The number of people in the United States requiring removable prosthodontic therapy has increased dramatically over the past twenty years.\textsuperscript{1-3} Current predictions suggest that over the next two decades, the declining incidence of edentulism\textsuperscript{4,5} will be more than compensated by a 79\% increase in adults over 55 years of age.\textsuperscript{6} In the United States alone, the number of adults requiring complete denture therapy is expected to increase from 33.6 million in 1991 to 37.9 million in 2020.\textsuperscript{6} Considering the projected decrease in edentulism, the expected increase in the number of older individuals, and the need for both maxillary and mandibular complete denture by many patients, it has been estimated that the 56.5 million complete dentures made in the United States in 2000 will increase to more than 61 million dentures in 2020.\textsuperscript{6}

Marked atrophy of alveolar bone following tooth loss\textsuperscript{7-9} complicates prosthodontic rehabilitation. This phenomenon has been termed “reduction of residual ridges” by Atwood\textsuperscript{7}, who considered it a major oral disease entity. Although consensus regarding etiology is lacking,\textsuperscript{10-16} alveolar bone and oral soft tissue changes observed in denture wearers may be an inevitable consequence of the loss of natural teeth, tissue remodelling, occlusal factors, and/or prolonged denture wear.\textsuperscript{16-26} Alveolar bone loss subsequent to long term edentulism may be severe and the process may progress throughout life.\textsuperscript{19,20,25,27,28} Although generally more pronounced in the mandible and characterized by individual variability in volume and rate,\textsuperscript{15,20,21,24,26,29,30} advanced reduction of residual ridges presents a significant restorative challenge.

Edentulous patients encountered in dental practice may have been wearing complete dentures for decades. Significant atrophy of alveolar processes following the loss of natural teeth is an all too familiar consequence of long term edentulism. This oral
condition complicates both the dentists’ ability to construct adequate complete dentures, and the patients’ ability to successfully manage their new prostheses.

More than 50 years ago it was suggested that local factors were primarily responsible for edentulous ridge resorption. Schlosser\textsuperscript{31} implicated ill-fitting dentures and associated trauma to oral tissues as the primary causes of rapid destruction of the denture bearing structures. He lists faulty impressions, excessive occlusal vertical dimension, inaccurate centric jaw relationships, and occlusal disharmony as major contributing factors. Lammie\textsuperscript{32} suggested that a detrimental external molding force may adversely impact the residual bony ridges as overlying oral soft tissues contract or atrophy with time. This molding force may, in turn, accelerate resorption of the edentulous ridges.

In a review of 18 complete denture patients, Atwood\textsuperscript{33} suggests that the deterioration of edentulous ridges is a complex biophysical process involving functional factors (i.e., the intensity and duration of applied forces), prosthetic factors (i.e., techniques and materials used in denture construction), and metabolic factors (i.e., systemic influences on bone formation and resorption). For example, occlusal parafunction may adversely affect the denture bearing tissues. It is likely that many complete denture wearers limit both separation of the denture teeth and mandibular movement in order to avoid unintentional prosthesis movement.\textsuperscript{34} If this clenching habit occurs over extended periods of time and with sufficient force, damage to the denture bearing hard and soft tissues may result.

Others\textsuperscript{35,36} support Atwood’s conclusions by suggesting that despite careful prosthodontic management and apparent short-term successful outcomes, aggressive reduction of residual edentulous ridges may still occur. Consequently, systemic disease or systemic factors must be considered as an etiologic factor in alveolar resorption. Though difficult to substantiate, an association may exist between residual ridge reduction and osteoporosis.\textsuperscript{7,37-39}

**Complete Denture Stability & Retention**

For edentulous patients, successful denture therapy is influenced by the biomechanical phenomena of support, stability, and retention.\textsuperscript{40-42} Retention, or the resistance to movement of the denture away from the supporting tissues, is critical. Unfortunately, the physical, physiological, and mechanical factors associated with denture retention are not completely understood. Physical forces influencing denture retention are believed to include adhesion, cohesion, capillary attraction, surface tension, fluid viscosity, atmospheric pressure, and external forces originating from the oral-facial musculature.\textsuperscript{53-59} Of these, the interfacial surface tension developed as a result of the saliva layer between the denture base and the supporting soft tissues is quite important. This is particularly true for maxillary prostheses. Retention is realized as the saliva layer maximizes contact with approximating prosthetic and mucosal surfaces. Therefore, xerostomic patients who experience a quantitative or qualitative reduction in saliva may have reduced complete denture retention due to decreased interfacial surface tension.\textsuperscript{50,51}

In the maxilla, alveolar resorption may obscure anatomic landmarks needed to identify the postpalatal seal area. An ineffective or improperly located postpalatal seal may compromise denture retention.\textsuperscript{52} Therefore, reduced vertical alveolar height in a severely atrophic edentulous maxilla may result in poor denture stability and inadequate denture retention.\textsuperscript{53,54}

The typical pattern of residual ridge resorption results in the medial-lateral and anterior-posterior narrowing of the maxillary denture foundation and a widening of the mandibular denture foundation.\textsuperscript{55-59} Resultant changes in horizontal
maxillomandibular ridge relationships may necessitate setting the posterior denture teeth in cross-bite. This arrangement may complicate force distribution to the denture bearing tissues. If cross-bite posterior denture occlusion is not carefully developed and managed in patients with severe residual ridge resorption, denture instability may result.80

The objective of complete denture therapy for patients with severe reduction of residual ridges is not solely the replacement of missing teeth. Rather, complete dentures must be designed to replace both the missing dentition and associated supporting structures. In doing so, the denture base may occupy a substantial volume. Since denture base coverage of the hard palate is necessary to satisfy mechanical requirements of the prosthesis, and not to replace missing anatomic structures, care must be taken to limit denture base thickness in this area. In addition to replacing missing oral tissues, complete dentures structurally redefine potential spaces within the oral cavity. Inappropriate denture tooth positioning and physiologically unacceptable denture base contour or volume may result in compromised phonetics,61 inefficient tongue posture and function,58,62 and hyperactive gagging.63-66 Carefully designed external denture contours (i.e., cameo or polished denture surfaces) may contribute substantially to prosthesis stability and retention. Successful denture wearers display patterns of oral-facial muscular activity that serve to retain, rather than displace, the prostheses. When optimally contoured, complete dentures occupy space in the oral cavity defined by the physiologic limits of acceptable muscular function, thus acquiring stability and retention during mastication, deglutition, and phonation.67,68 Conversely, poorly designed prostheses that do not accommodate anticipated muscular function may yield compromised denture stability and reduced retention.

Complete denture retention is, in part, influenced by denture occlusion. Most denture wearers consciously or subconsciously perform random, empty-mouth occlusal contacts throughout the day. These contacts may result from functional activity (e.g., swallowing) or parafunction (e.g., bruxism or clenching). A bilaterally balanced denture occlusion will minimize the adverse consequences of functional and parafunctional loading by widely distributing these forces on the denture bearing structures. Therefore, a properly balanced denture occlusion may serve to dampen potentially detrimental occlusal forces acting to disrupt denture stability. A balanced occlusion is dependent on effective clinical and laboratory procedures. Accurate and precise registration of maxillomandibular relationships, meticulous articulation of master casts, careful positioning of denture teeth, and correct processing of denture bases must be accomplished. Both laboratory and clinical remount procedures are essential if optimal occlusal balance is to be achieved prior to delivery of the prostheses. Finally, periodic recall of all edentulous patients allows reevaluation of the denture occlusion; a clinical remount can be performed when correction is indicated.

Complete maxillary and mandibular dentures have long been considered the standard of care for treating edentulous patients. While most edentulous patients express relative satisfaction with their maxillary complete dentures, many do not enjoy equally successful mandibular denture comfort and function.59,70 The use of endosseous dental implants to assist in the support, stability, and retention of removable prostheses is now considered an effective treatment modality for the edentulous patient. Individuals wearing implant-assisted overdentures typically report improved oral comfort and function when compared to conventional, mucosa-supported prostheses.71-76 Except when contraindicated due to financial or surgical considerations, implant-assisted overdentures are usually the treatment of choice.
Recently, a symposium held at McGill University addressed the efficacy of implant-assisted overdentures for treatment of edentulism. After thorough, evidence-based review of existing information, the following consensus statement was formulated: “The evidence currently available suggests that the restoration of the edentulous mandible with a conventional denture is no longer the most appropriate first choice prosthodontic treatment. There is now overwhelming evidence that a two-implant overdenture should become the first choice of treatment for the edentulous mandible.”

The Use of Adhesives as Part of Complete Denture Therapy
Successful complete denture therapy must involve both technical excellence during prosthesis fabrication and effective patient management once the dentures are placed. Satisfying the expectations of many patients for optimal denture retention and stability is often beyond the technical skills of even the most accomplished practitioners. Discussing and implementing the judicious use of denture adhesives may satisfy patients’ expectations and achieve the intended treatment goals.

It is appropriate to prescribe a denture adhesive to augment retention and stability of conventional complete dentures. Adhesives are indicated for routine use when appropriately constructed complete dentures do not satisfy stability and retention expectations of the patient. Denture adhesives may also prove psychologically beneficial when the patient requires supplemental retention and stability, particularly during times of public interaction. Denture adhesives are not indicated to provide retention for ill-fitting prostheses.

When properly managed, adhesives enhance the interfacial surface tension occurring between the denture base and supporting soft tissues by (1) improving the adhesive, cohesive, and viscosity characteristics of the interfacial film layer, particularly in saliva-deficient patients, and (2) eliminating voids occurring in the interfacial space in the absence of absolute adaptation of the denture base to the bearing tissues. In addition to improved retention and stability, denture adhesives have been shown to reduce mucosal irritation, reduce food impaction beneath the denture base, improve chewing efficiency, increase bite force, improve functional load distribution across the denture-bearing tissues, and facilitate the psychological well-being of the patient. For patients with xerostomia, the use of a well-hydrated denture adhesive provides a cushioning or lubricating effect, reducing frictional irritation of the supporting soft tissues and preventing further tissue dehydration. Two currently available denture adhesives that function well in this regard are Fixodent (Procter & Gamble) and Denture Grip (Laclede Research Laboratories).

The composition of most modern denture adhesives includes constituents that promote bioadhesion via carboxyl groups once the adhesive is hydrated. Two commonly employed active ingredients in denture adhesives are poly[vinyl methyl ether maleate] and carboxymethylcellulose. The physical chemistry of these adhesive constituents is discussed in detail elsewhere. Once placed on the intaglio surface of the denture, the adhesive material must be substantially hydrated in order to achieve optimal performance.

Following complete denture fabrication and prior to definitive placement of the prostheses, it is prudent to reemphasize to the patient the anticipated outcome of therapy. For patients with favorable anatomic, physiologic, and psychological factors, including extensive denture wearing experience, the anticipated outcome of complete denture therapy is favorable. Conversely, for individuals who display compromised anatomic oral conditions, poor muscular control, psychological indifference, or a lack of successful denture experience, a fair or
guarded prognosis is more realistic. Discussing reasonable expectations with the patient prior to placing complete dentures may prepare them for an otherwise disappointing experience.

It is appropriate to prescribe adhesive to augment retention and stability of conventional complete dentures. Anticipating suboptimal stability and retention in the presence of compromised patient factors, e.g., xerostomia, is sound therapy. Informing patients that the proper use of a limited amount of denture adhesive can supplement existing denture stability and retention is both clinically acceptable and prudent patient management. The need for denture adhesive is not necessarily an indication of suboptimal therapy, or admission of failure by either to dentist or patient.

Most denture wearers, at one time or another, have attempted to use adhesive to facilitate comfortable denture function. Unfortunately, the concept that “more is better” does not hold true for denture adhesives. Table 1 presents the approach used by the authors when presenting to the patient the appropriate method for application of denture adhesive. It is equally important to make certain that patients are informed about removal of adhesive from both denture surfaces and oral tissues on a regular basis. Appropriate denture and oral hygiene should be accomplished by edentulous patients at least two times each day. Table 2 presents an effective technique for denture adhesive removal.

**Table 1.**

<table>
<thead>
<tr>
<th>Appropriate Application of Denture Adhesive</th>
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<td>1. Inform the patient that, due to existing conditions, achieving optimal complete denture retention and stability may not be possible. Also suggest that the proper use of denture adhesive is an acceptable means of augmenting the stability and retention of a new prosthesis. Honest and realistic communication of the anticipated results of therapy may ease future patient management problems.</td>
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<tr>
<td>2. The use of small amounts of hydrated paste adhesives (e.g., Fixodent, Procter &amp; Gamble) works well due to favorable adhesive, cohesive, and viscosity characteristics.</td>
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### Appropriate Application of Denture Adhesive

3. A small amount of the paste should be dispensed onto the clean and dry intaglio surface of the denture. The use of excessive adhesive will likely interfere with proper placement of the denture on the bearing tissues. For the maxillary denture, adhesive should be dispensed in the midpalatal region (Figure 1), while for the mandibular denture very small amounts can be placed in two or three locations along the ridge crest (Figure 2).

4. Once dispensed onto the dentures, the patient should evenly disperse the paste over the entire intaglio surface of the prosthesis with a clean, dry finger (Figure 3). This will result in a thin, even layer of adhesive.

5. The denture is submersed in a container of cool water to maximally hydrate the adhesive (Figure 4). The denture should remain submersed in water for approximately 20 to 30 seconds.

6. The denture is then placed in the mouth and firmly seated with finger pressure for approximately 10 seconds (Figure 5). Maintenance of seating pressure will cause the adhesive to flow throughout the interfacial space between the denture base and the denture bearing soft tissues.

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<tr>
<th>Figure 1.</th>
<th>Adhesive application to maxillary denture.</th>
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<tr>
<td>Figure 2.</td>
<td>Adhesive application to mandibular denture.</td>
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<tr>
<td>Figure 3.</td>
<td>Adhesive dispersed over intaglio surface.</td>
</tr>
<tr>
<td>Figure 4.</td>
<td>Denture submersed in cool water to hydrate adhesive.</td>
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<tr>
<td>Figure 5.</td>
<td>Denture placed and firmly seated.</td>
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Table 1. (continued)

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<th>Appropriate Application of Denture Adhesive</th>
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<td>7. The patient may be provided with the sample container of adhesive used during the demonstration. Suggesting local stores that carry this product will emphasize that adhesive use is a component of regular denture use. The patient should be told that the use of excessive adhesive may indicate an inadequate fit, necessitating denture reline or remake procedures.</td>
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Table 2.

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<tr>
<th>Technique for Denture Adhesive Removal</th>
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<tr>
<td>1. Use of an electric toothbrush can enhance thorough cleaning of both denture surfaces and denture bearing oral tissues (Figure 6). Inexpensive, battery powered brushes are now widely available to consumers (e.g., Crest SpinBrush Pro, Procter &amp; Gamble). A small amount of toothpaste on the electric toothbrush will serve to freshen the patient's breath and improved taste (Figure 7).</td>
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![Figure 6. Battery powered toothbrush and toothpaste.](image)

![Figure 7. Small amount of toothpaste dispensed onto toothbrush.](image)

2. Remove the dentures from the mouth, and thoroughly scrub the entire intaglio surface of the dentures with the electric toothbrush (Figure 8). This procedure is not intended to eliminate adhesive from the dentures. Rather, this initial scrubbing will loosen residual adhesive material, facilitating subsequent removal.

![Figure 8. Initial scrubbing of the denture.](image)
3. The denture is then held submerged in a container of warm water and simultaneously scrubbed using the electric toothbrush (Figure 9). Firm pressure should be applied to the brush in order to eliminate adhesive from the denture surface. Particles or clumps of adhesive material will be seen rising to the surface of the water (Figure 10). This procedure is continued until the entire denture surface is free of residual adhesive.

4. To clean and stimulate the oral tissues, the electric toothbrush may again be used. A small amount of toothpaste is applied to the brush. All denture bearing soft tissues and tissues that contact the cameo surfaces of the dentures, including the tongue, are gently massaged (Figure 11). At first, this may cause a tingling sensation for the patient. This sensation will disappear with repeated use.

5. Following thorough massaging of the oral soft tissues, warm water is introduced into the patient’s mouth (Figure 12). Holding this water in the mouth, the electric toothbrush is again used to massage all oral soft tissues (Figure 13). The patient is then instructed to expectorate the water and residual debris into a sink, leaving the oral tissue free of adhesive.
Conclusion
The phenomenon of residual ridge reduction following loss of the natural teeth, and its impact on successful complete denture therapy, have been reviewed. Anatomic, physiologic, and mechanical factors associated with the stability and retention of complete dentures are important for achieving optimal therapeutic results. The proper use of denture adhesive to supplement sound complete denture therapy should be carefully presented to patients prior to delivery of the prostheses. Denture adhesives can effectively augment denture stability and retention to improve overall denture performance, and patient comfort and satisfaction.

Authors
Dr. Massad is Adjunct Associate Professor, Tufts University School of Dental Medicine, and Adjunct Associate Professor, Department of Prosthodontics, University of Texas Health Science Center at San Antonio, and Adjunct Associate Professor, Department of Forensic Sciences, Oklahoma State University Center for Health Sciences, and Adjunct Associate Professor, University of Oklahoma College of Dentistry. He is also Associate Faculty, The Pankey Institute.

Dr. Davis is Professor, Division of Dentistry, Department of Otolaryngology, Medical College of Ohio, and Adjunct Associate Professor, University of Oklahoma College of Dentistry. Additionally he serves as Director, General Practice Residency Program, and Director, Continuing Medical Education, Medical College of Ohio. He is also Associate Faculty, The Pankey Institute.

Dr. June is Adjunct Associate Professor, University of Oklahoma College of Dentistry. He is also in private practice, Peoria, Illinois.

Dr. Lobel is Assistant Clinical Professor, Department of Restorative Dentistry, Tufts University School of Dental Medicine, and Adjunct Associate Professor, University of Oklahoma College of Dentistry.

Dr. Thornton is Adjunct Associate Professor, University of Oklahoma College of Dentistry. He is also in private practice, Duluth, Georgia.

Dr. Cagna is Associate Professor, Department of Prosthodontics, University of Texas Health Science Center at San Antonio, and Adjunct Associate Professor, University of Oklahoma College of Dentistry. He is a Diplomate, American Board of Prosthodontics and a Fellow, American College of Prosthodontists.

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