Prosthodontic Treatment for Edentulous Patients

Complete Dentures and Implant-Supported Prostheses

Thirteenth Edition

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This text is dedicated to the memory of Carl O. Boucher and Judson Hickey,
as well as to Gunnar E. Carlsson and Charles L. Bolender.
We remain grateful to these exceptional scholars, mentors, and friends
for their legacy of clinical scholarship in all its aspects—education, research, and service.
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Preface

The 13th edition of Prosthodontic Treatment for Edentulous Patients seeks to maintain our commitment to guiding dental students, dentists, and prosthodontists to make the best-informed clinical decisions while optimally managing the needs of edentulous patients. As practicing dentists and clinical educators, we continue to seek educational formats that reconcile established clinical protocols with research developments, while never losing sight of the ultimate beneficiaries of our professional skills—our patients. The latter have become increasingly aware of their right to receive efficacious and effective dental therapies, and hence a text that brings context and understanding to a participatory partnership between patient and dentist.

Choosing an eclectic approach to our synthesis of optimal care knowledge for caring for this special patient cohort, we invited leading international educators and scholars to join us in articulating the strongest case possible for understanding the edentulous predicament and its management. We are confident that the end result reflects an approach that never loses sight of the biological underpinnings of each patient’s unique situation. Moreover, the best current management of the edentulous predicament is now seen in a far broader and more rational context than past descriptions. This is because the educational and research focus in prosthodontics has continued to grow and evolve in the past near-decade since we published the 12th edition. Advances in dental materials and increased objectivity in the understanding of limitations of mechanical analogues for the masticatory system had already facilitated significant progress in the discipline. However, the single most compelling catalyst for change has been the technique of osseointegration. This ushered in an exciting new therapeutic era, especially for prosthetically maladaptive patients.

As a result, compromised denture stability and retention are now being confidently addressed in a far more versatile and predictable manner.

An entirely new implant-related protocol can now be employed to address the edentulous predicament, given the spectrum of changes that have been catalyzed by commercially pure titanium implants combined with traditional surgical protocols employing delayed loading. Three decades of clinical experience and research have demonstrated the potential of different biomaterials with roughened surfaces, immediate loading, and various surgical techniques for host site improvement. Time and even better research in patient-mediated concerns—particularly economic benefits—will ultimately determine to what extent the complete denture may be eclipsed by the implant-supported prosthesis. In the meantime, there is little doubt that both techniques can address the needs of the edentulous individual.

Both patients and dentists have already benefited enormously from this enriched spectrum of treatment possibilities. This edition therefore continues to emphasize osseointegration’s unique and adjunctive role in patient treatment, but without losing sight of the truism that basic principles of complete denture construction are now more necessary than ever. Our entire editorial team remains convinced that our professional and educational mandate is to continue to take full advantage of currently available alternative treatment choices. However, we also remain committed to managing edentulous patients in the context of established and traditional prosthodontic principles.

George Zarb, John A. Hobkirk, Steven E. Eckert, and Rhonda F. Jacob
Numerous teachers and colleagues influenced and guided our clinical academic commitment over the years; we stood on their shoulders as we sought to expand the scope of our discipline. They, together with our dental technicians and assistants, secretaries, and photography personnel, contributed immeasurably to the continuum of effort that culminated in both past and this particular edition. These individuals are far too numerous to mention, but they continue to occupy a special place in our hearts.

We are also grateful to contributors to previous editions, notably Ejvind Budtz-Jorgensen, Thuan Dao, Mary Faine, Douglas Chaytor, Ross Bryant, Nancy Arbree, Howard Landesman, David Davis, Stig Karlsson, Alan Carr, Kenneth Shay, and Regina Mericske-Stem. Their original contributions provided outstanding frameworks for some of the revised and updated chapters in this 13th edition.
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HISTORICAL CONTEXT AND CURRENT CONSIDERATIONS

Although the face represents only a small proportion of the surface of the body, it embodies our social identities and is one of the major vehicles for interpersonal communication. Facial appearances that depart from culturally acceptable concepts of attractiveness have been shown to be disadvantageous to the individual; this is especially the case when those deviations are significant. They reflect inherited characteristics on which may be superimposed the effects of disease or trauma, the most common of which are probably untreated or poorly treated edentulism. Negative changes in facial appearance are often perceived by the persons affected, as well as those around them, as negative changes to the individuals themselves. Therefore when we treat edentulous patients, we are managing not just their oral biomechanics but more importantly their individuality (Fig. 1-1). Success demands not only technical expertise but also empathy with the patient's fears and aspirations.

This text seeks to provide an understanding of the edentulous state and its clinical management. It recognizes that tooth loss causes adverse anatomic, esthetic, and biomechanical sequelae, a predicament compounded by the resultant demise of the periodontal ligament with its support and sensory functions for which the residual ridges are a poor substitute.

For a long time, prosthodontic therapy focused mainly on the technical and clinical expertise required to fabricate complete dentures. This approach helped nurture the development of new materials and knowledge about overlapping considerations in esthetics, occlusion, and patients' expectations. Strong convictions also emerged about the inherent merits of complete denture treatment, and dentists all over the world presumed that their endeavors would virtually match the gold standard of the healthy intact natural dentition. Subsequent experience revealed the inability of treatment with complete dentures to match this standard. Nevertheless they considerably improved the lot of many who were edentulous or suffering from mutilated dentitions. The majority of patients appear to have benefited from this approach, as compromised oral health and appearance were managed with extractions and complete denture replacements. Regrettably, these successes resulted in partial and sometimes entire dentitions being needlessly sacrificed as complete denture treatment was all-too-often regarded as a preferable alternative to expensive periodontal and restorative therapy. Nonetheless, clinical experience suggests that the skills and ingenuity of complete denture fabrication contributed to a predictable and satisfactory quality of life for most edentulous patients. The passage of time also permitted dentists to refine the requisite technical skills and to develop scientifically based rationales for their use. As a result, treatment with complete dentures became, and indeed remains, an integral and important part of dental education and practice.

In a public-health context, complete denture prosthodontics is a relatively routine and inexpensive treatment method that offers scope for virtually universal application. As a clinical teaching and professional activity, it also demands knowledge of applied basic sciences, biomaterials, occlusion, and esthetics. In fact, the basis for most of the esthetic clues or decisions currently used to improve the appearance of the natural smile is an extension of the complete denture esthetic principles described in Part IV of this.
Figure 1-1  A to D, Characteristic facial and circumoral changes associated with a dentate young woman in her 20s. Parts A to D are in stark contrast with those observed in an aging woman who has been wearing dentures for several decades (E to H). The denture’s three surfaces (G)—intaglio or fitting, polished, and occlusal—were established separately by the dentist. They were integrated to replace the missing teeth and the severely reduced supporting tissues as an integral part of routine prosthodontic protocol. Optimal esthetic support combined with adequate renewed function usually can be achieved for most edentulous patients with complete dentures.
text (Fig. 1-2). Above all, it offers dentists the challenge and satisfaction of managing patients’ behavioral and age-related concerns and infirmities. It is not, however, a panacea for the edentulous predicament.

It has been demonstrated that within a population the decision of patients to become edentulous reflects not only their levels of caries and periodontal disease but also the effects of several nondisease factors such as attitude, behavior, dental attendance history, the characteristics of their health care system, and cost concerns associated with a low socioeconomic status. Indeed some authors have argued that tooth loss does not even bear a close relationship to the prevalence of dental disease, although this viewpoint is probably excessively polarized. It is nevertheless reasonable to conclude that edentulism is due to various combinations of dental disease together with cultural, financial, and attitudinal determinants, as well as previous dental treatment.

The heterogeneous etiology of edentulism has been tackled on several worldwide fronts by the dental profession. Recent reviews of tooth loss and edentulism in various countries have shown that in several countries, edentulism has declined and is predicted to continue to do so. At the same time, the number of partially dentate individuals is likely to increase in the short term. Although these observations may be used to imply the need for a reduced dental educational commitment to treatment of edentulous patients, some very compelling points must be underscored:

1. Documented evidence reveals that despite projections of declining edentulism, the unmet need for complete denture treatment will remain high even in industrialized countries and may even increase in some.
2. Predictions from several surveys of healthy elderly populations indicate that a high percentage of older people will be edentulous. The effective demand for prosthetic care for this expanding population cohort is therefore likely to increase.
3. The impact of longevity on edentulism has not been fully ascertained, although it is recognized that the treatment of the elderly long-term edentulous patient can be considerably more challenging than that of the younger recently edentulous individual. This will confront dentists with a significant increase in the number of edentulous patients requiring difficult treatment.
4. Many of the skills required for successful treatment of the edentulous patient are important to other areas of patient management.

Irrespective of precise future population needs, the psychological and biomechanical consequences of tooth loss must never be overlooked. Most patients regard tooth loss as a form of mutilation and as a strong incentive to seek dental care for the preservation of a healthy dentition and socially acceptable appearance. Dentists, on the other hand, also regard tooth loss as posing the additional hazard of an even greater mutilation: the destruction of part of the facial skeleton with the accompanying distortion of soft tissue.

Figure 1-1, cont’d.
shape and varying degrees of functional inadequacy (see Fig. 1-1, E to H)

**BIOMECHANICAL SUPPORT FOR THE NATURAL DENTITION**

The edentulous state represents a loss of the integrity of the masticatory system, which is frequently accompanied by adverse functional and esthetic sequelae. These are varlyingly perceived by the affected patient, ranging from feelings of inconvenience to severe handicap. Many also regard total tooth loss as equivalent to the loss of a body part. Consequently, the required treatment must address a range of biomechanical problems that involve a wide spectrum of individual tolerances and perceptions.

The natural or prosthetic dentition and its supporting mechanism are the most visible, accessible, and frequently treated parts of the masticatory system. This is made up of closely related morphological, functional, and behavioral
components whose interactions are affected by changes in the dentition’s support mechanism when natural teeth are replaced by prosthetic ones. An understanding of the many subtleties associated with the transition from a dentate to an edentulous state requires a comparison of the support mechanisms for natural teeth and complete dentures (Fig. 1-3).

The masticatory apparatus is involved in the trituration of food in which the teeth and their supporting tissues play key roles. The attachment of teeth in sockets is but one of many important modifications that took place when the earliest mammals were evolving from their reptilian predecessors. The success of this modification is indicated by its rapid adoption throughout the many different groups of emerging Mammalia. Teeth function properly only if adequately supported, and this support is provided by the periodontium.

The periodontium attaches the teeth to the bone of the jaws, providing a resilient suspensory apparatus resistant to functional forces. It is comprised of the hard connective tissues (cementum and bone) and soft connective tissues (the periodontal ligament and the lamina propria of the gingiva), which are covered by epithelium. It also allows the positions of the teeth to change in response to stress. The periodontium is regarded as a functional unit and is attached to the dentin by cementum and to the jawbone by
Figure 1-3  The transition from a dentate to an edentulous state requires an understanding of the entirely different support mechanisms available for natural teeth and complete dentures. The natural dentition (A and B) is supported and retained via an area of 45 cm² of periodontal ligament. This attachment mechanism, which evolved quantitatively and qualitatively for its specialized role, is substituted for by a compromised one when a patient becomes progressively more edentulous both in the maxilla (C to E) and mandible (F to H).
the alveolar process. The periodontal ligament and the lamina propria maintain continuity between these two hard tissue components, providing the means by which forces exerted on the tooth are transmitted to the bone that supports it, while the periodontium also allows the positions of the teeth to change in response to stress.

The two principal functions of the periodontium are support and positional adjustment of the tooth, together with the secondary and dependent function of sensory perception. The edentulous patient is deprived of this functionality.

The physiological occlusal forces exerted on the teeth are intermittent, rhythmic, and dynamic in nature, and are controlled by the neuromuscular mechanisms of the masticatory system. Reflex mechanisms with receptors in the muscles, tendons, joints, and periodontal structures regulate mandibular movements and the functional forces that are transmitted to the periodontal structures.
The greatest forces acting on the teeth are normally produced during mastication and deglutition and are essentially vertical in direction. Each thrust is of short duration, and for most people, chewing is restricted to short periods during the day. Deglutition, on the other hand, occurs about 500 times a day, and tooth contacts during swallowing are usually of longer duration than those occurring during chewing. Loads of a lower order but longer duration are produced throughout the day by the tongue and circumoral musculature. These forces are predominantly in the horizontal direction. Estimates of peak forces from the tongue, cheeks, and lips have been made, and lingual forces appear to exceed buccolabial forces during activity. During rest or inactive periods, the buccal and lingual forces may be of similar magnitude.

During mastication, biting forces are transmitted via the bolus to the opposing teeth whether or not they make contact. These forces increase steadily (depending on the nature of the food fragment), reach a peak, and abruptly return to zero. The magnitude, rise time, and interval between thrusts differ between individuals and depend on the consistency of the food, the point in the chewing sequence, and the individual’s dental status. The direction of the forces is principally perpendicular to the occlusal plane in normal function, but the forward angulation of most natural teeth leads to the introduction of a horizontal component that tends to tilt the teeth medially, as well as buccally or lingually. Upper incisors may be displaced labially with each biting thrust, and these tooth movements probably cause proximal wear facets to develop.

In healthy dentitions, teeth are in occlusion during deglutition, occasionally while masticating and during the clenching and grinding associated with parafunction. It has been calculated that within a 24-hour period the teeth are subjected to the functional forces of mastication and deglutition for a total of some 17.5 minutes (Table 1-1). More than half of this time is attributable to jaw-closing forces applied during deglutition. These values indicate the tolerance threshold of the normal healthy supporting tissues. However, it must be emphasized that the collective forces acting on a prosthetic occlusion are unlikely to be controlled or attenuated as effectively as they appear to be by the natural dentition. Consequently, the time-dependent responses of tissues supporting complete dentures are likely to be different from those seen around natural teeth.

**TABLE 1-1  CALCULATION OF TOTAL TIME DURING 24 HOURS WHEN DIRECT FUNCTIONAL OCCLUSAL FORCE IS APPLIED TO THE PERIODONTAL TISSUES**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chewing</strong></td>
<td></td>
</tr>
<tr>
<td>Actual chewing time per meal</td>
<td>450 sec</td>
</tr>
<tr>
<td>Four meals per day</td>
<td>1800 sec</td>
</tr>
<tr>
<td>One chewing stroke per sec</td>
<td>1800 strokes</td>
</tr>
<tr>
<td>Duration of each stroke</td>
<td>0.3 sec</td>
</tr>
<tr>
<td>Total chewing forces per day</td>
<td>540 sec (9 min)</td>
</tr>
<tr>
<td><strong>Swallowing</strong></td>
<td></td>
</tr>
<tr>
<td>Duration of one deglutition</td>
<td>1 sec</td>
</tr>
<tr>
<td>During chewing, three deglutinations per min, one third with occlusal force</td>
<td>30 sec (0.5 min)</td>
</tr>
<tr>
<td><strong>Between Meals</strong></td>
<td></td>
</tr>
<tr>
<td>Daytime: 25/hr (16 hr)</td>
<td>400 sec (6.6 min)</td>
</tr>
<tr>
<td>Nighttime: 10/hr (8 hr)</td>
<td>80 sec (1.3 min)</td>
</tr>
<tr>
<td>Total</td>
<td>1050 sec = 17.5 min</td>
</tr>
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**BIOMECHANICAL SUPPORT MECHANISMS FOR COMPLETE DENTURES**

The basic challenge in the treatment of edentulous patients lies in the differences between the ways natural teeth and their artificial replacements are supported. The previous section emphasized the superbly evolved quantitative and qualitative aspects of periodontal ligament support for a functioning dentition. This has an approximate area of 45 cm² in each arch, viscoelastic properties, sophisticated sensory mechanisms, and the potential for bone remodeling to cope with the diverse directions, magnitudes, and frequencies of occlusal loading. In contradistinction, the tissues pressed into service to support complete dentures are inherently unsuited to this role.

**MUCOSAL SUPPORT AND MASTICATORY LOADS**

The mean area of mucosa available for denture support has been calculated to be 22.96 cm² in the edentulous maxillae and approximately 12.25 cm² in an edentulous mandible. These figures, particularly in the mandible, are in dramatic contrast to the 45-cm² area of periodontal ligament available in each dental arch (see Fig. 1-3). It also must be remembered that the denture-bearing area (basal seat) becomes progressively smaller as the residual ridges resorb. Furthermore, the mucosa itself demonstrates little tolerance or adaptability to denture wearing, a disadvantage worsened by the presence of systemic diseases such as anemia, hypertension, or diabetes, as well as nutritional deficiencies. Indeed, any disturbance of the normal metabolic processes may lower the upper limit of mucosal tolerance and initiate inflammation.

Reported masticatory forces using complete dentures are much smaller than those produced by the natural dentition, which is of the order of 200 N. Although maximum forces of 60 to 80 N have been reported for complete dentures, the average loads are probably much less than these. Indeed
maximal bite forces appear to be five to six times less for complete denture wearers than for persons with natural teeth. Moreover, the forces required for mastication vary with the type of food being chewed. Patients with prostheses frequently limit the loading of supporting tissues by selecting foods that do not require masticatory effort that exceeds their tissue tolerance.

THE RESIDUAL RIDGES

The residual ridge consists of denture-bearing mucosa, the submucosa and periosteum, and the underlying bone. When the alveolar process is made edentulous, the alveoli that contained the roots of the teeth become filled with new bone, forming the residual alveolar processes. These become the residual ridges and are the foundation for dentures, a role for which they are ill-suited.

The loss of teeth and their periodontal support results in the removal of an important sensory mechanism and a change in the loading pattern of the alveolar bone from tensile to compressive with forces being predominantly vertical as well as horizontal. The edentulous ridge also has a considerably smaller surface area than that of the preceding periodontal ligaments, and the denture-supporting tissues demonstrate very little adaptation to their new functional requirements. This is in marked contrast to the frequently remarkable adaptive range of the dentate masticatory system.

Following teeth loss, the alveolar ridge is subject to ongoing resorption, which results in its gradual reduction and virtual disappearance (Fig. 1-4). This process apparently occurs at an exponentially reducing rate and is typically most rapid in the anterior mandible. The loss of bone does not occur evenly over the surface of the ridges, and so with time, their shapes and size become altered. The rate of bone resorption also varies markedly from person to person and is not predictable at an individual level. Little is known about which factors are most important for the observed variations. Two concepts have been advanced concerning the inevitable loss of residual bone: one contends that as a direct consequence of loss of the periodontal structures, the latter's organizational influence on adjacent bone is altered and variable progressive bone reduction occurs. The other maintaining that residual bone loss is not an inevitable consequence of tooth removal but depends on a series of poorly understood factors.

Clinical experience strongly suggests a definite relationship between the presence of a healthy periodontal ligament and the maintained integrity of alveolar bone (Fig. 1-5). This accounts for a strong professional commitment to the preservation and protection of any remaining teeth to minimize or avoid advanced residual ridge reduction. The tissue support for complete dentures is conspicuously limited in both its adaptive ability and inherent capability of simulating the roles of the periodontium. These disadvantages are compounded by the movement of complete dentures in relation to the underlying bone during function. This is related to the resiliency of the supporting mucosa and the inherent instability of the dentures during functional and parafunctional movements. Because these recurrent movements and the forces that produce them can cause damage to the supporting tissues, almost all "principles" of complete denture construction have been formulated so as to minimize them. Although unproven, it is tempting to conclude that the recurrent functional movements of removable prostheses may be a major factor contributing to residual ridge reduction.

Two physical factors are involved in denture retention that are under the control of the dentist and are technique driven. One is the optimal extension of the denture base; the other is the maximally intimate contact of the denture base to its basal seat.

Muscular factors can be used to increase the retention (and stability) of dentures. The actions of the buccinator, the orbicularis oris, and the intrinsic and extrinsic muscles of the tongue can be harnessed by the dentist to achieve this with appropriate impression techniques. Furthermore, the design of the labial, buccal, and lingual polished surfaces of the dentures and the forms of the dental arches must be considered when balancing the forces generated by the tongue and the perioral musculature. As the form and size of the denture-supporting tissues (the basal seat) change, harnessing muscular forces in complete denture design becomes particularly important for denture retention.

Wearing dentures may have an adverse psychological effect on some patients, and the nervous stimuli that result may influence salivary secretions and thereby adversely affect retention. Eventually, most patients seem to acquire an ability to retain their dentures by means of oral muscle control. This muscular stabilization of the prostheses is probably also accompanied by a reduction in the physical forces used in retaining the dentures. Clearly, the physical forces of retention can be improved and reestablished, up to a point, by careful and frequent attention to the status of the dentures. Periodic inspection, including relining procedures, will help prolong the usefulness of the prostheses.

NATURAL AND PROSTHETIC DENTAL OCCLUSION: FUNCTIONAL AND PARAFUNCTIONAL CONSIDERATIONS

The masticatory system appears to operate best in an environment of continuing functional equilibrium. This depends on the interactions of the occlusion's components—the dentition, the neuromuscular system, and the craniofacial structures—that are disturbed by the substitution of a complete denture for the teeth/periodontium.

The development and maturation of these components are interrelated so that growth, adaptation, and change actively participate in the development of an adult occlusion. Dentition development is characterized by a period of
Figure 1-4  A, The overall reduction of the edentulous residual alveolar ridges. The a refers to bone height following extractions, while the b shows the bone level several years later. B, The bone reduction may be generalized or uneven but appears to be inevitable and variable. C to H illustrate the range of clinical and radiographic changes seen in two different edentulous mouths. Note that potential denture-bearing support can be compromised even further as a result of the presence of a congenital anomaly (I) or by an oncological surgical intervention (J). (A, Modified from Tallgren A: The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years, J Prosthet Dent 27[2]:120-132, 1972.)
Figure 1-4, cont'd.
Figure 1-5  A and B, The contrast between alveolar bone sustained by a healthy periodontal ligament and the resorption-vulnerable residual ridges that have been “periodontally deprived” for several years.  C, Periodontal disease also leads to a similar result, a process that is even more dramatic once such teeth are extracted.  D, In contrast, implant placement in the mandible aims at preserving what is left of the residual ridge and presumably reducing the risk of even further bone loss in the posterior ridges, a result of a prosthesis design that is more favorable for adverse occlusal stress distribution. The masticatory system’s potential for self-inflicted enamel wear and tear (the body’s hardest substance) is underscored in parts E to H.
dental alveolar and craniofacial adaptability (Table 1-2), which is also a time when motor skills and neuromuscular learning are developing. Clinical treatment at this time may take advantage of such responsive adaptive mechanisms; for example, teeth can be guided into their correct alignment by orthodontic procedures.

In a healthy adult dentition, dental adaptive mechanisms are restricted to wear, extrusion, and drifting of teeth. Bony adaptions are essentially a reparative nature and are slow in their operation. Protective reflexes are learned so as to avoid pain and inefficiency in the masticatory system. If and when an adult dentition begins to deteriorate, the dentist frequently uses fixed or removable prosthodontic therapy in attempts to maintain a functional occlusal equilibrium. This period is also characterized by greatly diminished dental and reflex adaptation and by bone resorption. Obviously, the presence of tooth loss and disease plus the depletion of reparative processes pose major prostodontic problems. Finally, in the edentulous state, few natural adaptive mechanisms remain. The prosthesis rests on tissues that will change progressively and irreversibly, and the artificial occlusion serves in an environment characterized by constant and predominantly regressive change.

The design and fabrication of prosthetic occlusions have led to fascinating controversies. Dental occlusion was studied first in the field of complete dentures and then in other disciplines. Early workers encountered enormous mechanical difficulties in constructing reasonably well-fitting dentures that would be both durable and esthetic. Quite inevitably, dentists had to be mechanically minded. Because anatomy was the first of the biological basic sciences to be related to prosthodontic services, its application dominated prosthodontic protocol. Later, histology, physiology, and bioengineering were recognized as playing essential roles in the treatment of edentulous patients. The emphasis on and application of these basic sciences lifted prosthodontics from the early mechanical art to the applied clinical science it is today.

The modern complete denture service is characterized by an integration of biological information with instrumentation, materials, and clinical techniques. Complete dentures are designed so that their occlusal surfaces permit multidirectional contact movements of the mandible. Orofacial and tongue muscles play an important role in retaining and stabilizing complete dentures. This is accomplished by arrangement of the artificial teeth to occupy a so-called “neutral zone” in the edentulous mouth, determined by the functional balance of the orofacial and lingual musculature.
FUNCTION: MASTICATION AND OTHER MANDIBULAR MOVEMENTS

Mastication consists of a rhythmic separation and apposition of the jaws and involves biophysical and biochemical processes, including the use of the lips, teeth, cheeks, tongue, palate, and other oral structures to prepare food for swallowing. During masticatory movements, the tongue and cheek muscles play an essential role in keeping the food bolus between the occlusal surfaces of the teeth. The control of mastication within the narrow limits of tolerance of the mouth requires considerable sensory information because deviations from the normal path of mandibular movement can injure the tongue, buccal mucosa, and even the teeth and their supporting tissues. Here again, the reader’s attention must be drawn to the importance of the correct positioning of the artificial dental arches when making complete dentures. It is important that the teeth are placed within a zone defined by the functional balance of the musculature involved in controlling the food bolus if the denture is to be minimally displaced and the bolus positioned between the occlusal surfaces of the teeth.

The comminution of much twenty-first century food does not demand a vigorous masticatory performance. Mastication has other functions however. It is necessary for a full appreciation of the flavor of foods and is therefore indirectly involved in the excitation of salivary and gastric secretions. Because mastication results in the mixing of food with saliva, it facilitates not only swallowing but also the digestion of carbohydrates by amylase. Although this is of minor importance while food is in the mouth, it is responsible for the continuation of carbohydrate digestion in the stomach, a phase that can account for as much as 60% of total carbohydrate digestion. Although data on the importance of chewing on the various stages of digestion are limited, it has been concluded that masticatory efficiency as low as 25% is adequate for complete digestion of foods.

Patients do not however compensate for a smaller number of teeth by more prolonged, or a larger number of, chewing strokes—they merely swallow larger food particles. Nevertheless, loss of teeth can lead to a diminished masticatory efficiency, and there is evidence of this restricting dietary choice with resultant systemic effects. Thus while it appears that the importance of a good dentition or denture in promoting digestion and use of food has not been adequately demonstrated, food choices themselves may be restricted. Clinical experience suggests a relationship between the quality of the prosthetic service and denture wearer’s masticatory performance.

As mentioned previously, the maximal bite force in denture wearers is five to six times less than that in dentate subjects. Edentulous patients are clearly handicapped in masticatory function, and even clinically satisfactory complete dentures are a poor substitute for natural teeth.

Studies of patterns of mandibular movement in dentate patients and those using complete dentures have shown them to be similar; consequently prosthodontic treatment of partially dentate and edentulous patients could improve their chewing efficiency and masticatory muscle activity. This would be typically accompanied by a decreased duration of the occlusion phase and contribute to a lessening of elevator muscle activity.

Chewing occurs chiefly in the premolar and molar regions, and both right and left sides are used to a similar extent. The position of the food bolus during mastication is dependent on the consistency of the food, and the tougher the consistency the greater is the person’s preference for using the premolar region. This is apparent even in patients who have worn bilateral, soft-tissue-supported, mandibular partial dentures opposing complete upper dentures. Such findings demonstrate an obvious advantage that the patient accrues with the replacement of missing premolar and molar segments, especially as these patients do not chew predominantly in the segments where natural teeth are present.

The pronounced differences between persons with natural teeth and patients with complete dentures are conspicuous in this functional context: (1) the mucosal mechanism of support as opposed to support by the periodontium, (2) the movements of the dentures during mastication, (3) the progressive changes in maxillomandibular relations and the eventual migration of dentures, and (4) the different physical stimuli to the sensory motor systems.

Dentures move during mastication because of the dislodging forces of the surrounding musculature. These movements manifest themselves as displacing, lifting, sliding, tilting, or rotating of the prostheses. Furthermore, opposing tooth contacts occur with both natural and artificial teeth during function and parafunction when the patient is both awake and asleep. The denture-bearing tissues are thus constantly exposed to the frictional contact of the overlying denture bases.

Displacement of the supporting tissues under loaded dentures typically results in tilting of the prostheses and tooth contacts on the nonchewing side. In addition, occlusal forces on the dentures displace the soft tissues of the basal seat and allow the dentures to move closer to the supporting bone. This change of position under load induces an alteration in the relationship of the opposing dental arches.

PARAFUNCTIONAL CONSIDERATIONS

Nonfunctional or parafunctional habits involving repeated or sustained occlusal contacts can be harmful to the teeth or other components of the masticatory system. The profession lacks compelling epidemiological studies of the incidence of parafunctional occlusal stress in populations with both natural and artificial dentitions. Nevertheless, clinical experience indicates that tooth clenching is common and that parafunctional habits (Table 1-3) in the denture wearer may cause additional loading on the denture-bearing tissues with a consequent complaint of soreness.
The neurophysiological basis underlying bruxism (tooth grinding) has been studied experimentally both in animals and in human beings, and part of its mechanism can be explained by an increase in the tonic activity in the jaw muscles. It is a very complex area of research and bruxism has been shown to result from psychosocial factors (such as stress or anxiety) or to be a reaction to strong emotions (e.g., anger, frustration). It also may be associated with specific medical conditions (e.g., oral tardive dyskinesia, Parkinson's disease) or with sleep parasomnia (e.g., bruxism, rapid eye movement [REM] behavior disorders, oromandibular myoclonus) or sleep disorders (apnea). It also may be found concomitantly with certain intraoral conditions such as pain, oral lesions, xerostomia, and discomfort associated with prostheses or occlusal problems.

The initial discomfort associated with wearing new dentures is known to evoke unusual patterns of behavior in the surrounding musculature. Frequently, the complaint of a sore tongue is related to a habit of its being thrust against the denture. The patient usually is unaware of the causal relationship between the painful tongue and its contact with the teeth. Similarly, patients tend at first to frequently occlude the teeth of new dentures. This is perhaps to strengthen confidence in retention until the surrounding muscles become accustomed to their presence or to provide some accommodation in the chewing pattern, experimental closure of the teeth being part of the adaptation process. A strong response of the lower lip and mentalis muscle has been observed electromyographically in long-term complete denture wearers with impaired retention and stability of the lower denture. It is feasible and indeed probable that the resulting tentative occlusal contacts may trigger the development of habitual nonfunctional occlusion.

The mechanism whereby pressure causes soreness of the mucous membrane is probably related to an interruption or a diminution of the blood flow in the small blood vessels in the tissues. These vascular changes could very well upset the metabolism of the involved tissues. The relationship between the incidence of parafunction in denture-wearing population groups and residual ridge reduction has not been investigated. However, it is tempting to consider, or even include, parafunction as a possible prosthetic variable that may contribute to the magnitude of ridge reduction.

### Changes in Morphological Face Height and the Temporomandibular Joints

While the final stage of skeletal growth is usually accepted as occurring at 20 to 25 years of age, growth and remodeling of the bony skeleton continue well into adult life and account for dimensional changes in the adult facial skeleton. It has been reported that morphological face height increases with age in persons possessing an intact or relatively intact dentition. Nevertheless, a premature reduction in morphological face height can occur as a result of occlusal tooth surface loss, predominantly due to attrition and abrasion of the occlusal surfaces of the teeth. This reduction tends to be even more conspicuous in edentulous and complete denture-wearing patients because the widely used acrylic artificial teeth are less wear resistant than the natural dentition, and resorption of the ridges allows the dentures to move closer to the basal bone. In Table 1-3 the presumed range of changes that take place during the development and adaptation of the occlusion is summed up. It also underscores the resiliency of the masticatory system as it adapts to the effect of disease and attendant tooth loss.

Morphological changes in the maxilla and mandible occur slowly over a period of years and depend on the balance of osteoblastic and osteoclastic activity. The articular surfaces of the temporomandibular joints (TMJs) also are involved, and at these sites, growth and remodeling are mediated through the proliferative activity of the articular cartilages. Changes in morphological face height or the shapes of the jawbones due to tooth loss are inevitably transmitted to the TMJs. It is not surprising, then, that these articular surfaces undergo a slow but continuous remodeling throughout life. Such remodeling is probably the means whereby the congruity of the opposing articular surfaces is maintained, even in the presence of dimensional or functional changes in other parts of the facial skeleton.

Resorption of the residual ridges supporting complete dentures and the consequent reduction in the vertical dimension of occlusion tend to cause a decrease in total face height and a resultant mandibular prognathism. Indeed in complete denture wearers, the mean reduction in height of the mandibular process measured in the anterior region may be approximately four times greater than that in the corresponding maxillary process. Furthermore, longitudinal studies suggest that the rest vertical dimension of the jaws, which was once considered unrelated to the presence of teeth, is not stable and can change over time. These findings contradict the previously popular and convenient concept

### Table 1-3 Direction, Duration, and Magnitude of the Forces Generated During Function and Parafunction

<table>
<thead>
<tr>
<th>Force Generated</th>
<th>Direction</th>
<th>Duration and Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastication</td>
<td>Mainly vertical</td>
<td>Intermittent and light</td>
</tr>
<tr>
<td>Parafunction</td>
<td>Frequently horizontal and vertical</td>
<td>Diurnal only</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prolonged, possibly excessive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Both diurnal and nocturnal</td>
</tr>
</tbody>
</table>

The table lists the direction, duration, and magnitude of the forces generated during function and parafunction.
of a rest vertical dimension, which was fixed throughout the patient’s adult lifetime.

Complete dentures constructed to conform to clinical decisions regarding jaw-relation records are placed in an environment that retains considerable potential for change. Consequently concepts of reproducible and relatively unchangeable mandibular border movements may not apply as closely to edentulous patients as they do to persons with a healthy dentition. Nevertheless, it must be reemphasized that while jaw relations are not unchangeable, this does not invalidate the clinical requirement of using a centric relation record as a starting point for developing a prosthetic occlusion.

Concepts of centric relation (CR) of the upper and lower jaws have long been a dominant factor in prosthodontic thinking on occlusion (Fig. 1-6). CR is defined as the most posterior position of the mandible relative to the maxillae at the established vertical dimension. It coincides with a reproducible posterior hinge position of the mandible, and it may be recorded clinically with a high degree of accuracy. It is therefore regarded as a very useful reference or starting point for establishing jaw relationships in any prosthodontic treatment, particularly in complete denture fabrication. It also is conceded that in the natural dentition, most functional tooth contacts occur in a mandibular position slightly anterior to centric relation, a position referred to as centric occlusion (CO). The lack of natural teeth makes it impossible to record the centric occlusion position in the edentulous patient; therefore this cannot be used as a basis for establishing the occlusal scheme for complete dentures (Fig. 1-7). Consequently, a logical clinical protocol objective when fabricating complete dentures is to record the CR, which is not dependent on the presence of occluding teeth, and to then establish CO at this jaw relationship.
Chapter 1  The Edentulous State

Figure 1-6, cont'd  B, Envelope of motion (mandibular border movements) in the sagittal plane builds upon the previous illustration. C, The envelope of motion (mandibular border movements) as seen in the frontal plane. CO, Centric occlusion; CR, centric relation; MHO, maximum hinge-opening position; MO, point of maximum opening of the jaws; P, most protruded position of the mandible with the teeth in contact; Rest, postural rest position.

Figure 1-7  Overt facial changes, especially circumoral, also may be seen in elderly patients with an intact dentition (A) as well as edentulous ones (B).
using the preferred vertical dimension of occlusion (VDO), CR and CO thus being coincident. It should be noted that the preferred VDO reflects an informed decision based on a range of clinically derived information.

In addition to its utility, the employment of CR has a physiological basis because unconscious swallowing in the vast majority of patients is carried out with the mandible at or near the centric relation position. The unconscious, or reflex swallow, and its frequency are important in the developing dentition because the activity of the adjacent muscles (the muscle matrix) strongly influences tooth positions and occlusal relations, whereas the position of the mandible is determined by its location in space during the act of unconscious swallowing. The contacts of the inclined planes of the teeth also aid in the alignment of the erupting dentition. During this developmental period most of the mandibular activities have not yet been learned, or at least not in their adult form. The occlusion of complete dentures is therefore designed to harmonize with the primitive and unconditioned reflex of the patient's unconscious swallow. Tooth contacts and mandibular bracing against the maxillae occur during this process, suggesting that complete denture occlusions must be compatible with the forces developed during deglutition to prevent disharmonious occlusal contacts that could cause trauma to the basal seats of the dentures.

Nevertheless, it must be recognized that an integral part of the definition of centric relation—at the established vertical dimension—has potential for change. This is brought about by alterations in denture-supporting tissues and facial height, as well as by morphological changes in the TMJs. An appreciation of the dynamic nature of centric relation in denture-wearing patients, particularly in the context of an aging patient, recognizes the changing functional and adaptive requirements of the masticatory system. It also accounts for different concepts and techniques when designing an occlusion.

**TEMPOROMANDIBULAR JOINT CHANGES**

The numerous descriptions of TMJ function reflect the range of research methods used to study them. The basic physiological relationships between condyles, disks, and glenoid fossae appear to be maintained during maximal occlusal contacts and during all movements guided by occlusal elements. It is therefore logical that the dentist should seek to maintain or restore these basic physiological relations when treating a patient with complete dentures. The classic “envelopes of motion,” which define the border movements of the mandible are reproducible, and it is within these that all other movements occur. Researchers have concluded that the passive hinge movement tends to have a constant rotational and reproducible character. This reproducibility of the posterior border path is of tremendous practical significance in patients undergoing prosthodontic treatment, although it has largely been established only in healthy young persons. It also must be recognized that before becoming edentulous, many patients have had a mutilated dentition of varying severity over often extensive periods, during which resultant pathological or adaptive structural alterations or changes in the TMJs may have occurred. These considerations are, however, largely based on autopsy investigations and must therefore be regarded as unproven.

It also has been reported that impaired dental efficiency resulting from partial tooth loss, inappropriate prosthodontic treatment, or indeed its absence can influence the outcome of temporomandibular disorders (TMDs). This is thought to be particularly the case when arthritis or degenerative changes have occurred. The hypothesis has been advanced that degenerative joint disease is a process rather than a disease entity. This process involves joint changes that cause an imbalance in adaptation and a degeneration that results from alterations in functional demands or the functional capacity of the joints. However, because the onset of degenerative conditions is frequently encountered in adults, the more likely to be edentulous, the treatment of such conditions is very much the concern of the dentist. Clinical experience and long-term studies indicate that a combination of occlusal prophylactic protocols (including the use of soft liners to restore the VDO) together with appropriate pharmacological and supportive therapy, are usually adequate to provide these patients with comfort. A reduction and stabilization of TMD signs and symptoms should nevertheless precede the fabrication of new complete dentures.

One of the difficulties in managing degenerative joint involvement is achieving joint rest. Because of the necessity for mastication and for the avoidance of parafunctional habits, voluntary or even enforced rest may be difficult to achieve; although here too the use of soft liners is regarded as a valuable adjunctive step that can be readily repeated.

**ESTHETIC CHANGES**

In most cultures it is thought highly desirable to appear to be dentate, and socially evident tooth loss is thus considered unacceptable. In addition, the edentulous state is typically associated with old age, and even when effectively treated, underlies to the patient their advancing years. These attitudes are so deeply ingrained that it is common for edentulous patients to have a great fear of being seen without their dentures even by their closest family members.

There is little doubt that tooth loss can adversely affect a person’s appearance and that the resultant changes may range from subtle to overt. Box 1-1 lists some of the conspicuous and clinically challenging features that frequently accompany the edentulous state. It must be emphasized that one or more of these items also are frequently encountered in persons with intact dentitions since the compromised facial support of the edentulous state is not the exclusive cause of such morphological changes (Fig. 1-8). In clinical
For over 30 years, maladaptive edentulous patients have been very successfully treated with osseointegrated, implant-retained fixed prostheses, especially in the mandible. The clinical technique also proved to be equally efficacious, indeed meritorious, for maxillary prescriptions. In this patient, advanced anterior bone resorption that resulted from prolonged occlusal overload at this site precluded traditional location for edentulous maxillary implant locations. The patient in parts G to I had enjoyed a prolonged adaptive complete denture experience but requested a “cure” for his edentulism. This was achieved via provision of osseointegrated teeth root analogues to support and retain fixed prostheses.
practice, situations are frequently encountered in which factors such as a patient’s weight loss, age, and heavy tooth attrition produce orofacial changes suggestive of compromised, or absent, dental support for the overlying tissues.

Patients seek dental treatment for functional, esthetic, or cosmetic reasons and dentists have been quite successful in restoring or improving many a patient’s facial esthetics.

Some individuals, however, fail to appreciate that aspects of their facial appearance for which they are seeking a solution are merely magnified perceptions or are unrelated to their edentulous predicament. Treatment with complete dentures, with its potential ability to modify facial contours, can raise hopes of a significantly altered appearance, sometimes with imagined benefits for the patient’s interpersonal relationships or career prospects. Often such aspirations are beyond the scope of prosthodontic care. In such circumstances, the dentist must be prepared to guide the patient with a referral where appropriate to an experienced specialist in the field of cosmetic surgery. This does, however, depend on the patient’s wishes being articulated or recognized from the outset. If this does not happen, then unrealistic expectations may only become evident after the dentures have been delivered, when it is more difficult to rescue the situation. Such events can cause the dentist considerable frustration. These issues underline the importance of the patient and clinician agreeing from the outset.

Box 1-1  Morphological Changes Associated with the Edentulous State

Deepening of nasolabial groove
Loss of labiodental angle
Decrease in horizontal labial angle
Narrowing of lips
Increase in columella-philtral angle
Prognathic appearance

Figure 1-8, cont’d.
on treatment objectives, procedures, likely outcomes, and potential problems.

Such discussions can be aided by patients providing photographs of their pre-edentulous appearance, and relevant details from these photographs should be carefully analyzed and discussed with the patient. If this is not possible, photographs of siblings or of children who resemble the patient may be helpful. This process also can help identify whether the patient’s cosmetic desires exceed morphological or functional realities.

**BEHAVIORAL AND ADAPTIVE RESPONSES**

While the clinician can design and fabricate the prostheses so as to optimize the patient’s appearance and create dentures that are as well supported and retained as circumstances will allow, success ultimately depends on the patient accepting their need for prostheses and learning to use them. This is a challenging matter for both patient and dentist, who must work together on the task, often for some time. It is also a process that should start at the onset of care so that the patient is mentally prepared for the challenge rather than experiencing profound disappointment at the delivery stage.

The process whereby an edentulous patient can accept and use complete dentures is complex, and the patient’s ability and willingness to learn to do so ultimately determine the degree of success of the clinical treatment. The process requires the interpretation of new sensory inputs by the central nervous system (CNS) and the acquisition of additional motor skills so as to use the dentures when speaking and eating. Much of this has to occur in the company of others and in the knowledge that any lapses will be extremely embarrassing. Helping a patient adapt to complete dentures can be one of the most difficult but also one of the most rewarding aspects of clinical dentistry.

Edentulous patients expect, indeed are often expected, to adapt to their dentures more or less instantaneously. That adaptation must take place in the context of the patient’s oral, systemic, emotional, and psychological states. Consequently, a real need exists for dentists to be able to understand a patient’s motivation in seeking prosthetic care and to identify potential difficulties before starting treatment. Emotional factors are known to play a significant role in the etiology of dental problems. The interview and clinical examination are obvious ways to observe the patient and form the best treatment relationship. Successful management begins with identification of anticipated difficulties before treatment starts and with careful planning to meet specific needs and problems. Dentists must train themselves to reassure the patient, to perceive their wishes, and to know how and when to limit the patient’s expectations. An essential accompaniment of a denture design that is physically compatible with the oral complex is a good interpersonal relationship between dentist and patient. It is up to the dentist to explore the patient’s symptoms and tensions. The way the patient handles other illnesses and dental situations will aid in the prediction of future problems. It has been observed that the secure patient will adjust readily, cope with discomfort, and be cooperative.

Optimal denture control requires the interpretation of impulses from both exteroceptors and proprioceptors, which are probably affected by the size, shape, position, and mobility of the prostheses and the pressures they generate. The exact role and relative importance of mucosal stimuli in the control of jaw movements need clarification, but it has been clearly demonstrated that control of dentures by muscle activity is reduced if a surface anesthetic is applied to the oral mucous membrane. There have been a number of investigations of the ability of patients to identify three-dimensional shapes placed in their mouths (oral stereognosis) or to assemble simple three-dimensional test pieces as a measure of oral manipulative ability. These were intended to test the hypothesis that such abilities were related to skill in using dentures; however, the results have been equivocal.

Learning means the acquisition of a new activity or change of an existing one and often involves the acquisition of muscular skill, that is, the capacity to coordinate muscular activity to execute movement. In the light of current knowledge, however, it remains very difficult to apply learning theory concepts to the presumed process by which an edentulous patient develops the skills to use their prostheses.

The acceptance of complete dentures is accompanied by a process of habituation, which is defined as a “gradual diminution of responses to continued or repeated stimuli.” The tactile stimuli that arise from the contact of the prosthesis with the richly innervated oral cavity are probably ignored after a short time. Because each stage of the decrease in response is related to the memory trace of the previous application of the stimulus, storage of information from the immediate past is an integral part of habituation. Furthermore, stimuli must be specific and identical to achieve habituation. This is what probably prevents the transfer of habituation evoked by an old familiar denture to a new prosthesis, which inevitably gives rise to a different range of stimuli. Storage of information becomes more difficult in older age, which is why patients in this group often have difficulties becoming comfortable with dentures. In addition advancing age tends to be accompanied by progressive atrophy of elements in the cerebral cortex and a consequent loss in the facility of coordination.

A typical clinical adaptation problem is often encountered in the patient who has worn a complete upper denture opposing only a few natural anterior mandibular teeth. Such a patient usually finds it difficult to adapt to a complete lower denture, which commonly requires marked changes in the shape and activity of the tongue. The latter frequently responds to the loss of posterior mandibular teeth and alveolar bone by spreading laterally so as to contact the
buccal mucosa. The insertion of a new denture introduces an altered environment for the tongue, requiring its intrinsic musculature to reorganize both its shape and learned activity patterns so as to conform to the reduced available space. This process is often accompanied by frequent displacement of the lower denture. Furthermore, the posterior residual ridges are exposed to new sensations from the overlying prosthesis. Pressures transferred through the denture base replace tactile stimuli from the tongue and frictional contact with food. In addition, control of the upper denture frequently must be relearned because the posterior part of the tongue is no longer required to counter the tipping effect on the denture of the few remaining mandibular teeth.

Patient motivation is also important in dictating the speed at which adaptation to dentures takes place, and it is consequently imperative that the dentist determines and cultivates the patient’s motivation in requesting treatment, seeking to foster it if lacking or absent.

It also has been reported that when a population including complete denture users was examined for depression most of the depressive symptoms were found in the age groups that included the greatest proportion of denture wearers. Understanding by the dentist of high-risk groups for depression within the patient pool may help explain difficulties in achieving patient satisfaction with dentures, facilitate recognition of a problem, and make possible suitable referral for diagnosis and appropriate treatment.

The absence of a yardstick to gauge a patient’s adaptive potential to wearing a prosthesis is one of the most challenging facets of treating edentulism. The success of prosthetic treatment is predicated not only on the dentist’s manual dexterity but also on the ability to relate to patients and to understand their needs. The importance of empathy and correct clinical judgment on the part of the dentist can hardly be overemphasized. The dentist’s ability to understand and recognize the problems of edentulous patients, to select the proper course of treatment, and to reassure them has proven to be of greatest clinical value.

Many health care professionals also may forget that although much research and attention have been devoted to the effects of various types of organ loss, such as mastectomies and hysterectomies, the edentulous state has received relatively little attention by psychologists. Only a few authors have acknowledged the fact that it is a serious emotional life issue, albeit not a life-threatening one. Furthermore, outcome measures of health care treatment are only partially defined by technical excellence and are not exclusively dentist determined. Patient perceptions and responses to health care measures are now regarded as an integral part of the clinical decision-making paradigm. It is therefore not surprising to note that many edentulous patients may be described as unable to adapt to complete dentures and are labeled as prosthetically “maladaptive.” The term is used in this very specific context in this text. It is recognized that such patients perceive their denture-wearing experience as one to which they cannot adapt and that this can occur despite the dentist’s optimal skills and humanitarian concerns. Some dentists have been inclined to regard maladaptive denture wearing as a result of anatomical or physiological causes, to which they have sought technical solutions. Nevertheless the use of even more complex techniques and occasional surgical attempts to enlarge the denture-bearing areas has often proved to be palliative at best in these situations. Regrettably, these patients have also been frequently identified as long-term complainers and sometimes even regarded as needing psychiatric help to cope with their maladaptation.

Clinical experience also has demonstrated that patients who are initially adaptive may eventually become maladaptive as regressive, or degenerative, changes in the supporting tissues and neuromuscular control gradually reduce their abilities to adapt. It also must be admitted that the research into determinants of treatment outcomes and the measurement of those outcomes themselves has been characterized by a lack of methodological rigor. As a result, there is a shortage of practical, clinically valid data on predictors of treatment outcomes for the edentulous patient, while methods for measuring patients’ quality of life following prosthodontic treatment in these situations are still evolving.

**TREATMENT OPTIONS: COMPLETE DENTURES**

The edentulous patient faces many challenges: the loss of a major part of their facial structure, threats to their public and self-images, the emphasis on the aging process, a possible loss of self-confidence, and the need to learn to use new and possibly novel prostheses. While the tendency of complete dentures to move in relation to their bases is but one item on a long list, it can be a key concern, especially in relation to the lower prosthesis, since it can be frightening to lose control of a denture, particularly in a public situation. Looseness also can cause mucosal trauma and makes speech and mastication more challenging.

Ideally a denture should maintain a fixed relationship with the underlying bone; however, this is rarely possible with conventional techniques in which stability is optimized by maximizing retention via the peripheral seal, adhesion and cohesion and minimizing displacing forces by appropriate denture base extension, contouring of the polished surfaces, and design of the occlusion. Even with the greatest care, such prostheses tend to move in function as a result of the imbalance between displacing and stabilizing forces and the case with which the supporting mucosa deforms under load. Where there has been severe alveolar resorption then the denture-bearing area may become essentially featureless. In these circumstances the prosthesis can be free to slide horizontally on its saliva lubricated mucosal bed at the whim of the many forces to which it is subjected.
The principal alternatives open to the dentist are rather limited. Where the patient is still partially dentate, then treatment with immediate dentures should be considered. Where edentulous, then the key issue relates to the extent to which the new dentures should inherit the characteristics of the old and the appropriateness of employing implant stabilization, which is discussed in the next section. If there are to be significant similarities with the old dentures, then this may be aided by employing a denture-copying technique. In any case, great care should be taken to optimize denture stability.

When assessing denture stability, it is important to recognize that this is based on the dentist's objective consideration, unlike complaints of looseness, which reflect the patient's subjective views. A degree of denture movement that one patient finds intolerable may be dismissed by another as of no concern. Although both observations must be treated with due respect, the ability to improve the former situation may be somewhat limited.

**TREATMENT OPTIONS: IMPLANT PROSTHODONTICS**

The possibility of linking dental prostheses to the facial skeleton via an implanted device was conceived as a way of overcoming the manifest disadvantages of conventional removable prostheses. Despite numerous pioneering efforts over many decades, predictable time-dependent and morbidity-free documented outcomes proved to be elusive until the publication of P-I Brånemark's seminal research on the technique of osseointegration. The ability to safely locate alloplastic tooth roots in the jawbones had finally become a reality. In 1982, the Toronto Conference on Tissue Integrated Prostheses introduced the concept of inducing a controlled interfacial osteogenesis between dental implant and host bone to the broader dental academic community. This was soon followed by an international research endorsement of the merits of the technique for treating maladaptive edentulous patients with implant-retained fixed or removable overdenture prostheses.

In subsequent publications, implant prosthodontics was demonstrated to be a valid treatment option for any adaptive denture-wearing patient, provided that the necessary systemic and local criteria for implant treatment could be met. These included the willingness of the patient to undergo the required preprosthetic surgical procedures and incur the necessary additional expenses.

The thirteenth edition of this book continues the half-century-old tradition of describing the objectives and methods of treating patients with complete dentures. The text has evolved over this period to reflect developments in the subject, including, since 1985, the significant impact of implant-supported prostheses on clinical decision making when treating the edentulous patient. This development has led many dentists to regard implant prosthodontics as a virtual panacea for managing all complete denture situations and problems. Although implants can provide impressive denture stability, their successful use can be far from straightforward or guaranteed to be problem free. Many challenges in the treatment of the edentulous stem from factors other than denture stability, and the misguided use of dental implants has proved a far from adequate substitute for a lack of knowledge and expertise in removable prosthodontics. It is for this reason that the current edition of this text continues to emphasize the importance of the clinical skills and judgment required to treat patients with conventional complete dentures. The use of osseointegrated implants represents not a different treatment modality but simply one side of the treatment currency coin that permits optimal prosthodontic therapy for edentulous patients (Fig. 1-9).

Because of these requirements, there is a need for this text to underscore a dual purpose. Today's dentist can potentially offer all edentulous patients two treatment options: complete dentures or implant-retained or supported prostheses (Table 1-4). Choosing the best form of therapy is not

<table>
<thead>
<tr>
<th>TABLE 1-4 TREATMENT OPTIONS FOR EDENTULOUS PATIENTS*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diagnosis</strong></td>
</tr>
<tr>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Edentulous in one or both arches</td>
</tr>
<tr>
<td>I. Without prior denture experience</td>
</tr>
<tr>
<td>II. With an adaptive complete denture experience</td>
</tr>
<tr>
<td>III. With a current history of maladaptive denture-wearing experience</td>
</tr>
</tbody>
</table>

*Treatment choice is influenced by both patient- and dentist-mediated concerns. However, scientifically documented evidence shows that the impact of time-dependent regressive changes in the prosthodontic adaptive experience can be significantly reduced through an implant-supported/retained prosthesis.
Figure 1-9  The osseointegration (OI) technique also can be used in an “abbreviated form” via the overdenture application. The technique lends itself to even more versatile applications. A to D, An example of an adult patient with surgically repaired edentulous cleft lip and palate. Both potential implant host bone site availability and circumoral morphology demanded the design of polished and occlusal surface that ensured the best facial support possible. The more routine use remains for edentulous mandibles using two or more abutments as well as diverse retentive components. E and F, Two implants splinted with a bar are used for clip retention.
always a clear-cut process. The clinical decision should reflect the dentist’s thorough assessment of the patient’s general health and oral status and an appraisal of how their needs may be best met, based on an understanding of all the available treatment options. In arriving at an informed decision, the patient will require an appreciation of the procedures involved, their risks, and likely outcomes. Biological, functional, personality, and fiscal considerations may preclude one option or the other. Admittedly, the conventional complete denture option lends itself to more frequent application than a fixed implant-supported prosthetic one, with costs being a major determinant of patient choice. On the other hand, an implant-supported overdenture appears to combine the best of both options without either method’s restrictions. Functional and esthetic requirements are better achieved and maintained, with the risk of time-dependent supporting tissue morbidity compellingly reduced. These observations endorse the emerging clinical educational view that the current standard of complete denture service for prosthodontically maladaptive patients should be an implant-supported overdenture, particularly in the mandible (Fig. 1-10).

Osseointegration, with its robust research base, has ushered in a new era for the management of edentulous patients. Reconciliation of the technique’s potential with the proven merits and ingenuity of complete denture fabrication can only improve dentists’ ability to resolve the edentulous predicament.
The challenge and dilemma of managing the edentulous predicament by means of complete dentures (with their time-dependent and unpredictable reliance on labile biological support) has been dramatically improved by the introduction of the osseointegration technique. The notion of a progressive, inevitable if variable RRR is no longer the dominant treatment concern since alternative and biologically tenable interventions are now available. The predicament of dealing with the substitution of PL support (A) by significantly less biomechanically suitable residual ridges (B) has been dramatically rectified by the predictability of successful outcomes associated with the induction of osseointegration (C). RRR, Residual ridge resorption; PL, periodontal ligament.
Bibliography


Denture wearers' supporting tissues may be particularly vulnerable to specific oral-systemic conditions and compromised nutritional health. Because most oral-systemic conditions in edentulous patients are difficult and challenging to manage by health specialists, they may require alternative management strategies such as consideration for implant-supported prostheses. In addition, a professional dietician's help and dietary guidance should be an integral part of the optimal overall prosthodontic management.

The interplay between the mouth and the body is intricate and of great importance when considering the health and treatment of edentulous patients. A number of systemic conditions affect the oral cavity and specifically influence the prognosis for wearing complete dentures or for accepting osseointegrated prostheses. Furthermore, the role of replacing missing teeth in improving the nutritional status of edentulous patients also deserves consideration.

Systemic conditions affecting the denture-bearing tissues are listed in Box 2-1.

**MUCOSAL CONDITIONS**

**VESICULOEROSIVE**

A number of vesiculoerosive conditions (VEC) may significantly limit the ability of oral mucosal tissues to withstand the mechanical pressures that result from wearing complete dentures. The most common VECs that can have this impact are oral lichen planus (OLP), mucous membrane pemphigoid (MMP), and erythema multiforme (EM). These conditions are often associated with periods of quiescence and exacerbation with the latter routinely characterized by pain. Briefly, all three disorders are inflammatory in nature and the role of autoimmunity in their development is likely critical for OLP and MMP. In the case of EM, a viral or bacterial etiology is often presented. Therefore treatment of these conditions with steroids or retinoids is common although benefits are unpredictable.

The episodic nature of these conditions (i.e., their time-dependent and fluctuant severity) is also a challenge. Clearly, a patient who suffers from one of these conditions has a poorer prognosis for complete denture therapy. Therefore the use of fixed osseointegrated prostheses is a prudent alternative so as to limit reliance on mucosa for prosthesis support.

**SYSTEMIC LUPUS ERYTHEMATOSUS (SLE)**

Systemic lupus erythematosus has been reported to favor women over men at a ratio of 10:1 and is believed to be a form of autoimmune type III hypersensitivity reaction consequent to an environmental trigger (e.g., the Epstein-Barr virus). Other systems, such as the skin, hematologic, and musculoskeletal, are often involved and like the VECs described above are characterized by routine periods of remission and exacerbation. Subepithelial inflammation of the oral mucosa accompanies the intraoral erosive lesions with a resultant compromise in tissue tolerance to complete denture loading. Prosthodontic management of patients with SLE follows a similar philosophy as patients with VECs and osseointegrated prostheses also may be indicated. However, any planned surgical interventions must be considered in light of the fact that patients with SLE are sometimes placed on blood-thinning medications because of the increased risk of stroke.

**BURNING MOUTH SYNDROME**

The diagnosis of burning mouth syndrome (BMS) as a clinical entity is usually based on subjective reports by patients rather than by pathological signs. The majority of patients, the most prevalent of whom are postmenopausal women, describe a painful, burning sensation affecting the oral mucosa. Although the tongue is the most frequently affected site, BMS also may occur in the lips, buccal mucosa, and/or floor of the mouth. The intensity ranges from mild to severe.
Box 2-1  Oral-Systemic Considerations That May Influence an Adaptive Prosthodontic Experience

1. Mucosal conditions
   a. Vesiculoerrosive
      i. Oral lichen planus
      ii. Erythema multiforme
    b. Systemic lupus erythematosus
    c. Burning mouth syndrome
2. Oral movement disorders
3. Salivary dysfunction
   a. Xerostomia/hyposalivation
   b. Sjögren's syndrome
4. Diabetes
5. Nutrition

Figure 2-1  Geographic tongue. Irregularly bordered areas of dekeratinized and desquamated filiform papillae appear as erythematous patches on the dorsum of the tongue bordered by elevated grayish white areas of acantholysis and hyperkeratosis.

While BMS may be associated with Sjögren's syndrome or postradiation treatment in the head and neck region, it is more frequently associated with antipsychotic medications and/or other systemic diseases and drugs affecting salivary flow.

Box 2-2  Documented Possible Causes of Burning Mouth Syndrome

Local Factors
- Mechanical irritation
- Allergy
- Infection
- Oral habits and parafunctions
- Myofascial pain

Systemic Factors
- Vitamin deficiency
- Iron deficiency anemia
- Xerostomia
- Menopause
- Diabetes
- Parkinson's disease
- Medication

Psychogenic Factors
- Depression
- Anxiety
- Psychosocial stressors

[e.g., vitamin B₁₂, iron], hormonal disturbances, anemia, diabetes), psychogenic (anxiety, depression), or due to neurogenic factors (alterations in peripheral nerves, dopamine levels). Mouth burning arising from systemic diseases or local factors is distinguishable from BMS, which is frequently associated with emotional disorders. The salivary alterations noted in patients with BMS include xerostomia, increased saliva viscosity, and altered taste (Box 2-2). The management of BMS is usually palliative and not curative. Although multiple combinations of medications may be available, patient education and encouragement may be the best approaches to improve the patient's quality of life.

ORAL MOVEMENT DISORDERS

The knowledge gap in the management of oral movement disorders is a particularly challenging problem for the health professions. Clinical presentation as excess or diminished movement may be hyperkinetic (bruxism, dystonia, dyskinesias) or hypokinetic (Parkinson's disease), respectively, with the reduced ability of patients to control muscular movement of the jaws thereby seriously impacting the prognosis for complete denture therapy. Numerous complications such as pain, compromised function, and depression may be encountered, and early recognition and appropriate medical referral are essential whenever uncontrolled jaw movement is encountered. Furthermore, patients with oral dyskinesias and other movements disorders are encouraged to consult with their primary care provider or a neurologist.
syndrome, or Huntington’s disease) and their ability to handle their prostheses with necessary dexterity and control may be very limited. Therefore the use of removable prostheses in patients suffering from dyskinesias should only be considered after careful review of the patient’s limitations and capabilities.

SALIVARY DYSFUNCTION

Saliva plays a significant role in the preservation and maintenance of oral health and function. It aids digestion by preparing food for mastication and swallowing and contributes to taste perception and the facilitation of communication while providing protection of the oral tissues from desiccation, microbial penetration, or ulceration. By reducing clotting time and accelerating wound contraction, saliva can stimulate soft tissue repair. In addition, the lubricating ability of saliva provides comfort while wearing dentures.

SJÖGREN’S SYNDROME

The most common disorder associated with xerostomia is Sjögren’s syndrome (SS). This chronic inflammatory autoimmune disorder can appear at any age, but the peak incidence occurs between 40 and 50 years of age. Approximately 3% of the American population is estimated to suffer from SS, 90% of whom are women. A diagnosis of SS is based on a subjective feeling of dry mouth and dry eyes (xerostomia and xerophthalmia, respectively), objective oral and ocular signs of dryness, definite lymphocytic infiltration within minor salivary glands of the lip, and the presence of auto-antibodies to Ro/SSA and La/SSB. Although the manifestations vary according to the individual, symptoms may include persistent or intermittent enlargement of the salivary glands; dry, gritty, sore, or burning eyes that may be sensitive to the sun and/or tear excessively; recurrent eye and mouth infections; difficulty speaking, chewing, or swallowing; frequently using liquids to help swallow dry foods; increased dental decay (Fig. 2-2, A and B); altered sense of
taste/smell; fatigue; sore weak muscles; joint pain; dry nasal passages and throat; headaches; digestive problems; dry skin and rashes; dry cough; sore or cracked tongue (Fig. 2-2, C and D) or lips; constipation; and vaginal dryness. Diagnosis of xerostomia may be based on the patient's history, especially complaints of dry mouth, particularly at night. Upon oral examination, a tongue depressor may stick to the buccal mucosa. Since it takes anywhere from 5 to 9 years for SS to be diagnosed definitively, we in the dental community must be alert to patients with reduced salivary flow and suggest appropriate medical consultations.

**HYPERSALIVATION/HYPOSALIVATION**

Hypersalivation is associated with Parkinson's disease, Down's syndrome, autism, cerebral palsy, and atrophic lateral sclerosis. An increase in salivary flow rate is also a common phenomenon associated with the insertion of dentures. This is true regardless of whether the dentures are for the partially or completely edentulous patient, or whether it is an initial insertion, or insertion of a replacement set of removable dentures. It is speculated that the dentures act as foreign bodies in the mouth and consequently as sialogogues, thereby stimulating salivary flow.

Yet dry mouth is a frequent complaint of the elderly, primarily caused by dehydration, therapeutic medication (especially parasympathetic drugs), head and neck radiotherapy, autoimmune disorders such as SS, rheumatoid arthritis, diabetes, or even an age-related decline in salivary gland function. Hyposalivation may leave patients susceptible to dry or cracked lips, angular cheilitis, dry tongue, oral candidiasis, difficulty swallowing, and difficulty wearing removable dental prostheses. Dry mouth has been reported to be associated with dissatisfaction with chewing and speaking, as well as soreness in denture-bearing areas in complete denture wearers. Clearly, dry tissues are not well-prepared to support removable dentures. On a cautionary note, although there are only a limited number of short-term case studies in the literature involving the outcome of implant-supported prostheses in patients with dry mouth, the use of osseointegrated prostheses should be considered in such instances even though some of the other difficulties that ensue from hyposalivation, such as difficulty chewing, swallowing, and speaking, are still very possible. However, it may be such that the xerostomia patient may be noticing the discomfort associated with a lack of unstimulated saliva that coats the oral tissues and provides lubrication and relief from desiccation rather than a decreased stimulated salivary flow rate and that the decline in salivary gland function may be associated with reduced masticatory function. By providing an optimal occlusal force through prosthetic treatment with more functional complete dentures, a synergistic effect of stimulation for salivary glands on bolus formation in addition to lubrication and protection of the oral mucosa may be generated. In such a manner, proper prosthetic rehabilitation may contribute to the treatment of hyposalivation.

**DIABETES**

The microvascular complications of diabetes have wide-ranging systemic and oral effects. Systemic consequences include coronary artery disease, cerebrovascular disease, and peripheral vascular disease that predisposes to retinopathy, neuropathy, and nephropathy. Oral consequences of microvascular compromise include hyposalivation, mucositis, OLP, and candidiasis. In addition, diabetic patients are at increased risk of infection and also have poorer healing potential, again a consequence of microvascular compromise. However, it should be noted that many symptomatic and satisfied denture wearers are controlled or nonbrittle diabetics and that diabetes per se is not a contraindication for complete denture therapy. Following on, there is conflicting evidence whether diabetes is a contraindication for dental implant therapy. Current best evidence indicates that poorly controlled diabetes may increase the risk for dental implant failure, whereas implants placed in patients whose diabetes is well-controlled have similar survival profiles as implants placed in healthy nondiabetics.

**NUTRITION AND THE IMPACT OF DENTAL STATUS ON FOOD INTAKE**

The food choices of older adults are closely linked to their dental status and masticatory efficiency. Although an intact dentition is not a necessity for maintaining nutritional health, the loss of teeth often leads adults to select diets that are lower in nutrient density. Investigators in the United States and Sweden have reported that adults with compromised dentitions are overrepresented in groups with nutritionally poor diets. Furthermore, denture wearers invariably report that food such as raw carrots, lettuce, corn on the cob, raw apples with peels, steaks, and chops are difficult to chew.

Viewed solely in the context of nutrition, restoration of missing or depleted masticatory function has limited importance. A review of the scientific literature indicates that diminished chewing function does not lead to a loss of nutritional status that has significant physiologic consequences. This is especially noteworthy in spite of the fact that complete denture wearers have more difficulty eating harder foods and are typically able to generate only approximately 20% of the bite force generated by dentate individuals. Consequently, admonishing edentulous patients to receive treatment in order to improve their nutritional state is unjustifiable. Indeed, the fact that loss of chewing ability in complete denture wearers does not have nutritional consequences underscores the multifactorial etiology of poor nutrition with patient age, socioeconomic status, general health, and education level influencing nutritional status greatly.
However, with regard to quality of life, there is strong evidence that improving the ability of edentulous patients to chew does matter a great deal and that the contribution of chewing ability to a patient's perception of overall quality of life is pertinent to the patient-centered clinician.\textsuperscript{27,28} Even though denture wearers are not able to perceive food taste, temperature, texture, and consistency as well as non-denture wearers, the many interactions with family and friends that involve enjoyment of meals together increase the importance of chewing confidence and how patients perceive their quality of life.

It also should be noted that replacing a complete denture with a prosthesis supported by osseointegrated implants results in significant improvement in masticatory function. Increased intake of fresh fruits and crisp bread was reported by a small group of Swedish adults who received tissue-integrated prostheses in the lower jaw. Others who previously wore dentures reported that their chewing ability was markedly improved after insertion of a mandibular fixed prosthesis on osseointegrated dental implants. However, it has to be reiterated that improved oral function does not automatically lead to selection of a higher quality diet. Some individuals will eat a more varied diet and increase their intake of fruits and vegetables, but nutrient intake of patients with dental implants is generally similar to complete denture subjects. To improve diet quality, individual patients undergoing prosthodontic care also require dietary counseling.

**DIETARY COUNSELING OF PATIENTS UNDERGOING PROSTHODONTIC TREATMENT**

The quality of a denture-wearing patient’s diet can be improved with nutrition counseling. One expectation of patients seeking new dentures is that they will be able to eat a greater variety of foods, and such patients often are receptive to suggestions aimed at improving their diet composition. Consequently, the long-term relationship dentists establish with their patients can create an ideal situation for the identification of older patients at nutritional risk, increasing nutrition awareness, and referral to a physician or dietitian. However, a single structured nutritional interview is not likely to result in much change in choice of foods.

It often is difficult, based on a visual inspection or an interview, to identify patients in need of nutritional care because most patients are inclined to tell the dentist that they eat a healthy diet. Patients receiving dentures also should be carefully screened for nutritional risk factors at the first appointment so that suitable counseling and follow-up can occur during the course of treatment (Box 2-3). The dentist and dental hygienist who have backgrounds in basic nutrition can often provide nutrition care, although clinical signs of frank malnutrition are not seen very often in industrialized nations. However, certain denture-wearing patients are known to be at greater risk for malnourishment (Box 2-4). Dietary evaluation and counseling should be included in treatment if patients have any of the following physical or social conditions: older than 75 years of age, low income, little social contact, involuntary weight loss, daily use of multiple drugs, or assistance required with daily self-care.

The main objective of diet counseling for patients undergoing prosthodontic care is to correct imbalances in nutrient intake that interfere with body and oral health. The dentist is not expected to diagnose specific nutrient deficiencies, but to determine the general adequacy of the diet. If the patient reports involuntary weight loss or gain greater than 10 lb during the past 6 months, untreated hypertension, a diabetic state, or demonstrated oral tissue changes suggestive of malnutrition, referral to a physician

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**Box 2-3 Nutrition Guidelines for Patients Undergoing Removable Prosthodontic Treatment**

- Eat a variety of foods.
- Build diet around complex carbohydrates (fruits, vegetables, whole grain breads, and enriched cereals).
- Eat at least five servings of fruits and vegetables daily.
- Select fish, poultry, lean meat, eggs, or dried peas and beans every day.
- Consume four servings of calcium-rich foods daily.
- Limit intake of bakery products high in fat and simple sugars.
- Limit intake of prepared and processed foods high in sodium and fat.
- Drink several glasses of water, juice, or milk daily.

**Box 2-4 Risk Factors for Malnutrition in Patients with Dentures**

- Eating less than two meals per day
- Difficulty chewing and swallowing
- Unplanned weight gain or loss of more than 10 lb in the last 6 months
- Undergoing chemotherapy or radiation therapy
- Alcohol or drug abuse
- Unable to shop for, cook for, or feed oneself
- Specific prosthodontically related determinants:
  - Oral lesions (glossitis, cheilosis, or lingual discomfort)
  - Loose denture or sore spots under denture
  - Severely resorbed mandible with consequent inability to wear lower denture
should be made. Patients who express concern about obesity or low body weight or who report poor adherence to a diabetic, reduced sodium, or low cholesterol diet can be referred to a consulting dietician.

Providing nutrition care for the denture-wearing patient entails the following steps and can be readily carried out by dentists should they feel that this is a responsibility they would want to undertake.

1. Obtain a nutrition history and an accurate record of food intake over a 3- to 5-day period or complete a food frequency form.
2. Evaluate the diet and assess nutritional risk.
3. Teach about the components of a diet that will support the oral mucosa, bone health, and total body health.
4. Help the patient establish goals to improve the diet.
5. Follow up to support the patient in efforts to change food behaviors.

Dietary questions can be incorporated into the medical history form or presented in one of the readily available nutrition questionnaires administered at the first appointment. However, seeking help from a qualified dietician is arguably the better way to optimize this objective.

Nutrition goals for the denture-wearing patient are to eat a variety of foods, including protein sources, dairy foods, fruits, vegetables, grains, and cereals, and to limit salt, fat, and sugar intake. Lack of diet diversity, that is, omitting one or more food groups from the daily diet, has been associated with greater risk of death over time. Using the USDA’s MyPyramid or recently released (June 2011) MyPlate (Fig. 2-3) as a visual tool, the dentist can suggest desirable, nutrient-dense foods to improve the diet, but patients must establish their own dietary goals.

For socially isolated or disabled older adults, there are community-based nutrition programs including food stamps, home-delivered meals, and communal meal programs served in local senior centers, churches, or community centers. Nutrition education, as well as food, is provided. These nutrition services can have a significant impact on nutrient intake and nutritional status of participating older adults. Dental providers can refer patients to these programs.

The quality of a denture-wearing patient’s diet can be influenced positively by nutrition counseling. Since many patients are hoping to chew better, they may be well engaged in conversations regarding their dietary habits, and these conversations that extend out over time into the maintenance phase of therapy have a better chance of long-term impact because of the reinforcement of valuable principles. If desirable, clinicians may choose to incorporate diet questions into their standard medical history questionnaire, which also would provide for the opportunity for annual evaluation as medical histories are updated. In some instances, using a diet history in which a patient records all dietary intake over a period of days can provide valuable opportunity for discussion and may highlight key areas for diet changes to improve a patient's nutrition. For patients who are crippled by poor chewing function and who are at risk of compromised nutrition, commercially available liquid supplements exist that provide for adequate intake of proteins, carbohydrates, vitamins, minerals, and calories. For lactose-intolerant patients, soy milk-based products are available. However, it is advisable for these patients to consult with their physician regarding their overall nutritional condition in order to obtain a full evaluation. It is conceivable that other liquid products like milkshakes or instant breakfast drinks can provide the nutritional elements missing without the extra cost involved in purchasing liquid dietary supplements.

**SUMMARY**

Denture wearers may be particularly vulnerable to both oral-systemic conditions and compromised nutritional health. The latter can be addressed relatively readily with a professional dietician’s help and dietary guidance should be an integral part of the overall management of the denture-wearing patient. On the other hand, most oral-systemic conditions are very difficult and challenging to manage and may require alternative treatment interventions such as osseointegrated implant prostheses.

**References**

THE AGING POPULATION

Some world populations are aging at unprecedented rates (Table 3-1), whereas others, mostly in Sub-Saharan Africa, Southeast Asia, and Central America, are increasing slowly because of short life expectancies that have been devastated by acquired immunodeficiency syndrome (AIDS). The increase is particularly remarkable among the "middle-old" (75 to 84 years) and "old-old" (≥85 years) populations. In Canada, for example, about half (47.8%) of the elderly population (≥65 years) is older than 75 years, and in Japan the population over 75 years will more than double (from 3.7% to 7.5%) between 2000 and 2020. These demographic changes have produced a major shift in health care from cure of acute disorders to management of chronic illness and an almost panic of concern for the likely effects on health care costs. However, as yet, the aging population has had little direct impact on the cost of health care in most industrialized countries, and debate continues on whether or not the impact will be as ominous as some health care economics reports project. Cardiovascular disease, cancer, and cirrhosis of the liver have been particularly hazardous to men during the earlier part of the twentieth century, probably because of environmental pollutants, nicotine, and alcohol abuse. Women, in contrast, use preventive health care services more often than men and have benefited more from improved health care, especially in obstetrics, so that there are nearly twice as many older women than older men globally. Women on average have a longer life expectancy, although we do not understand fully why this is so or whether the difference will remain for much longer.

A small proportion (~6% to 10%) of elders (≥65 years) in most industrialized countries resides in long-term facilities, and, of course, the proportion increases substantially with advancing age. Nearly everyone by 75 years of age is burdened by at least one chronic disorder that may limit access to dental care and influences dental treatment. Furthermore, most elders feel that they have very little flexibility with their income, and a large proportion, at least in North America, live under considerable financial stress. Although Canada has no clear definition of low income or poverty, 7% of elders were living on incomes below the poverty line in 2003, whereas almost 20% were living near the line even though the overall poverty rate in Canada has fallen. The poverty line is closely associated with economic vulnerability or marginalization not only in terms of insufficiency of income for clothing, food, and shelter but also in terms of loss of dignity and social inclusion. Consequently, many older people are very concerned by unexpected dental costs, unless they feel that the need for treatment is obvious and reasonable.

DISTRIBUTION AND IMPACT OF EDENTULISM IN OLD AGE

DISTRIBUTION

The prevalence of edentulism can vary greatly worldwide, but it is believed to be in decline in most industrialized countries, but with large regional and age-related variations. Men rather than women are more likely in old age to have teeth, probably because many women have had unsightly and aching teeth removed earlier in life. Loss of natural teeth is associated also with less affluent people. For example, about three quarters (74.7%) of the less educated, compared with only one third (37.2%) of the more highly educated, older adult population were edentate in the United States and Canada, which reflects most likely the scope of health services accessible to individuals. The decrease in total tooth loss in the United States, for example, has dropped by about 10% each decade for the last 30 years or so, yet with the net increase in the numbers of older people everywhere, many of whom are or will be edentate, the management of edentulism will remain a considerable challenge for the foreseeable future. Moreover, those with little income or education are more prone to tooth loss because of difficulty accessing the knowledge and treatment needed to prevent caries and periodontal diseases.

IMPACT

Residual alveolar ridges continue to resorb for several decades following extraction of teeth; however, elders rarely seek treatment for denture-related problems, possibly
because many of them have been dissatisfied with previous treatment. In general, old people usually adapt poorly to new dentures, which probably explains why they seldom return to have old but familiar prostheses replaced. However, when they do complain, it is usually about difficulty chewing hard foods with uncomfortably loose dentures on flat residual ridges, and this is not an easy complaint to manage.

### MUCOSA

Stomatitis and other mild inflammations are the mucosal lesions encountered most frequently in older edentulous mouths, especially of older men who wear dentures, smoke tobacco, and drink alcohol excessively. Oral cancer or precancerous lesions are unusual in Western countries (2% to 4% of all malignancies), although it is among the most common forms of cancer in Asia. The incidence of oral cancer is higher and the prognosis poorer among African Americans than among the rest of the U.S. population, which probably reflects the influence of low socioeconomic status more than genes or culture. External carcinogens, such as nicotine and alcohol, and viral infections, such as human papillomavirus, might be more damaging to the oral mucosa in old age because of atrophy, increased mitosis with slow turnover of cells, and an increased number of elastic fibers. There is, however, no strong evidence to fully support these associations. Possibly of greater importance to the initiation and progress of oral cancer is the neglect of oral care by elderly denture wearers, especially if they smoke tobacco and drink alcohol to excess.

### BONE

Bone mass is at its maximum in midlife with substantially more in men than in women and in some racial groups more than others. However, even within individuals, the quality of bone in all parts of the skeleton, including the jaws, varies greatly and decreases with age. The decrease occurs in old age because osteoblasts are less efficient and estrogen production declines along with an overall reduction of calcium absorption from the intestine.

Turnover and metabolism of bone are influenced by many factors including exercise, genes, hormones, and nutrition, but usually resorption surpasses formation somewhere around midlife in both men and women. The jaws independently of gender also become more porous with time probably because of metabolic rather than functional changes in the bone.

Osteoporosis is a disorder caused by an accelerated loss of trabecular bone. It happens usually, but not exclusively, in women after menopause and is discovered frequently when an older person breaks a vertebra, hip, or forearm. It has primary and secondary forms that are difficult to diagnose. The more prevalent type I (postmenopausal) form affects women for a decade or so after menopause, whereas the type II (senile or idiopathic) form can attack men and women alike at any age for no obvious reason. Actually, the type II form can develop as a consequence of any disease, such as hyperparathyroidism, inducing bone loss. Residual ridge resorption may be a manifestation of primary type I osteoporosis, but there is very little evidence to show that the two conditions are associated. Estrogen replacement therapy, bisphosphonates, or other systemic treatments for osteoporosis do affect the density and content of jawbones as in other skeletal bone, but the extent of the effect varies considerably at different sites, and the preventive attributes of the treatments are unknown.

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**TABLE 3-1 PERCENTAGE DISTRIBUTION AND PROJECTED INCREASES IN OLDER POPULATIONS BETWEEN THE YEARS 2000 AND 2020**

<table>
<thead>
<tr>
<th>Country</th>
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<th>65+ years 2020</th>
<th>Increase</th>
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SALIVA

The role of saliva as a lubricant and as a chemical buffer is central to the comfort and function of the mouth. The electrolytes, glycoproteins, and enzymes of mucous saliva lubricate, cleanse, and protect the mucosa, and they ease the passage of food around the mouth while contributing to the breakdown of carbohydrates and overall sense of taste. Inadequate quality or quantity of saliva is particularly difficult for complete denture wearers because mucous saliva produced by the minor glands of the palate helps retain and lubricate the dentures. We do not know whether or not the quantity or quality of saliva in healthy individuals is disturbed by age, but we do know that that elders take a vast array of potentially xerostomic medications for depression, sleeping disorders, hypertension, allergies, heart problems, and many other troubles of old age. Indeed, stress, depression, tobacco use, and abuse of alcohol alone can disturb salivary flow, whereas hyposalivation of the minor salivary glands of the palate, which disturbs denture retention, is a common side effect of digitalis preparations, tranquilizers, and polycyclic antidepressants. Pharmacological side effects, especially on submandibular glands, are complicated further by the biochemical interactions of multiple medications. Sjögren's syndrome and radiation treatment also cause dry mouth. Food may have a metallic or salty taste, and an unpleasant sensitivity to bitter and sour foods increases when salivary flow is poor, whereas reduced sensitivity to sweet tastes can generate an unhealthy craving for sugar. A change in the quality of saliva might not be obvious clinically, but it should be suspected as a cause of denture intolerance when a patient is taking multiple medications. Management of hyposalivation is difficult, but recent evidence indicates that secretion of mucous saliva from the palate improves measurably after drinking 2 liters of water, when chewing, or when taking estrogen or pilocarpine.

JAW MOVEMENTS IN OLD AGE

Although age per se has little effect on the ability to chew, people usually chew more slowly, and with less vertical movement of the mandible as they age. Movements of the mandible are governed by a generator in the brain stem influenced by proprioceptors in muscles, joints, and mucosa. Advancing age may delay the central processing of nerve impulses, impede the activity of striated muscle fibers, and inhibit decisions. It can reduce also the number of functional motor units and fast muscle fibers, and decrease the cross-sectional area of the masseter and medial pterygoid muscles. Consequently older people tend to have poor motor coordination and weak muscles. Muscle tone can decrease by as much as 50% between middle and old age, which probably explains the shorter chewing strokes and prolonged chewing time. Elders also have a less coordinated chewing stroke close to maximum intercuspation, probably because of a general deficit in the central nervous system, and some individuals who assume the characteristic stoop of old age experience pain on swallowing because of osteoarthritic spurts growing on the upper spine adjacent to the pharynx. A noticeable change in swallowing is not a part of normal aging, and suggests strongly that there might be an underlying pathosis, such as Parkinson's disease or palsy.

TASTE AND SMELL

Sensations of taste and smell are frequently confused because the sensory mechanisms are closely related and dependent. Indeed, the sensation of "tasting" rarely occurs in isolation, but results from an interaction of proprioception and smell—texture is felt, chemical constituents stimulate taste, and aromatic gases smell. Bitter, sweet, sour, and salty tastes stimulate receptors independently, so one may be damaged without necessarily disturbing the others. Olfactory cells send projections directly to the brain, so they can be traumatized anywhere along the way.

Sensitivity to taste declines with age and especially with Alzheimer's disease. Although the preference for specific flavors also may change over time, complaints of an impairment affecting the sense of taste at any age should be investigated thoroughly because they forebode an upper respiratory infection or a serious neurological disorder. The three cranial nerves (V, IX, and X) carrying sensations of taste can be disturbed and damaged by tumors and viruses (e.g., Bell's palsy, herpes zoster), and by trauma (e.g., head injury, ear washing). Fortunately, damage in one part of the system can be compensated readily by increased sensitivity elsewhere.

NUTRITION

The elderly population is at particular risk of malnutrition because of a variety of factors that range from socioeconomic stress to an overconsumption of drugs and including to some extent the state of the dentition. National surveys in the United States and in the United Kingdom revealed that older people frequently had inadequate calories, fibers, or calcium in their diet and that many of them did not consume adequacies of vitamins (notably A, B, and C) and minerals (Fig. 3-1).

The role of the dentition in mastication and food selection is complicated. Some edentulous people with self-reported faulty dentures restrict themselves to soft foods high in fermentable carbohydrate, whereas others, even with uncomfortable and well-worn dentures, can eat nearly all of the food available to them. A population-based study in the United Kingdom found that some edentulous elders, compared with elders with natural teeth, had significantly lower levels of plasma ascorbate and plasma retinol, which could disturb their skin and eyesight.