin graft - Ashley

C. Labiolingual approach

1. Submucosal approach, periosteum intact
 - a. Anterior buccal and sublingual sulcus extension with fenestration procedure - Baurmash
 - b. Ridge skin grafting vestibuloplasty combined with total lowering of floor of mouth - Obwegeser.

Recommended procedures

Maxillary procedures

Submucosal Vestibuloplasty

Indications. This procedure is indicated for patients with a small clinical ridge and healthy overlying mucosa and without excessive submucosal fibrosis, hyperplasia, or scarring. A useful test to determine whether there is sufficient mucosa to warrant sulcus extension is to push a mouth mirror superiorly into the labial sulcus. If the upper lip is significantly

inverted or drawn superiorly, there is insufficient mucosa for this type of vestibuloplasty. Submucosal vestibuloplasty should be performed in the operating room using general anesthesia.

Technique. The submucosal soft tissues are distended with local anesthetic solution, using 1:100,000 epinephrine solution for hemostasis and to facilitate the dissection. A midline vertical incision is made from the nasal spine to the incisive papilla. From this incision, dissection of the submucosa proceeds distally on either side (preferably with a Lincoln or small Metzenbaum scissors), separating the tissue inferiorly to the crest of the ridge and superiorly to restore good vestibular height. If the malar buttress cannot be negotiated blindly in this tunnel, another vertical incision can be made in the muco-buccal fold at the root of the zygoma, enabling the dissection to be completed posteriorly to the region of the tuberosity.

The next dissection frees the submucosal connective tissue from the periosteum. This is done by establishing a supraperiosteal plane and is best accomplished with curved scissors. The freed tissues now can either be repositioned superiorly to fill in a defect in the canine fossa or resected. The anterior nasal spine, if prominent or interfering with denture seating, is approached by the same vertical incision and is resected with an osteotome. The incisions are closed with No 3-0 Dexon. The patient's denture periphery is extended with dental compound and guttaform to the new vestibular height. Excess blood is then drained from the tunnel to prevent hematoma formation. The splint is fixed to the maxilla with peralveolar wires or nylon sutures. The stent is removed in 1 week, at which time impressions are made for immediate relining of the denture.

Secondary Epithelization Vestibuloplasty

Indications. According to McIntosh and Obwegeser, secondary epithelization vestibuloplasty is the procedure of choice for patients with extensive scarring or epulis fissuratum in the sulcus or who have good quality mucosa cover available without sufficient height.

Secondary epithelization vestibuloplasty requires supraperiosteal dissection of the mucosa to form a flap (similar to a periodontal mucosal flap for push-back procedure) and superior repositioning by suturing the flap high onto the periosteum. The exposed periosteum is allowed to granulate and reepithelize without benefit of cover from a denture.

Neidhardt studied a large number of cases in which this technique was used and found that 50% of maxillary cases relapsed in three years. This relapse incidence can reach 80% to 95% for patients subjected to this surgery in the mandible and is the reason for using skin or mucosa grafts to hold the repositioned muscles in their new position to gain a more acceptable, less frequent, contracture relapse incidence of 20% to 30%.

Free mucosa grafts transplanted from one site in the oral cavity to another are not new. Many authors have advocated their use for specific surgical problems. In my experience with patients suffering from war injuries to the maxilla, which result in extensive scarring and loss of substance, I have found that it is best to replace the lost tissue with like tissue whenever possible. Similarly Steinhauser has pointed out that skin-grafting extension vestibuloplasty in the maxilla has been unsatisfactory for denture retention and has instead recommended free cheek mucosa grafts, which provide an autochthonous vestibular mucosa that enhances denture adhesion.

Maloney and associates recommend free split-thickness mucosa grafts from the cheeks for all types of preprosthetic and oral reconstructive soft tissue procedures. Their method of obtaining split-thickness donor tissue will also be described below.

Although I agree with Steinhauser, I have found that masticatory, stress-bearing mucosa similar to attached gingiva works better for me. This mucosa can readily be procured from the covering of the hard palate. The palatal mucosa is an ideal tissue for stress bearing since it is keratinized, and therefore, it is the preferred transplant tissue to the maxilla when increased vestibular height is needed. With the new technique of fenestrating palatal mucosa grafts, small donor sources can be expanded to cover larger areas.

Buccal Mucosa Graft Vestibuloplasty

Technique. This is usually a general anesthesia operation in the hospital operating room, although a short-span, spot graft can certainly be an office procedure.

Preparation of the recipient bed involves submucosal infiltration with 2% lidocaine and 1:100,000 epinephrine solution to distend the tissues, provide hemostasis, and facilitate the dissection. Incision is made through the mucosa at the junction of the attached and nonattached mucosa from malar buttress to malar buttress. A supraperiosteal flap is developed by sharp dissection. It is carried superiorly and laterally from the canine fossa to the region of the infraorbital nerve. Anteriorly at the midline, the dissection approaches the pyriform aperture without perforating the nasal mucosa. The anterior nasal spine, if prominent, is removed as outlined previously.

The margin of the freed flap is sutured superiorly to the periosteum with No 4-0 Dexon so as to delineate the new vestibular height. This would normally complete the procedure for secondary epithelization vestibuloplasty, but the placing of a denture this raw tissue tends to accelerate secondary granulation and contribute to relapse. As previously mentioned, to avoid relapse the operator can use mucosa grafts to secure the repositioned flap.

The procedure to obtain the donor mucosa graft is as follows: The size of the donor mucosa is measured on the recipient site, using sterilized tinfoil. The foil is adapted to the palate, which was previously injected with 2% lidocaine and 1:100,000 epinephrine for hemostasis. The outline of the graft is incised down to the submucosa but above the periosteum. The submucosa dissection is started by mobilizing an end of the graft with a scalpel and maintaining it under tension with a skin hook. Once the graft is well mobilized, mucosa removal proceeds rapidly, using periodontal knives and strabismus scissors. The graft is severed at its base and stored in a saline-moistened sponge.

Hemostasis of the vascular bed is the first consideration after removal of the donor mucosa, since the palate contains many vessels. This is accomplished by electrocautery and ties as indicated. A previously prepared palatal stent or denture with an extended periphery is tested for fit.

After the graft is tried and measured to cover the recipient bed particularly at the height of the extended sulcus, it is trimmed and then tacked to the periosteum with No 6-0 Dermalon sutures when hemostasis has been meticulously achieved. This is the most delicate and time-consuming part of the operation. If the recipient bed has any tendency to ooze, horizontal mattress sutures are placed in the middle of the graft to hold it in place. The graft is further covered with an acrylic splint lined with dental compound and guttaform and is

fastened to the maxilla with peralveolar wires or nylon suture. Areas of localized necrosis caused by excessive pressure on the graft occasionally occur with this method. Unless suitable relief can be afforded in the stent, I recommend suturing the graft and covering it with isobutyl cyanoacrylate.

The procedure for obtaining split-thickness cheek mucosa grafts is described by Maloney and associates. A suitably bent Deaver retractor is secured to the patient's cheek with heavy silk sutures so that it can serve as a handle to evert and support the cheek while the graft is taken. A Castroviejo Electro-Keratome set at 0.3 mm thickness is used to obtain the donor split-thickness mucosa. Up to two specimens of mucosa (4.0 by 1.5 cm) can be obtained from each cheek. Additional pieces can also be taken from the extended lower lip mucosa. Since the thickness includes only the epithelium and tunica propria, the donor sites need little postoperative attention beyond a coating of tincture of benzoin. The raw surfaces will reepithelize rapidly without scarring.

Postoperative care and sequelae. The splint remains undisturbed for 7 days, after which time it is removed to check on healing of the donor site and the viability of the graft. The mucosa will be covered with a white coagulum of desquamated cells that, when lavaged or wiped gently, will peel off to leave a bleeding granular surface. This is normal and is evidence of a viable graft. In less than 2 weeks the graft will assume the appearance of normal mucosa again. The patient wears the splint as a denture during the healing period. A soft wax impression is taken as soon as healing permits, and the splint is relined with acrylic as needed. It is important not to overextend but rather to underextend the periphery between 1 and 2 mm because this minimizes granulations, which are the cause of contracture relapse. An initial contracture of 20% to 30% occurs at the entire periphery of the vestibule during initial healing. Overcorrection is accomplished when possible for this reason. A final prosthesis can be made approximately 4 weeks after grafting.

Mandibular procedures

Buccal Mucosa Graft Vestibuloplasty

Buccal mucosa graft vestibuloplasty is the procedure of choice in avulsive or severely traumatized patients in whom the sulcus is entirely obliterated by scarring or by bone grafting reconstructive procedures. Small spot grafts can be accomplished in the office using local anesthesia. However, since many patients with this problem require varying amounts of extensive dissection, the operation should be performed in the hospital operating room using general anesthesia.

Indications. This procedure is indicated for patients in whom there is a sulcus obliterated by high muscle attachments, extensive local scarring, extensive mandibular bone atrophy with the mental nerves emerging at the crest of the ridge, or extension of a normal sulcus from canine to canine resulting from premature tooth loss caused by periodontal disease.

Technique. The procedure is identical to that of the maxillary mucosa graft, except in the manner of treating the lingual sulcus, which will be discussed in detail in the following section on buccal skin graft vestibuloplasty. The procedure parallels the method recommended by McIntosh and Obwegeser, except that it is accomplished in a localized area.

Use of Splints. A full palatal acrylic splint is used to cover the donor site in the palate. For the mandible, particularly for the partially edentulous one, an overextended splint relieved at the mental nerve is used. The splint is used to take a compound impression of the extended vestibule and is relieved to accommodate a guttaform liner. The graft is sutured in place as in the maxillary procedure, and the splint is inserted over the graft and immobilized with No 2-0 Mersilene or Tevdek sutures circumferentially placed around the bone and the splint. This minimizes pressure necrosis of the graft, effected by too much pressure from circumferential wirings.

Postoperative care. Both splints are removed in 7 days, and the healing of the donor site and the viability of the graft are checked. If the palatal splint was lined with a periodontal dressing, it is changed weekly to allow for granulation to proceed unimpeded. The mandibular splint is now relined and extended 1 to 2 mm short of the periphery and is worn as a temporary denture. In mandibular cases, a watchful postoperative course is required to prevent pressure points and granulations that predispose to contracture relapse. Definitive denture construction can start in 3 to 4 weeks.

Buccal Skin Graft Vestibuloplasty with Complete Lowering of the Floor of the Mouth

Although I prefer to use free mucosa transplant grafts in vestibuloplasty since mucosa has definite advantages over skin, enough palatal mucosa to cover the entire extended sulcus area cannot always be procured. As mentioned earlier, a system of extending donor mucosa and skin tissue is now available through fenestrating or meshing both skin and mucosa grafts using either a Padgett Graft Expander or a Tanner Van Derput mesh-graft dermatome. Grafts can be increased up to nine times the original size, but the ratio of 3:1 is the most commonly used. The advantages to mesh grafts, besides the obvious one of limited donor tissue coverage of a larger area, include a better adaptation of the fenestrated grafts to all types of recipient sites, seepage of fluids precluding formation of hematomas and dead space, shorter operating time, less hemorrhage, less discomfort, and shorter healing time of the donor site.

For patients needing extensive grafting, it is necessary to use skin from a nonhair-bearing area, such as the inner thigh, regions of the buttocks, and the lateral abdomen.

Indications. Indications for this procedure include an atrophic, but not pencil-thin, mandible, with high buccinator, frenum, and mylohyoid attachments covered by thin, movable, atrophic nonkeratinizing mucosa. In addition, the floor of the mouth bulges up to displace the lingual flange of the denture. The typical patient is one with a denture-sore mouth and a history of being unable to juggle or retain a full lower denture in a functional stress-bearing situation.

Case selection. With this surgery, more than with any other surgery discussed, thorough case selection and expected sequelae counseling is mandatory. The sequelae of mental nerve hyperesthesia, paresthesia, or anesthesia coupled with the severe dysphagia and pain on swallowing that is associated with operations in the floor of the mouth must be thoroughly explained in advance. The need for a splint fastened to the lower jaw for 1 week must be understood. The donor site will require special care until the fine mesh gauze dressing falls off between 3 and 5 weeks after surgery and new skin covers the donor site.

Preoperative planning. After patient counseling and workup, complete radiographic study of the mandible is accomplished to ascertain the size and shape of the basal bone,

position of the mental foramina, and presence or absence of sharp ridges. An overextended compound impression is used to pour a mandibular model, on which is made an overextended acrylic tray that is relieved in the mental nerve region and in which is embedded a U-shaped wire to be used as a handle during impression taking at surgery.

On the day before surgery the patient is typed and cross matched for two units of whole blood. The corticosteroid dexamethasone (Decadron), 4 mg intramuscularly, and procaine penicillin G, 600,000 units intramuscularly, are administered the evening before surgery and twice on the day of surgery. The dexamethasone is then decreased to 2 mg twice a day, then to 1 mg twice a day, then discontinued on the third postoperative day. This combination will materially decrease postoperative edema and the likelihood of postoperative infection, which could be a threat to the airway.

This is clearly a major operation and can only be done under general anesthesia in the operating room. It is greatly facilitated by a low-profile, endotracheal, general anesthesia technique that places the anesthetist at the level of the patient's thigh. This allows special head draping and the oral surgery team to stand around the head of the patient when operating in the floor of the mouth.

Technique. The operation involves the following procedures.

Donor Skin Procedure. The area of the lateral thigh is prepared and draped. A 4 by 10 cm split-thickness (0.18- to 0.25-inch) piece of skin is procured with a Brown or Padgett dermatome. The skin is stored until needed in a saline-moistened, fine mesh gauze.

More recently, because of the excellent adaptability of the donor skin, we have been fenestrating it at 3:1 expansion on a Tanner Van Derput mesh graft dermatome prior to storage.

The donor site is immediately dressed with fine mesh gauze and covered with a temporary pressure dressing throughout the remainder of the operation. Postoperative care to the donor site is minimized if it is exposed to a dry heat lamp in the immediate postoperative period. This will result in a dry donor site, with eventual loss of the dressing in 2 to 3 weeks as reepithelization occurs under the dressing.

Floor of the Mouth Procedure. Two percent lidocaine with 1:100,000 epinephrine is infiltrated immediately below the mucosa lingual to the mandible to balloon the tissue and provide vasoconstriction. A mucosa incision is made just medially to the crest of the ridge from retromolar pad to retromolar pad. The tongue is vigorously retracted laterally with a sponge stick to place the mylohyoid muscle on tension. This facilitates the dissection. By alternating sharp and blunt dissection, the muscle fibers can be made to bulge into the incision. A curved Kelly hemostat is threaded under the muscle, which is cut with scissors near the mandible without injury to the periosteum or the lingual nerve in the posterior portion of the incision. The remaining dissection from the lateral pharyngeal wall to the genioglossus attachment is done bluntly with the gloved finger. A similar dissection is performed on the other side at an angle to the symphysis area. In the midline, the lateral and superior fibers of the genioglossus muscle are sectioned, but the inferior muscle bundle is left intact to support the tongue. Although Obwegeser has cautioned against severing both the mylohyoid and the genioglossus-geniohyoid muscles because of the resulting total loss of tongue control and swallowing difficulty, a modification suggested by Anderson and associates has solved this problem when the genial tubercles are particularly high or large.

The periosteum over the tubercle is incised vertically, and the attached muscle insertions are identified. A No 2-0 chromic gut suture is tied to the bundle to serve as a traction suture. The bundle is severed from the insertion. The tubercles are reduced by mallet and osteotome. The periosteum is closed with chromic sutures.

When the skin graft, which is glued to the splint, is later inserted, a midline circumferential, splint-holding No 3-0 Tevdek suture is placed. The chromic traction suture is tied below a knot placed in the circumferential suture, thus permitting the bundle to be displaced inferiorly, and then held there when the circumferential suture is tied over the splint.

Ridge Preparation and Skin Grafting Procedure. The *lateral* mandibular mucosa is infiltrated with lidocaine to distend this tissue and to provide hemostasis. A superficial mucosal incision is made from retromolar pad just lateral to the crest of the ridge. Two lateral relaxing incisions are made posteriorly. Through these incisions a supraperiosteal flap is developed laterally and inferiorly, stopping short of the external oblique line. The mental nerve region dissection is meticulous to identify and dissect free these important nerves. If lowering is needed (which is determined by the presence of the foramen at the crest of the ridge) to eliminate undue nerve pressure that could be expected under the skin graft, then the nerve is retracted with a blunt nerve hook while the foramen is lowered and a trough is made in the bone with a No 6 round bur.

The anterior sulcus between the mental foramina is dissected laterally and inferiorly enough to sever part but not all of the mentalis and caninus muscles. If these muscles are severed completely, the patient will have a flaccid-appearing lower lip.

The same procedure is carried out on the other lateral side of the mandible.

Special Suturing Techniques. The freed mucosal edges obtained by means of the lingual and buccal flap dissections need to be repositioned and stabilized at their most inferior position. This is accomplished with eight carefully placed No 2-0 Mersilene or Tevdek sutures in sling position under the mandible. Eight sutures, four on each side of the midline with the first suture 1 cm from the midline, near the genioglossus bundle are passed through the lingual flap mucosa and are tagged with hemostats. Starting from lateral to the midline, an awl is passed from the submandibular skin into the floor of the mouth; both ends of the suture are threaded into the eye of the awl, which is withdrawn to the inferior border of the mandible, then passed buccally into the vestibule where one suture is removed from the awl's eye. The remaining strand is then passed through the mucosa of the buccal flap with the awl and removed from the eye of the awl, which is withdrawn. This completes placement of a single hammock suture. The suture is again tagged with a hemostat. Separate awls are used, and the remaining sutures are placed and tagged.

Suture tying is done over a No 2-0 black silk pullout suture that has been placed loosely in the lingual sulcus and threaded under all the hammock sutures. This will facilitate their removal in 7 days. This step can be omitted if No 2-0 Dexon resorbable sutures are used instead of No 2-0 Mersilene or Tevdek. The hammock sutures are brought under tension by alternating the pull on each end of the suture. Buccal and lingual tissues are pulled downward under the mandible, thus deepening the buccal and lingual vestibules. Excess fibrous tissue, muscle attachments, and gingival scar tissue are now removed with scissors, with care taken not to perforate the periosteum.

Impression of the Recipient Site. The clear acrylic tray is filled with soft red dental compound, and an impression of the extended ridge is taken, keeping the lingual flange short, since no skin graft will be placed in this undercut area. The compound is relieved, trimmed, and flamed until the fit is satisfactory and is further refined by lining the impression with low-fusing guttaform. The impression is then painted with a skin adhesive, such as gum mastic or a compound containing one-half dermatome cement and one-half ether, which is allowed to dry for at least 1 minute.

The skin is now placed in the splint (epithelial side against the adhesive) and is massaged into place with moistened cotton-tipped applicators. Excess skin is trimmed away at the periphery.

Final Preparation of the Recipient Bed. While the surgeon places the skin in the splint, an assistant obtains careful hemostasis of the bed by electrocautery of bleeders, pressure, and application of ice water. When hemostasis is satisfactory, the skin-containing splint is positioned over the recipient site and maintained with two circumferential No 2-0 Mersilene or Tevdek sutures (one anterior and one posterior to the mental foramen) tied circumferentially over the splint. This completes the procedure except for a superficial dressing over the awl skin puncture wounds.

Postoperative course. The immediate postoperative edema and swelling are controlled by dexamethasone, ice packs to the area, and withholding oral feedings until swallowing is less painful. Clear liquid, oral alimentation is usually started in 24 hours, progressing to a full dental liquid diet of a high caloric and protein nature.

The splint is removed in 7 days to check for viability of the graft and to trim excess skin that has not taken. Immediate prosthetic care is provided by relining the old dentures and relieving the periphery, short of the new sulcus extension by at least 1 to 2 mm. These dentures can be worn as long as 3 months under close supervision to prevent pressure points or granulations or both from developing. Final dentures can then be fabricated.

Ridge Augmentation Procedures

Ridge augmentation procedures must be considered for cases in which atrophy or injury to the jaws has been such that, although maximum ridge extension by sulcoplasty has been accomplished, the ridge is still inadequate to allow for a functional denture. This area of preprosthetic surgery has received little attention from surgeons, possibly because there seemed to be no effective operation for ridge augmentation using a sterile extraoral method of insertion. Since penetration into the oral cavity during the procedure was deemed tantamount to failure, few surgeons or patients would undertake this risk for elective augmentation of the mandible. This method of treatment was not accepted until the advent of antibiotics and early reports in the literature of successful peroral bone grafting.

Iliac bone crest and rib have traditionally been used to augment the jaws, but more recently, Boyne has described a bone regeneration method that employs a Vitallium mesh tray containing hemopoietic bone marrow encased in a nylon reinforced Millipore filter. The filter appears to enhance osseous generation at the surgical site by exclusion of connective tissue cellular elements from the defect where osseous healing is desired. This method has been successful in loss-of-substance bone grafting, particularly in the symphyseal region, and now it is being clinically tested in patients as a means of ridge augmentation.

Oral surgeons are constantly seeking to improve existing augmentation procedures in order to minimize the shrinkage by resorption that occurs when grafted bone is placed into function under a prosthesis. Danielson and Nemarich presumed that a subcortical insertion of the bone graft would have the advantage that the bone grafted tissue would be approximated on both sides by viable bone and used and used a Kazanjian modified flap. Farrell, Kent, and Guerra have reported on a similar interpositional bone graft and vestibuloplasty for the atrophic edentulous maxilla. Sanders and Cox advocated the use of inferior border rib grafting for augmentation of the atrophic mandible to minimize bone resorption and the delay in allowing a patient to return to denture wearing.

Lastly, Peterson and Slade have described a body sagittal osteotomy to raise the lingual cortical portion of the atrophic mandible without detaching the lingual tissues for blood supply, fixing the ridge in the new position while augmenting it buccally with cancellous marrow from the ileum. They claim less shrinkage by resorption because the lingual cortical basilar bone has already undergone atrophy and an immediate extension of the vestibulum can be done over the cancellous marrow graft, thereby assuring early return to denture wearing.

Freeze-dried bone, aorta, and cartilage grafts have been used in dogs by Blackstone and Parker to restore atrophic ridges. A large variety of alloplastic materials ranging from tantalum mesh to silicone plastics have been used to restore portions of the human body lost through atrophy, trauma, or radical surgical procedures. In general, these materials, except autogenous bone, do not do well when placed under functional stress.

For ridge augmentation surgery, I prefer iliac crest. Although a notched rib can readily be contoured to the arc of the mandible, as much as 50% loss by shrinkage can be expected in this type of augmentation surgery. My experience with purely cancellous iliac graft and iliac cortical-cancellous sectional grafts introduced perorally, with appropriate immobilization of the graft, shows excellent healing even in the event of an occasional incision dehiscence. It is noteworthy that best results are obtained if the augmented mandible is not stressed by denture wearing or a vestibuloplasty procedure for 4 months after grafting. This allows time for an excellent layer of cortical bone to form at the graft site.

Technique. After injection of 2% lidocaine with 1:100,000 epinephrine for hemostasis, a crest of the ridge incision is made from retromolar pad to retromolar pad, with care exercised not to incise the mental nerves if they emerge high on the crest. A full-thickness mucoperiosteal flap is reflected. The mental nerves are identified and dissected free as they enter the lip to minimize stress on these nerves during retraction. If pressure is going to be exerted on the nerve by the augmentation bone graft, the mental foramina are lowered as in the skin graft vestibuloplasty.

While the oral graft site is being prepared, another surgical team obtains an iliac inner-table, cortical-cancellous graft of the appropriate size. The average adult can easily provide a 8 by 3 cm block graft and approximately 25 to 30 mL of cancellous marrow for further deposition at junctions of the segments of the graft.

After exposure of the mandible to the oral cavity, the mucoperiosteum is widely relieved on the buccal side. The mylohyoid muscle insertion is severed on the lingual site to free the tissue enough to close over the graft. Increased tissue relaxation can be accomplished by cutting the intact periosteal sling as low as possible near the inferior border of the mandible and by further submucosal dissection of the flap. A similar bone augmentation

technique can be performed in the atrophic maxilla, with special care exercised during the undermining of tissue for closure to avoid entering the nasal cavity.

Bone Graft Technique. The iliac crest block graft is sectioned into 1 to 1.5 cm wide pieces with an oscillating Stryker saw. These are tried for fit and contoured as needed, the cortex is thinned but not completely removed, and fenestrations are made in the mandibular cortex, with care taken not to penetrate into the neurovascular canal. The individual pieces are notched, scored, and bent if necessary, and fixed by a combined transosseous circumferential technique. In a severely atrophied mandible, a circumferential wire can erode through the cortex, producing an iatrogenic fracture.

The fragments, usually three, are fixed to the host mandible. Cancellous marrow is packed into interstices beneath the graft around the butted joints to achieve good bone contact between graft and host bone, as well as to give a U-shaped form to the augmented ridge.

Closure is by continuous horizontal mattress sutures with No 3-0 Dexon, with care taken not to close the tissues under any tension. Interrupted sutures reinforce the incision for watertight closure.

Because all floor-of-mouth procedures are prone to significant edema and swelling, patients are placed on the same corticosteroid and antibiotic regimen as those who undergo the skin graft vestibuloplasty.

Postoperative course. If meticulous tension free closure has been accomplished, the incision heals by first intention. In several war wound cases in which there was extensive scarring, the incision dehiscence to expose small fragments of bone or wire. For exposed bone, good results can be obtained by allowing the exposed bony spicule to sequester or by removing it with a rongeur while irrigating the dehiscence with 9-aminoacridine and normal saline. For exposed wire, removal of the wire usually is necessary before irrigation, and secondary granulation succeeds in covering the graft. In all cases, the patient is not ready for final prosthesis insertion until after 4 to 6 months has been allowed for healing and extension vestibuloplasty with either mucosa or skin graft.

Mandibular Staple Bone Plate Fastener System

Small, in reviewing the efforts of early prosthodontists, dentists, implantologists, and oral surgeons to find a suitable metallic implant that could be placed in the jaws to replace lost teeth and act as abutments for either fixed or removable prostheses, came to the logical conclusion that the stress of function, the biological incompatibility of certain implants, the interface reaction between the tissues and the implant, the nature of the host tissue, and the host-invader relationship were responsible for the almost universal failure of dental implants.

He set for himself the task of finding a successful metallic implant device that would not have these difficulties and yet would be effective in retaining a full lower prosthesis.

He looked at the advantages of metal as an implant material, such as strength, resistance to fracture during intermittent loading, and ability to be fashioned into any desirable form. However, metals implanted into the body were well known as potential causes of corrosion, fatigue, and stress fracture. He reviewed the properties of pure metals and found them to be lacking either in strength, ductility, or hardness to perform well as implants. Alloys were the solution to these deficiencies. Starting with a pure metal such as titanium,

various other metals were added to achieve the properties of resistance to corrosion through protection of the implant with an oxide layer; elimination of crevices, cracks, and areas of stress concentration; and lastly minimization of the amount and area of metal in contact with oral mucosa.

Those metals near the noble end of the periodic chart were best suited for implantation into the body since they were the least reactive to chloride ions and corrosion. In 1959 Zimmer USA was developing an alloy of titanium (6 ACHV) later to be named Tivanium in 1970. Extensive research was done on the new alloy for orthopedic implants, bone screws, Jewett nails, Schneider intramedullary nails, Steinman pins, and allied surgical instruments to be used in insertion procedures.

Dr Small asked Zimmer USA to fabricate the mandibular staple bone plate out of Tivanium since this alloy shaped into the design chosen for the seven-pin staple best and could fulfill the criteria for a desirable implant, that is, keep as much metal as possible away from the oral mucosa, make it possible to bury the retentive pins into cortical bone at the inferior border of the mandible, allow placement of the transosseous bone holes between the mental foramina, and permit the joining of the intraoral fasteners to form a rigid metal frame.

The principle of minimizing direct stress on the implant and distributing it over the entire ridge area seemed paramount to prevent stress. A Dalbo stress-breaking precision attachment was used to fasten the prosthesis in the mouth, providing for resistance to lateral and superior displacing forces while avoiding direct pressure on the transosseous pins of the implant.

The implants were thoroughly investigated in animals and were given an extensive clinical trial. They were subjected to peer review with a rigid 5-year follow-up and were deemed worthy of continued clinical study and application.

I have followed with great interest Dr Small's study and success over an 8-year period and have reported on a case to illustrate the surgical and prosthetic techniques involved. A case report will be used to illustrate the techniques involved.

Case Report

The patient was a 62-year-old white man in good health. His chief complaint was inability to function satisfactorily with a mandibular complete denture. The patient had been completely edentulous for 10 years, having lost the mandibular anterior teeth last. Previous to these extractions he had worn successfully for 3 years a maxillary complete denture and a mandibular removal partial denture. The patient had a total of four maxillary dentures (all reasonably well tolerated) but only one mandibular complete denture, which did not meet his functional and social needs. He expressed the opinion that it would be a waste of time and effort to undergo additional conventional mandibular complete denture therapy. The patient reported that he had tried all type of powders, pastes, and relining devices in order to function with the denture but that none was successful. He had read about the staple implant in a national magazine and was referred to me for consultation.

Oral examination revealed no apparent soft tissue pathosis. The maxillary edentulous ridge had favorable local and anatomic factors, offering a good prognosis. The mandibular

edentulous ridge was moderately atrophied. Shallow vestibular depth was noted in the anterior lingual and labial segments. Severe bilateral undercuts of the mylohyoid ridges were present.

Radiographic examination revealed no osseous pathosis. There was sufficient bone height in the anterior segment of the mandible to accommodate the staple implant (a minimum of 9 mm is necessary).

The existing maxillary denture exhibited adequate retention and stability, although it was underextended labially buccally, and posteriorly. The mandibular denture was grossly underextended. Its form appeared to be totally unrelated to the functional anatomy of the bordering tissues.

The vertical dimension of the occlusion was insufficient. Centric relation and centric occlusion were not coincidental. New complete dentures were indicated.

A diagnosis of functional masticatory insufficiency caused by an atrophic mandible was determined.

Phases of therapy

Five distinct phases of therapy are involved in oral rehabilitation with the mandibular bone staple implant:

1. Conventional preprosthetic surgical preparation.
2. Conventional complete dentures or correction of existing dentures. This procedure will permit a determination of the prognosis of the mandibular denture and will serve as a prototype for the "implant prosthesis".
3. Hospitalization for surgery and implantation of the orthopedic appliance.
4. Conversion of the existing mandibular denture for use as an interim postsurgical prosthesis.
5. Construction of the definitive prosthesis.

The patient's expectations of potential treatment results were judged reasonable and obtainable, and he was accepted for treatment.

Phase I. This important phase of treatment involved routine and special preprosthetic surgical procedures the objective of which was a more suitable bony base and tissue foundation for dentures. The definitive prosthesis was to be supported by the edentulous ridge and had to be maximally extended within the limitations presented by the patient's tissues and functional anatomy. Maximum extension minimized the amount of force delivered to any given area supporting the prosthesis. Reduction of the mylohyoid shelves and of the genioglossus-geniohyoid attachment was indicated and accomplished for this patient to provide maximum extension. Additional considerations in this phase of therapy included a tuberosity reduction, excision of hyperplastic tissue, tori reduction, alveoloplasty to reduce spinous ridges, and mucosa or skin grafts to provide suitable tissue cover.

Phase II. Properly extended maxillary and mandibular complete dentures were constructed. The vertical dimension of occlusion was restored. Routine postinsertion adjustments were made. This patient expressed definitive criteria of function that he expected as a result of his treatment. It was recognized that conventional denture therapy could not meet his expectations and that the mandibular staple bone plate fastener system was indicated. The patient realized, however, that the new mandibular prosthesis would serve as the prototype for the definitive implant prosthesis. The basic differences were (1) an increase in stability and (2) positive resistance to vertical displacement.

Phase III. Specialized surgical instruments and armamentarium were needed for the insertion of the mandibular staple. In preparation for the surgical procedure, a dual-purpose clear acrylic resin template was constructed on a cast of the patient's mandible. The locations of the mental foramina were scribed on the template and transferred to the cast. The intraoral pin positions were marked medial to the foramina and in the center of the ridge, and two holes corresponding to the transosseous pin positions were drilled through the template. The template also could be used to position the drill guide accurately while seven parallel holes from the inferior border of the mandible, of which the two most lateral would be transosteal, were drilled.

The location of the incision was the crease line beneath the patient's chin. The mandibular bony symphysis was fully exposed, followed by insertion of the acrylic resin template intraorally. The drill guide and director rods were positioned and secured, and the seven holes were drilled with a low-speed, high-torque, air-driven bone drill. The Titanium implant was tapped into place, and the wound was closed in layers. Two metal fasteners machined to resemble premolar crown preparations were threaded on the intraoral pins and secured with locknuts 0.5 to 1 mm above the gingiva. The pins were cut off flush with the top of the fasteners.

Postoperative swelling and morbidity were controlled by the use of preoperative, interoperative, and short-term postoperative anti-inflammatory corticosteroids (Decadron in 4 mg doses). Infection was minimized by the use of therapeutic levels of penicillin during hospitalization and a prophylactic dose of 250 mg of penicillin V per day for 1 year after the surgical procedure. A pressure dressing was placed for 48 hours. Postoperative discomfort was considerably less than that which follows third molar surgery.

Phase IV. After the patient was discharged from the hospital 2 to 3 days postoperatively, his existing mandibular denture was converted to an interim prosthesis. Holes corresponding to the intraoral position of the fasteners were placed through the denture, allowing generous clearance around the fasteners. The tissue surface of the prosthesis was relieved and subsequently relined with a soft tissue-conditioning material. This procedure provided the patient with a stabilized, well-retained, and functional interim prosthesis.

The soft lining served as a stress-breaking mechanism between the prosthesis and the implant. For this reason, as well as for maintenance of tissue health, the lining was changed as frequently as required during the time that the interim denture was in use, a period of approximately 90 days.

Phase V. During this period, cast gold copings were fabricated for the fasteners. The copings were joined to a 14-gauge round gold bar that was positioned 1.5 to 2 mm above the gingiva over the ridge crest. Eventually the coping bar component was cemented to the fasteners, which, with the staple implant, completed the boxlike formation. This rigid form

was designed to allow a passive relationship to exist among the denture, the implant, and bone. Forces transmitted by the denture during function need to be distributed as broadly as possible to the supporting ridge.

The coping-bar component was picked up in a final impression from which the master cast was constructed. Dalbo stress-breaking precision attachments were soldered to the distal aspect of both copings, with their counterparts welded to a cobalt-chrome meshwork that was to be embedded in the denture.

The mandibular denture was constructed following accepted principles of conventional denture therapy. The prosthesis was processed and finished, with adequate relief between the copings and the denture. This allowed slight movement of the denture supported by the mucoperiosteum while it was positively retained by the implant. Compressive forces transmitted by the denture to the implant had to be minimized. It is theorized that eventually such forces may exceed the physiologic tolerance of the bone, resulting in bone resorption and loosening or failure of implanted devices. The designer of the staple implant concedes that some resorption will occur in the presence of a complete denture, but this resorption should not exceed normal resorption with age and should not jeopardize the staple implant since the bulk of the metal is away from the surface tissues and the objective of the prosthesis design is to minimize compressive forces transmitted to the transosteal pins.

The coping-bar component was temporarily cemented to the fasteners, and the patient was allowed to wear the prosthesis for 2 weeks, during which time postinsertion adjustments were made. This was followed by permanent cementation of the copings.

The implant has been in place for more than 18 months, and the definitive prosthesis has been in use for 1 year. The tissue response has been excellent. The patient is extremely well satisfied with the results and has commented that his ability to function with the prosthesis has far exceeded his expectations. In addition to immediate postoperative instructions, the patient has been provided with special home care instructions for the maintenance of the tissues around the transosseous pins and the cleansing of the denture. Patients must understand the importance of their role in maintaining tissue health and must establish a routine procedure for this.

Conclusion

The magnitude of sulcus extension and ridge augmentation procedures combined with the expected patient discomfort should not be used as excuses to deny patients the benefit of preprosthetic surgery. Patients who have been in pain or embarrassed by juggling an ill-fitting denture for years are most grateful when these conditions are corrected and successful denture wearing is restored.

The mandibular staple implant has application for the patient with severe mandibular atrophy with at least 9 mm of alveolar crest height and for the patient who has an absolute need for a stable and retentive prosthesis in order to lead a normal life, regardless of the degree of mandibular atrophy exhibited.

This preprosthetic surgical approach, however, calls for the utmost of surgical and prosthetic preplanning and cooperation, as well as meticulous attention to detail in all phases of treatment. When the principles of case selection and treatment outlined previously are followed, excellent results and patient satisfaction can be expected.