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Denture Adhesives Improve Mastication in Denture Wearers

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Purpose: This clinical trial evaluated the influence of denture adhesive (DA) use on masticatory function in denture wearers according to their denture-bearing ridge status. ***Materials and Methods:*** Thirty edentulous subjects, wearing new well-fitting dentures, were classified as having either a normal or resorbed ridge. Mastication was evaluated in patients who completed chewing tests with and without two DA substances (cream or strips), which were randomly assigned. A chewing test with a sieve method analyzed masticatory performance. A kinesiographic device evaluated chewing cycle, and a visual analog scale measured masticatory ability. Data were submitted to Mauchly's sphericity test, and PROC MIXED procedures were conducted on repeated measures. Tukey-Kramer tests performed appropriate statistical comparisons ($P \leq .05$). ***Results:*** DA use increased masticatory performance and ability in patients with both ridge types ($P < .05$). Subjects with resorbed ridges showed the best masticatory performance ($P < .001$) and lowest chewing cycle time ($P < .001$) with DA cream, followed by DA strips and the nonadhesive trial. For normal ridge subjects, decreases in $\times_{50}$ values were only significant with DA use ($P < .05$), regardless of DA type. The denture-bearing ridge status alone did not alter masticatory function in any of the parameters evaluated. ***Conclusion:*** DAs improve mastication by shortening the chewing cycle and by enhancing chewing ability and performance. *Int J Prosthodont 2014;27:140–146. doi: 10.11607/ijp.3674*

A main goal of prosthetic treatment is to restore masticatory function.[1] Compared to completely dentate subjects, conventional denture wearers have impaired masticatory function,[2] which is related to several factors, such as decreased oral proprioception due to the lack of periodontal receptors,[3,4] alterations in chewing dynamics that occur with artificial teeth and prosthetic devices,[5] and reduced denture stability and retention.[6] In addition, long-term physiologic reabsorption of the denture-bearing ridge[6] may further impair masticatory function by increasing the frequency of denture displacement; this instability may then reduce chewing capacity.[7]

Several approaches have been described regarding the use of implant-supported dentures to improve chewing movements.[2,6,8,9] Implant-provided stabilization to dentures significantly improves mandibular movement and creates a harmonious and more efficient chewing pattern.[8] Despite the fact that implants improve conventional denture retention and stability, medical contraindications and additional invasive surgery requirements, especially in individuals with unfavorable supportive tissue, may limit implant use.[10]

One option to enhance denture retention and stability is the use of a denture adhesive (DA).[11–14] However, adhesives are scarcely used and are recommended by clinicians primarily for subjects with an unfavorable denture-bearing ridge or a thinned and flabby ridged mucosa that is easily susceptible to trauma. DAs may also be used for subjects with impaired neuromuscular control, such as stroke patients, or denture wearers who have not adapted to the retention and stability of their new dentures.[12] According to manufacturer instructions, DAs must be used under the resin base of removable dentures to optimize the resin-tissue interface by increasing the adhesive/

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cohesive properties and viscosity of the medium between denture and tissue and to eliminate voids in the interface.[11] Studies have shown that DAs reduce denture displacement during function[12,13,15–17] and the frequency of compression ulcers and mucosal irritation by reducing food particles that accumulate over the prosthesis.[18,19] DAs also cushion and lubricate the mucosa interface, which reduces friction over the bearing tissue.[19]

Some authors[20,21] report that DAs increase maximum occlusal force,[22] improve occlusal force distribution over the denture-bearing ridge, enhance masticatory performance,[22,23] promote a faster and more natural chewing rate,[16] and balance masticatory muscle electromyographic activity during chewing.[22] It should be noted that not all researchers agree with these findings. For example, Kapur[24] found that DAs do not significantly affect masticatory performance of denture wearers. Unfortunately, research has yet to reveal the effects of adhesives on individual masticatory cycles. Moreover, while several types of DAs are commercially available, these products have not been directly compared to determine if one product is superior at improving masticatory function. Therefore, this study investigated the effect of DA use on masticatory performance, mandibular movements, and chewing ability in denture wearers, particularly in subjects with an unfavorable denture-bearing ridge.

Materials and Methods

Experimental Design

The local Ethics Committee at the Piracicaba Dental School, University of Campinas (Piracicaba, Brazil), approved this research (protocol no. 094/2011). This study was a cross-sectional, single-center clinical trial, and subjects functioned as their own controls. Patients who received new complete dentures from the Graduate Dental Clinic in the Piracicaba Dental School, were recruited from February to October 2012. Study participation was completely voluntary, and participants signed an informed consent document prior to enrolling in this research. Each subject attended a single study session, which classified the subject's denture-bearing ridge and evaluated the subject's chewing ability, masticatory performance, and chewing cycle movements. These masticatory parameters were then randomly assessed during three clinical trials: *(1)* subjects using their dentures without any DA (control), *(2)* subjects using their prosthesis with DA cream, and *(3)* subjects using their prosthesis with a DA strip.

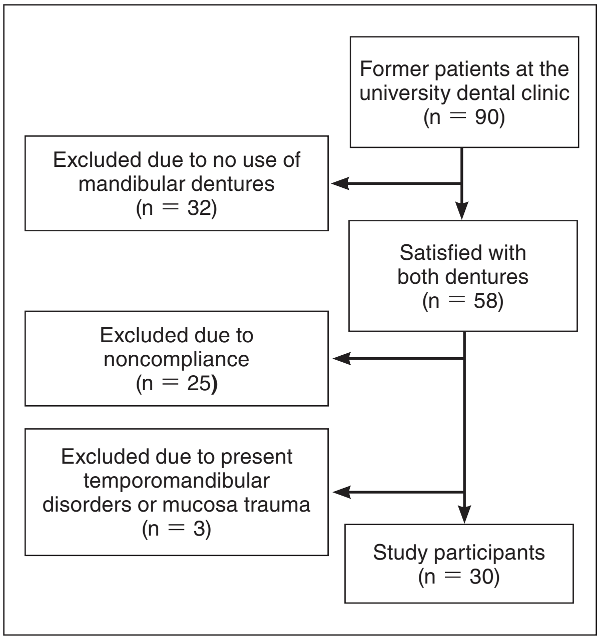

Fig 1 Flowchart of subject recruitment.

Subject Selection

Based on previous research[22] showing that at least 29 subjects are needed to establish statistical significance with these measures, 90 patients who had received new maxillary and mandibular complete dentures (Fig 1) were contacted. A total of 30 subjects, 17 men and 13 women (mean age, 68.1 ± 7.9 years; range, 55 to 87 years), were included in this clinical trial. To be selected for participation, volunteers had to have used their new maxillary and mandible complete dentures for at least 3 months, be free from any discomfort during chewing, be in good general health, display no signs or symptoms of temporomandibular disorders, and be free from uncontrolled medical problems, parafunctional habits, and oral tissue pathology, such as denture trauma.

Denture-Bearing Tissue

The mandibular denture-bearing ridge of all volunteers was clinically and quantitatively evaluated following Kapur´s method.[22,24] This procedure evaluates maxillary and mandibular dental arches by scoring ridge shape, tissue resiliency, and border tissue attachment location. However, since the present study evaluated only the mandibular jaw-bearing ridge, scores were based on a scale of 7 ($\geq$ 7 for normal denture-bearing ridge; $<$ 7 for resorbed denture-bearing ridge). Thus, 15 subjects (8 men and 7 women;

Table 1 Mean Values ± SDs for Chewing Ability (mm), Masticatory Performance (mm), and Broadness Variable (mm)*

Denture-bearing ridge status	Adhesive	Chewing ability (VAS)	$\times_{50}$	Broadness variable
Normal	Without	42.73 ± 14.72 A,a	5.17 ± 0.62 A,a	5.17 ± 0.62 A,a
	DA strip	72.33 ± 17.20 B,a	4.76 ± 0.68 B,a	4.22 ± 1.76 B,a
	DA cream	83.93 ± 10.28 C,a	4.76 ± 0.80 B,a	4.02 ± 1.78 B,a
Resorbed	Without	30.13 ± 12.90 A,b	5.40 ± 0.85 A,a	4.92 ± 2.42 A,a
	DA strip	68.06 ± 18.74 B,a	4.90 ± 0.87 B,a	4.00 ± 2.03 B,a
	DA cream	83.66 ± 16.38 C,a	4.58 ± 0.84 C,a	3.86 ± 1.60 B,a

*Uppercase letters indicate differences among treatments. Lowercase letters indicate differences between denture-bearing ridge status. PROC MIXED, Tukey honestly significant difference, $P < .05$.

Table 2 Mean Values ± SDs for Masticatory Cycle Time (mm/s) During Peanuts and Optocal Chewing*

Denture-bearing ridge status	Adhesive	Opening time	
		Peanuts	Optocal
Normal	Without	212.71 ± 48.55 A,a	230.99 ± 34.61 A,a
	DA strip	189.39 ± 42.67 B,a	213.97 ± 35.09 B,a
	DA cream	184.33 ± 42.94 B,a	204.76 ± 33.81 C,a
Resorbed	Without	191.93 ± 46.02 A,a	201.87 ± 50.31 A,a
	DA strip	175.21 ± 38.84 B,a	188.95 ± 52.50 B,a
	DA cream	155.41 ± 35.04 C,a	180.07 ± 46.90 C,a

*Uppercase letters indicate differences among treatments. Lowercase letters indicate differences between denture-bearing ridge status. PROC MIXED, Tukey honestly significant difference, $P < .05$.

mean age, 65.9 ± 7.87 years) presented a normal denture-bearing ridge, and 15 subjects (5 men and 10 women; mean age, 70.2 ± 7.62 years) showed a resorbed denture-bearing ridge.

Experimental Procedures

Chewing ability, masticatory performance, and chewing cycle movements were evaluated in subjects across three clinical trials, which were randomly established. All evaluations were conducted in a single clinical session, and two different DAs, strips and cream (Corega, Glaxo Smith Kline), were used. DA products were applied according to the manufacturer's instructions on the mandibular denture resin base, not close to its edges, and the prosthesis was reinserted in the mouth. After 20 minutes, masticatory function was assessed. Following the completion of these assessments with any of the DA agents (cream or strip), dentures were thoroughly cleaned and all summing effects among materials were eliminated. The same procedure was repeated with the other DA agent.

Masticatory Assessment

A visual analog scale (VAS) measured chewing ability. Subjects rated their ability to chew test materials after each clinical trial (DA cream, DA strip, and no DA use) by placing a dot on the VAS scale ranging from "very difficult" to "very easy." Higher scores represented greater chewing ability.

A masticatory performance test was performed by using the sieve method with the chewable artificial material, Optocal,[25] based on the silicon material Optosil (Heraus Kulzer). Subjects were instructed to chew 17 Optocal cubes (3-cm^3 portion size) in their normal habitual way for 40 chewing strokes, which were counted by a single calibrated researcher.[26] The chewed particles were then collected, processed, and shaken at 2 Hz for 20 minutes in a sieving machine (Bertel Industria Metalurgica) through a 10-sieve stack, with mesh sizes gradually decreasing from 5.6 to 0.5 mm, and a bottom plate.[27] Retained material on each sieve and on the bottom plate were weighed on an analytical balance (sensitivity to 0.001 g; Model 2060, Bel Engineering).[27] Masticatory performance was calculated as the median particle size, $\times_{50}$, which is the aperture of a theoretical sieve through which 50% of the weight of comminuted food can pass. The Rosin-Rammler equation (nonlinear regression analysis) mathematically describes the cumulative distribution of particle size by weight: $Qw\text{-}(\times) = 1 - ((2\text{-}^{\times/\times}50)^{b})$, where Qw is the weight fraction of particles smaller than $\times$, and b represents the spread of the distribution (broadness variable).[25]

A jaw tracking kinesiograph device (JT-3D, BioResearch) evaluated mandibular movements during chewing. A subject was seated comfortably in a dental chair with the Frankfort plane parallel to the ground. Next, a magnet was temporarily attached to the mandibular denture at the artificial incisive teeth according to the manufacturer's instructions. Magnetic sensors tracked jaw movements during chewing, and these movements were displayed as three-dimensional spatial coordinates on vertical, anterior-posterior, and lateral axes.

Two test materials, one natural (peanuts) and one artificial (Optocal), were used to evaluate jaw movements. First, subjects were requested to chew a 3.7-g portion of peanuts in their habitual way for 20 cycles. Then, subjects were asked to chew a 3.7-g portion of

Closing time		Occlusal time		Cycle time	
Peanuts	Optocal	Peanuts	Optocal	Peanuts	Optocal
306.76 ± 75.42 A,a	305.65 ± 60.13 A,a	173.45 ± 41.70 A,a	152.19 ± 38.91 A,a	677.36 ± 137.22 A,a	673.14 ± 111.49 A,a
283.57 ± 68.06 B,a	291.57 ± 54.21 B,a	155.68 ± 35.19 B,a	134.97 ± 32.59 B,a	629.68 ± 114.33 B,a	645.24 ± 104.47 B,a
259.67 ± 58.05 C,a	281.96 ± 58.40 C,a	139.83 ± 31.14 C,a	128.18 ± 32.63 C,a	598.35 ± 109.40 C,a	625.29 ± 114.07 C,a
297.21 ± 61.02 A,a	303.33 ± 59.47 A,a	195.82 ± 50.34 A,a	151.40 ± 39.70 A,a	669.24 ± 138.86 A,a	642.90 ± 135.22 A,a
272.33 ± 55.40 B,a	282.90 ± 59.98 B,a	168.28 ± 42.94 B,a	133.74 ± 30.98 B,a	608.59 ± 119.35 B,a	608.88 ± 123.50 B,a
254.79 ± 58.73 C,a	272.03 ± 58.18 C,a	141.63 ± 39.75 C,a	133.23 ± 30.14 B,a	574.73 ± 109.33 C,a	595.74 ± 124.96 B,a

Optocal (17 cubes) in the same manner for 40 cycles due to the fact that the chewed materials were posteriorly used to calculate the masticatory performance. However, only the first 20 chewing cycles were considered for analysis. The number of masticatory cycles was counted by a single calibrated researcher.

A custom computer program (BioPack, Bio-Research) analyzed chewing cycle movements. The first masticatory cycle of each chewing test was discarded because it involves the initial positioning of the test material over the teeth.[28] The following chewing movement parameters were analyzed: *(1)* duration of the opening, closing, and occlusal phase(s); *(2)* the entire masticatory cycle duration; *(3)* the angle of opening and closing movement measured on the frontal plane; and *(4)* the opening and closing maximum velocities (mm/s).[29]

Statistical Analyses

A PROC MIXED procedure (SAS Institute, Release 9.1, 2003) was applied for repeated measures, and the Tukey-Kramer test was conducted for multiple comparisons among independent variables. A *P* value less than .05 was considered statistically significant.

Results

Chewing Ability

According to VAS results, masticatory ability was significantly greater when subjects used DA cream compared to the other conditions ($P < .001$), regardless of denture-bearing ridge status (Table 1). The lowest VAS values relative to chewing ability were found in resorbed ridge subjects without DAs ($P < .05$) (Table 1).

Masticatory Performance

Table 1 also shows the mean values for X_{50} (mm) and the distribution spread (mm) of chewed particles for denture-bearing ridge status in all clinical conditions.

In general, subjects with normal and resorbed ridges showed improved masticatory performance with DAs ($P < .05$). Additional comparisons among treatments showed that subjects with resorbed ridges displayed lower X_{50} values and, consequently, higher masticatory performance ($P < .001$) with DA cream compared to DA strip (Table 1). Likewise, broadness was better when DAs were used on both denture-bearing ridge types ($P < .05$), regardless of DA type ($P = .92$). Denture-bearing ridge status isolated did not influence masticatory performance ($P = .43$) or the distribution of chewed particles ($P = .80$).

Chewing Cycle Movements

The masticatory cycle was faster when subjects used DA cream ($P < .001$) compared with the DA strip (Table 2), and this finding was independent of denture-bearing ridge status or chewing material. However, subjects with a normal ridge showed reduced opening time when chewing peanuts and applying DA ($P < .05$), regardless of DA type. A similar reduction was noted for the entire masticatory cycle duration when subjects with a resorbed ridge chewed Optocal and used DA. Denture-bearing ridge status isolated did not influence masticatory cycle duration or any of the evaluated chewing cycle phases ($P > .05$).

There were no statistically significant effects for the mean opening and closing angle values during peanuts and Optocal chewing ($P > .05$, data not shown).

Table 3 Mean Values ± SDs of Opening and Closing Maximum Velocity (mm/s) During the Peanuts and Optocal Chewing*

Denture-bearing ridge status	Adhesive	Maximum velocity during peanuts chewing		Maximum velocity during Optocal chewing	
		Opening	Closing	Opening	Closing
Normal	Without	112.00 ± 43.97 A,a	77.05 ± 31.33 A,a	128.21 ± 42.97 A,a	92.83 ± 26.67 A,a
	DA strip	122.34 ± 39.30 B,a	88.09 ± 32.07 B,a	143.93 ± 41.20 B,a	100.77 ± 23.89 B,a
	DA cream	133.43 ± 47.68 C,a	97.11 ± 36.71 C,a	147.03 ± 46.15 B,a	102.98 ± 30.25 B,a
Resorbed	Without	129.13 ± 44.26 A,a	85.58 ± 30.57 A,a	152.34 ± 51.91 A,a	102.34 ± 32.66 A,a
	DA strip	138.64 ± 49.69 B,a	95.73 ± 36.55 B,a	164.87 ± 59.76 B,a	111.81 ± 36.07 B,a
	DA cream	155.20 ± 53.79 C,a	111.31 ± 37.30 C,a	164.48 ± 51.66 B,a	113.83 ± 32.95 B,a

*Uppercase letters indicate differences among treatments. Lowercase letters indicate differences between denture-bearing ridge status. PROC MIXED, Tukey honestly significant difference, $P < .05$.

Table 3 presents the mean and SD of maximum opening and closing velocity when subjects chewed peanuts and Optocal. For peanut chewing, DA cream increased maximum velocity ($P < .001$) compared with DA strips and nonadhesive use, which represented the lower velocity. The use of either DA type increased opening ($P < .05$) and closing ($P < .05$) velocity when patients chewed Optocal, regardless of patient ridge type.

Discussion

The results of this study showed the positive influence of DA use on the masticatory function of denture wearers. In addition, despite the fact that both DA products revealed better masticatory results than no DA use, DA cream significantly improves mastication of complete dentures wearers.

Regardless of denture-bearing ridge status, the finding that DA use on mandibular dentures increased masticatory ability is similar to that found in previous clinical trials.[12,30,31] According to Koronis et al,[30] DA application increases the masticatory ability in 66% to 70% of denture-wearing patients and, in the present study, DA cream was responsible for a 36% increase in chewing ability. Moreover, the masticatory performance results also support this statement and are likely explained by the effects of DA retention forces. DA increases a denture´s retention and stability, which could enhance the occlusal force during mastication, leading to a more efficient comminution and smaller chewed particles.[12,22] Importantly, there were remarkable differences in masticatory performance values and chewed particle distributions when subjects used a DA (Table 1); subjects produced smaller particles and a uniformly ground bolus. These results demonstrate significant improvement in masticatory performance.

According to a recent study,[12] masticatory improvement in denture wearers is greater after DA cream application compared with the use of a DA strip, and these findings are in agreement with those found in the present study. The possible reason for the difference between cream and strips may be due to a long-acting synthetic polymer in the DA cream, which increases adhesive strength and resistance to dislocation of the resin base.[12] Thus, DA cream seems to be more efficient and lasts longer than DA strips.

One of the first studies[16] investigating mandibular kinematic changes by DAs revealed an increased chewing rate. The present results support this finding, as DA cream was associated with a faster chewing cycle, regardless of the test material (peanuts or Optocal) used to evaluate chewing movements.

Chewing cycle movements were evaluated using two test materials (peanuts and Optocal) to verify whether natural and artificial food substances would differentially influence mandibular movements in denture wearers. Natural foods are normally consumed and subjects are accustomed to chewing them, and mandibular movement represents a regular and normal chewing.[32] However, natural foods can present differences in consistency and texture,[32] and to avoid these variations, which could influence chewing process,[32] a standardized artificial material was also evaluated. Thereby, both analyses are important when studying chewing movements, and according to the present results, natural and artificial materials showed similar results on chewing pattern.

A recent study[33] revealed that masticatory performance and jaw movements are closely related, such that smaller particle size is associated with horizontal chewing patterns and faster chewing cycles. In the current analyses, higher X_{50} values were found when adhesives were not used. Moreover, the condition where DA was not used produced longer opening, closing, and occlusal duration cycles, as well as greater total time, regardless of a subject's denture-bearing ridge status. Similar trends were observed in maximum opening and closing velocity. Nevertheless, the positive influence of DA use by denture wearers is clearly evident, providing faster, more efficient chewing cycles.

Denture-bearing tissue condition isolated did not significantly influence masticatory parameters. This result is similar to that found by Fujimori et al,[22] who reported increased maximum occlusal forces in both normal and resorbed denture-bearing ridge subjects following DA application. However, in contrast to the present research, these same authors found that, after DA use, masticatory performance improved only when resorbed-ridge subjects were evaluated. This disagreement can be due to methodologic differences, since Fujimori et al[22] used a simplified method of mastication analysis and a single-sieve method.

It is important to highlight that the current study did not evaluate masticatory variables when subjects were wearing their old complete dentures, and this may be viewed as a study limitation. However, the authors believe that the current results are clinically valuable since subjects served as their own controls and experienced all conditions. In addition, uncontrollable factors, such as denture misfit, may have confounded the mastication process, which would make it difficult to assign the masticatory changes imputed to DA use.

Although DAs offer several advantages for denture retention and stability, dental professionals should monitor long-term DA use and provide proper guidance to their patients. Patients need to be informed that DAs should be used sparingly because excessive applications may mask ill-fitting dentures.[12] In addition, denture patients should be periodically evaluated for denture relining or replacement, which can prevent denture-bearing ridge reabsorption.[34]

Conclusion

Denture retention and stability may play a crucial role in masticatory impairment, and the increased retention of dentures provided by DA may represent a key factor. Thus, the results of the present study clearly show the influence of DA products on masticatory function even for well-fitting dentures.

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References

1. Mendonca DB, Prado MM, Mendes FA, et al. Comparison of masticatory function between subjects with three types of dentition. Int J Prosthodont 2009;22:399–404.
2. Fontijn-Tekamp FA, Slagter AP, Van Der Bilt A, et al. Biting and chewing in overdentures, full dentures, and natural dentitions. J Dent Res 2000;79:1519–1524.
3. Luraschi J, Schimmel M, Bernard JP, Gallucci GO, Belser U, Muller F. Mechanosensation and maximum bite force in edentulous patients rehabilitated with bimaxillary implant-supported fixed dental prostheses. Clin Oral Implants Res 2012; 23:577–583.
4. N'Gom PI, Woda A. Influence of impaired mastication on nutrition. J Prosthet Dent 2002;87:667–673.
5. Slagter AP, van der Glas HW, Bosman F, Olthoff LW. Force-deformation properties of artificial and natural foods for testing chewing efficiency. J Prosthet Dent 1992;68:790–799.
6. Stellingsma K, Slagter AP, Stegenga B, Raghoebar GM, Meijer HJ. Masticatory function in patients with an extremely resorbed mandible restored with mandibular implant-retained overdentures: Comparison of three types of treatment protocols. J Oral Rehabil 2005;32:403–410.
7. Dervis E. Clinical assessment of common patient complaints with complete dentures. Eur J Prosthodont Restor Dent 2002; 10:113–117.
8. Benzing U, Weber H, Simonis A, Engel E. Changes in chewing patterns after implantation in the edentulous mandible. Int J Oral Maxillofac Implants 1994;9:207–213.
9. Weinlander M, Piehslinger E, Krennmair G. Removable implant-prosthodontic rehabilitation of the edentulous mandible: Five-year results of different prosthetic anchorage concepts. Int J Oral Maxillofac Implants 2010;25:589–597.
10. Cordaro L, Amade DS, Cordaro M. Clinical results of alveolar ridge augmentation with mandibular block bone grafts in partially edentulous patients prior to implant placement. Clin Oral Implants Res 2002;13:103–111.
11. Polyzois G, Lagouvardos P, Frangou M, Stefaniotis T. Efficacy of denture adhesives in maxillary dentures using gnathodynamometry: A comparative study. Odontology 2011;99:155–161.
12. Munoz CA, Gendreau L, Shanga G, Magnuszewski T, Fernandez P, Durocher J. A clinical study to evaluate denture adhesive use in well-fitting dentures. J Prosthodont 2012;21:123–129.
13. de Baat C, van't Hof M, van Zeghbroeck L, Ozcan M, Kalk W. An international multicenter study on the effectiveness of a denture adhesive in maxillary dentures using disposable gnathometers. Clin Oral Investig 2007;11:237–243.
14. de Gomes PS, Figueiral MH, Fernandes MH, Scully C. Cytotoxicity of denture adhesives. Clin Oral Investig 2011; 15:885–893.
15. Grasso J, Gay T, Rendell J, et al. Effect of denture adhesive on retention of the mandibular and maxillary dentures during function. J Clin Dent 2000;11:98–103.
16. Rendell JK, Gay T, Grasso JE, Baker RA, Winston JL. The effect of denture adhesive on mandibular movement during chewing. J Am Dent Assoc 2000;131:981–986.

17. Hasegawa S, Sekita T, Hayakawa I. Effect of denture adhesive on stability of complete dentures and the masticatory function. J Med Dent Sci 2003;50:239–247.
18. Boone M. Analysis of soluble and insoluble denture adhesives and their relationship to tissue irritation and bone resorption. Compend Contin Educ Dent 1984;(suppl 4):S22–S25.
19. Nicolas E, Veyrune JL, Lassauzay C. A six-month assessment of oral health-related quality of life of complete denture wearers using denture adhesive: A pilot study. J Prosthodont 2010;19:443–448.
20. Zhao K, Cheng XR, Chen Q, Li SQ, Gao SH. A clinical investigation into the effect of comfort denture adhesive on masticatory function with complete dentures. Shanghai Kou Qiang Yi Xue 2001;10:207–209.
21. Wang YB, Chen YY. Adhesive-mediated enhancement of occlusal force measurements in patients with existing and new complete dentures: A pilot study. Int J Prosthodont 2010;23:155–157.
22. Fujimori T, Hirano S, Hayakawa I. Effects of a denture adhesive on masticatory functions for complete denture wearers: Consideration for the condition of denture-bearing tissues. J Med Dent Sci 2002;49:151–156.
23. Neill DJ, Roberts BJ. The effect of denture fixatives on masticatory performance in complete denture patients. J Dent 1973;1:219–222.
24. Kapur KK. A clinical evaluation of denture adhesives. J Prosthet Dent 1967;18:550–558.
25. van der Bilt A, Fontijn-Tekamp FA. Comparison of single and multiple sieve methods for the determination of masticatory performance. Arch Oral Biol 2004;49:193–198.
26. Slagter AP, Bosman F, Van der Bilt A. Comminution of two artificial test foods by dentate and edentulous subjects. J Oral Rehabil 1993;20:159–176.
27. Olthoff LW, van der Bilt A, Bosman F, Kleizen HH. Distribution of particle sizes in food comminuted by human mastication. Arch Oral Biol 1984;29:899–903.
28. Lepley CR, Throckmorton GS, Ceen RF, Buschang PH. Relative contributions of occlusion, maximum bite force, and chewing cycle kinematics to masticatory performance. Am J Orthod Dentofacial Orthop 2011;139:606–613.
29. Ohkubo C, Kobayashi M, Suzuki Y, Hosoi T. Effect of implant support on distal-extension removable partial dentures: In vivo assessment. Int J Oral Maxillofac Implants 2008;23:1095–1101.
30. Koronis S, Pizatos E, Polyzois G, Lagouvardos P. Clinical evaluation of three denture cushion adhesives by complete denture wearers. Gerodontology 2012;29:e161–169.
31. Kulak Y, Ozcan M, Arikan A. Subjective assessment by patients of the efficiency of two denture adhesive pastes. J Prosthodont 2005;14:248–252.
32. van der Bilt A. Assessment of mastication with implications for oral rehabilitation: A review. J Oral Rehabil 2011;38:754–780.
33. Lepley C, Throckmorton G, Parker S, Buschang PH. Masticatory performance and chewing cycle kinematics-are they related? Angle Orthod 2010;80:295–301.
34. Ozan O, Orhan K, Aksoy S, Icen M, Bilecenoglu B, Sakul BU. The effect of removable partial dentures on alveolar bone resorption: A retrospective study with cone-beam computed tomography. J Prosthodont 2013;22:42–48.

Literature Abstract

Periodontal innate immune mechanisms relevant to obesity

The article is a review of the immunologic consequences of obesity that exacerbate the effects of infection by pathogens. The facts that obesity affects over 35% of the adult population in the United States and it's related illnesses have emerged as the leading cause of preventable death worldwide are well known. There is also evidence to show the epidemiologic association between obesity and periodontal disease. The degree of the host's immune response to infectious microbes determines the severity of precipitating periodontal disease. Obesity affects the host's immune response in several ways. First, obesity renders the body in a state of hyperinflammation characterized by increased numbers of macrophages, leukocyte and lymphocyte infiltration into adipose tissue, and an activated cytokine network. Furthermore, recent research showed that persistent low-level exposure to *P gingivalis* infection or obesity muted the innate immune response and further exacerbated periodontal disease. In other words, the host's inflammatory response was suppressed upon low-level stimulation of critical pattern recognition receptors, leading to a muted local immune response. The contribution of so-called homotolerance induced by obesity could be an addition to the homotolerance induced by *P gingivalis* exposure. Therefore, a higher degree of homotolerance exists in the combined obese and *P gingivalis*-infected individual than in individuals with either condition alone. The authors opined that homotolerance has been emerging as a critical driver in periodontal disease progression and the effects of obesity on the immune system. Understanding the mechanism of homotolerance on the immune system would be an important research area.

Amar S, Leeman S. *Mol Oral Microbiol* 2013;28:331–341. **References:** 83. **Reprints:** Salomon Amar, Center for Anti-Inflammatory Therapeutics, Boston University, 650 Albany Street, X-343, Boston, MA 02118, USA. Email: samar@bu.edu—*John Chai, Evanston, Illinois, USA*