J Med Dent Sci 2002; 49: 151–156

Original Article

Effects of a denture adhesive on masticatory functions for complete denture wearers
—Consideration for the condition of denture-bearing tissues—

Takuto Fujimori, Shigezo Hirano and Iwao Hayakawa

Section of Complete Denture Prosthodontics, Department of Masticatory Function Rehabilitation, Graduate School, Tokyo Medical and Dental University, Tokyo, Japan

The purpose of this study was to examine effects of a denture adhesive on masticatory functions for complete denture wearers considering the condition of denture-bearing tissues. Sixteen edentulous subjects wearing well-fitting complete dentures volunteered to participate in this study. According to the condition of denture-bearing tissues, subjects were divided into two groups; "good group" and "poor group". Maximum biting forces, masticatory performance, and electromyography of the masseter muscle during mastication were recorded with and without a denture adhesive. Durations of chewing burst and cycle, and coefficients of variation for these variables were calculated using electromyography recordings. Data were analyzed by using two-way repeated-measured ANOVA and paired t-test in order to assess the effect of the use of a denture adhesive. The use of the denture adhesive increased maximum biting force and provided rhythmic masseter muscle activity during mastication for both groups. Masticatory performance was improved and duration of chewing burst was decreased only for "poor group". It was concluded that the effects of the denture adhesive on masticatory functions were observed overall for both groups, and more significant for denture wearers with poor denture-bearing tissues than with good denture-bearing tisuues.

Key words: Denture adhesive, Denture-bearing tissues, Complete denture.

Correspondence: Takuto Fujimori
Section of Complete Denture Prosthodontics, Department of Masticatory Function Rehabilitation, Graduate School, Tokyo Medical and Dental University, 1-5-45, Yushima Bunkyo-ku Tokyo 113-8549, Japan
Tel: +81-3-5803-5584, Fax: +81-3-5803-0214
E-mail: t.fujimori.ore@tmd.ac.jp
Received August 16; Accepted September 27, 2002

Introduction

Denture wearers sometimes use denture adhesives to enhance the retention of their prostheses without any advice of dentists. In general, denture wearers' attitude to denture adhesives is likely to be favorable. It is reported that most denture wearers responded that retention of their dentures became better by using denture adhesives[1]. A questionnaire study also shows that a majority of participants who wore dentures felt more comfortable when chewing and speaking with denture adhesives than without[2].

On the other hand, opinions on denture adhesives have not been consentaneous among dental professionals. Several reports show that denture adhesive may extend the wearing period of ill fitting dentures, resulting in sever residual ridge resorption[3]. Moreover, it is reported that denture adhesives may act as allergens and irritants to denture-bearing tissues[4,5]. However, positive effects of denture adhesives have also been reported. Some studies demonstrated several positive aspects for denture adhesives; prevention of food particles impaction under the denture, reduction of imfavorable mechanical irritation[6,7], improvement in denture stability and retention[8-13]. Furthermore, it is also reported that some 75% of dentists recommend the use of denture adhesives[14].

By using denture adhesives, mobility of the mandibular and maxillary dentures during mastication are reduced[8-13]. The reduction of the denture mobility may affect the masticatory functions. However, there are few studies that showed the clear effect of denture adhesives on masticatory functions scientifically. Especially, as to effect of a denture adhesive on masticatory performance, no common aspect has been established. A report[15] showed that the use of the denture adhesive showed no effect for the improvement of masticatory performance, and yet another report[16] found a significant positive effect. A possible reason for this disagreement may have resulted from the bias that should have been considered in the analysis. A report[17] mentioned maxillary complete denture wearers with unsatisfactory denture-bearing tissues increased better maximum inciasl biting forces than those with satisfactory denture-bearing tissues by use of a denture adhesive. In the same way, it is inferred that effects of denture adhesives on masticatory functions may depend on the conditions of denture-bearing tissues. If residual ridge is severely resorbed, dentures are likely to move, often causing pain during mastication. In such cases, it is conceivable that the use of denture adhesives can improve masticatory functions. On the contrary, it is also possible that the use of denture adhesives have little effects of masticatory functions for complete denture wearers with good condition of denture-bearing tissues. However, none of reports are examined effects of denture adhesives on masticatory functions considering the condition of denture-bearing tissues.

The purpose of this study was to examine the effects of denture adhesive on relevant measures to masticatory function[18,19], biting force, masticatory performance, and masseter muscles activity for complete denture wearers considering the condition of denture-bearing tissues.

Materials and Methods

Subjects

Sixteen complete denture wearers, whose dentures were fabricated at the dental hospital of Tokyo Medical and Dental University, volunteered to participate in this study, after giving their informed consent. All the subjects had used the existing dentures for six months or more since the completion of the correction and were satisfied and free of any chewing discomfort with dentures. According to the condition of denture-bearing tissues described by Kapur[15], the subjects were classified into two groups; “good group” (G group) with sum of score ≥ 14, and “poor group” (P group) with sum of score < 14 (Table 1). The number of subjects, age and scores for denture-bearing tissues for G and P groups are presented in Table 2.

Study Design

A paste type of denture adhesive was used

Table 1. Scoring method used for the clinical apprasal of denture-bearing tissues

Score	Ridge shape	Tissue resiliency	Location of border tissue attachment
1	Flat	Flabby	High
2	V-shape	Resilient	Medium
3	Shaped between U and V	Firm	Low
4	U-shaped	–	–

The denture-bearing tissues were evaluated with sum of scores for maxillary and mandibular: G group ≥ 14, P group < 14.

Table 2. Subjects’ age and scores of denture-bearing tissues

Group	Gender (n)		Age (yr)		Score of denture bearing tissues	
	Male	Female	Mean	SD	Mean	SD
G group	2	6	74.8	6.1	16.5	1.2
P group	3	5	73.8	6.3	12.3	2.2
Total	5	11	74.3	6	14.4	2.8

SD = standard deviation.

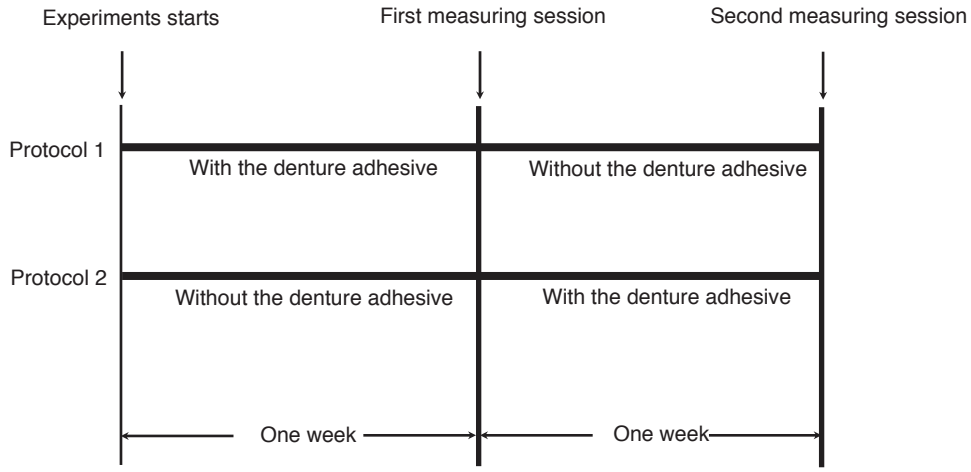

Fig. 1. Study design.

(Correct Sionogi). This denture adhesive was typically and available easily. Subjects were instructed to apply the denture adhesive onto the tissue surface of maxillary and mandibular dentures according to the manufacturer's direction before the experiment had started. The following test protocols were set for the application of the denture adhesive and measurements. For one testing protocol, subjects used the denture adhesive in the daytime for the first testing period of one week, and measurements were performed. After the first mesurement, they stopped applying the denture adhesive. One week later, the same measurements were repeated. For the other testing protocol, subjects used the denture adhesive for the second half testing period. Maximum biting forces, masticatory performance, and muscular activity of the masseter muscle whilst chewing peanuts were measured at end of first and latter half testing period (Fig.1). Subjects of G and P groups were randomly assigned these two testing procedures.

Maximum Biting Force Measurements

Maximum biting forces during maximal voluntary clenching were recorded unilaterally and bilaterally in the first molar region on the preferred chewing side with a hand-held occlusal force meter (Model GM10, Nagano). When the denture was dislodged in measuring unilateral maximum biting force, the maximum value measured before dislodging was recorded. In measuring bilateral maximum biting force, an acrylic resin block with a same thickness as the sensor chip of the occlusal force meter was bitten on contra-lateral side to prevent dislodgment of the denture. All the measurements were carried out three times with 3-minute intervals and then mean values were subject to analysis.

Masticatory Performance Tests

The sieving method described by Manly and Braley[20] was employed to evaluate masticatory performance. Each subject was instructed to masticate a 3-g portion of peanuts with 20 chewing times in their habitual manner. The chewed portion of peanuts was expectorated into a beaker containing 50 c.c. of 0.3 % detergent solution, and was filtered through a 10 mesh sieve. The peanut particles remaining on the sieve were dried in an oven at 80°C for 24 hours, and weighed. The weight of peanuts passing through the sieve was divided by the total weight, and then masticatory performance was obtained. All measurements were carried out three times and then mean values were subject to analysis.

Electromyography (EMG) Recordings

EMG activity of a masseter muscle of the preferred chewing side during chewing of a peanut (1g) was recorded. The EMG activity was recorded from the beginning of chewing until the end of swallowing using bipolar surface electrodes while a clip electrode on the ipsilateral earlobe served as a ground. The distance between bipolar surface electrodes was set at 20 mm. The EMG of a masseter muscle activity was amplified and filtered with polygraph (AB-621, Nihonkohden). The obtained data was digitized with

transducer (Power lab/16sp, AD Instruments) at 1 kHz sampling rate per second. The consecutive 10 strokes after initial 5 strokes, which were often used to assess masticatory rhythm[21-23], were chosen to assess duration of the chewing burst and cycle, and their coefficient of variation. EMG recordings were repeated three times and then mean values were subject to analysis.

Statistical Analysis

Mean values of maximum biting forces, masticatory performance, and EMG parameters were statistically analyzed using two-way repeated-measured ANOVA, in which the condition of denture-bearing tissues and the use of denture adhesive were taken into account as factors. If the significant interaction between two factors existed, a paired t-test was performed to test the effect of the use of the denture adhesive within the group. The significance level was set at 0.05.

Results

The two-way repeated-measured ANOVA results for bilateral and unilateral maximum biting forces and masticatory performance are shown in table 3. The use of the denture adhesive and the condition of denture-bearing tissues influenced both bilateral and unilateral maximum biting forces. Masticatory performance was affected by both the use of a denture adhesive and the condition of denture-bearing tissues, but significant interaction was also found ($p<0.05$).

The means and standard deviations of bilateral and unilateral maximum biting forces and masticatory performance are shown in table 4. The use of a denture adhesive produced the increase of both maximum biting forces in both G and P groups ($p<0.05$). A paired t-test found that the masticatory performance significantly increased only for P group by using the denture adhesive ($p<0.05$).

The two-way repeated-measured ANOVA results for duration of chewing burst and cycle and coefficients of these variables are shown in table 5. The use of the denture adhesive influenced the duration of chewing burst, but significant interaction existed ($p<0.05$). For coefficients of variation for the duration of the chewing burst and cycle, only the use of a denture adhesive showed the significant effect ($p<0.05$).

The means and standard deviations of duration of chewing burst and cycle and coefficients of these variables are shown in table 6. A paired t-test found that the duration of chewing burst significantly decreased only for P group by using the denture adhesive ($p<0.05$). The duration of the chewing cycle was slightly prolonged by using a denture adhesive for both groups, but the difference was not significant. Both

Table 3. Two-way repeated-measured ANOVA results of bilateral and unilateral biting force and masticatory performance

	Bilateral maximum biting force				Unilateral maximum biting force				Masticatory performance			
Source of variation	df	MS	*F* value	*P* value	df	MS	*F* value	*P* value	df	MS	*F* value	*P* value
Denture-bearing tissues	1	207.551	4.268	0.0377	1	113.628	5.486	0.0345	1	2589.24	11.121	0.0049
Denture adhesive	1	27.568	6.893	0.02	1	23.052	30.145	<0.0001	1	137.884	5.08	0.0408
Interaction	1	5.239	1.31	0.2716	1	0.045	0.59	0.8118	1	194.395	7.162	0.0181

df = degree of freedom. MS = mean square.

Table 4. Bilateral and unilateral biting force and masticatory performance without and with the denture adhesive for G and P groups

		Maximum biting force				Masticatory performance (%)	
		Bilateral (N)		Unilateral (N)			
		Mean	SD	Mean	SD	Mean	SD
G group	Without adhesive	112	54.2	71.6	39.5	45.5	15.3
	With adhesive	123	65.8	82.6	38.5	44.7	13.8
	P value	0.02		<0.001		0.75	
P group	Without adhesive	54.9	20.1	31.4	18.8	22.6	3.92
	With adhesive	81.1	25.6	51.5	21.9	31.7	8.95
	P value	0.02		<0.001		0.02	

SD = standard deviation. P value of bilateral and unilatral biting force are caluculated by using two-way repeated-measured ANOVA. P value of masticatory performance is calculated by using paired t-test.

Table 5. Two-way repearted-measured ANOVA results of duration of chewing burst and cycle and CV for these parameters

	Duration of chewing burst				Duration of chewing cycle				CV of duration of chewing burst				CV of duration of chewing cycle			
Source of variation	df	MS	*F* value	*P* value	df	MS	*F* value	*P* value	df	MS	F value	P value	df	MS	*F* value	*P* value
Denture-bearing tissues	1	0.019	4.558	0.509	1	0.02	0.648	0.4342	1	<0.0001	0.039	0.8468	1	0.002	1.162	0.2994
Denture adhesive	1	0.008	10.878	0.0053	1	0.005	2.467	0.1386	1	0.008	12.284	0.0035	1	0.002	4.99	0.0423
Interaction	1	0.007	10.713	0.0056	1	0.003	1.4	0.2564	1	<0.0001	0.589	0.4557	1	0.001	1.803	0.2008

CV = coeffient of variation. df = degree of freedom. MS = mean square.

Table 6. Duration of chewing burst and cycle and CV for these parameters without and with the denture adhesive for G and P group

		Duration of chewing burst (ms)		Duration of chewing cycle (ms)		CV of duration of chewing burst		CV of duration of chewing cycle	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
G group	Without adhesive	257	53.4	640	108	0.16	0.05	0.12	0.03
	With adhesive	255	73.4	687	177	0.14	0.04	0.11	0.04
	P value	0.99		0.14		0.003		0.04	
P group	Without adhesive	309	62.4	613	92.1	0.18	0.02	0.14	0.01
	With adhesive	258	35.7	625	81.6	0.14	0.01	0.11	0.02
	P value	<0.001		0.14		0.003		0.04	

CV = coeffient of variation. P value of duration of chewing burst is caluculated by using paired t-test. P values of other parameters are caluculated by using two-way repeated-measured ANOVA.

groups' coefficient of variation for duration of chewing burst and the cycle were significantly decreased by using the denture adhesive ($p < 0.05$).

Discussion

The incisal biting force has been used to examine the effect of denture adhesives on enhancement of denture retention[17]. On the other hand, the unilateral biting force at molar region was employed in this study because it seemed to be more related to masticatory function than incisal biting force. Therefore, the observed increase of unilateral maximum biting force for both groups means not only increase of denture retention but also the enhancement of the resistance against the dislodgment of dentures during mastication. As to bilateral biting force, the increase was not explained as the enhancement of resistance against dislodgment of dentures because the bilateral biting did not dislodge the dentures. It is conceivable that the high viscosity of the denture adhesive[24,25] might play a roll in the equal distribution of occlusal forces over the denture-bearing area[7,26,27] leading to the increase in the tolerable occlusal force of the residual ridge. As a result, the increase in bilateral biting force may be observed.

The improvement of masticatory performance for P group was probably derived the increase of the retentive force by the denture adhesive, which increased biting force and enhanced stability of dentures during mastication, consequently, subjects could efficiently comminute peanuts. Inversely, the effect of the use of the denture adhesive was not observed for the G group. In a previous study[28], the use of denture adhesives for complete denture wearers who have good denture-bearing tissues did not improve masticatory performance, which was in agreement with this present data. The possible reason is that retention and stability of dentures of denture wearers with good denture-bearing tissues were originally acceptable, and therefore biting force was large and dentures' stability was sufficient enough to comminute peanuts without using the denture adhesive. However, it may be possible that a denture adhesive positively functions in chewing tougher foods than peanuts.

The decrease of the duration of the chewing burst by using the denture adhesive only for P group could be interpreted as a sequence of the improvement of denture stability during mastication[29]. The significant decreases of the coefficient of variation of the duration of chewing burst and cycle by the use of a denture adhesive for both groups indicate that the improvement in masticatory rhythm. Previous report[28] disaffirmed the effect of denture adhesive on a masticatory rhythm, where EMG recordings of maxillary complete denture wearers with good denture-bearing tissues during mastication did not change when using a denture adhesive. This inconsistency would result from the difference in the usage of the denture adhesives. In the present study, subjects were instructed to apply the denture adhesive for both maxillary and mandibular dentures, while only for maxillary denture in the previ-

ous study. The movement of the mandibular complete denture during mastication was larger than that of the maxillary denture, and amount of the reduction by using a denture adhesive was greater for the mandibular denture than that of the maxillary denture[13]. Thus, it is probable that the improvement observed in the chewing rhythm for not only P group but also G group was mainly due to the improvement in retention and stability of mandibular dentures.

In this study, effects of the use of a denture adhesive to complete denture wearers on masticatory function were investigated in a short term. The improvement in masticatory ability with the increase in biting force may provide larger stress onto residual ridges during mastication. Too large stress would be a causative factor of destroying residual ridges. The effects onto oral tissues by the long-term use of a denture adhesive should be investigated in future studies.

As conclusions, it was revealed that the use of the denture adhesive increased maximum biting force, retention and stability, and stabilizes masticatory rhythm of complete denture wearers with both good and poor denture-bearing tissues. It was also denoted that the effect of a denture adhesive on masticatory performance was more significant for denture wearers with poor denture-bearing tissues than with good denture-bearing tissues.

References

1. Kelsey CC, Lang BR, Wang R. Examining patients' responses about the effectiveness of five denture adhesive pastes. J Am Dent Assoc 1997;128:1532-1538.
2. Benson D, Rothman RS, Sims TN. The effect of a denture adhesive on the oral mucosa and vertical dimension of complete denture patients. J South Calif Dent Assoc 1972;40:468-73.
3. Dentisits' Desk Referece. ed 2. Chicago: American Dental Association, 1983: 422-433.
4. Heatwell CM, Rahn AO. Syllabus of Complete Dentures. ed 3. Philadelphia: Lea & Febiger, 1980: 98.
5. Hogan W. Allergic reaction to adhesive denture powders. NY State Dent J 1954;20:65-66.
6. Adisman KI. The use of denture adhesives as an aid to denture treatment. J Prosthet Dent 1989;62:711-715.
7. Boone M. Analysis of soluble and insoluble denture adhesives and their relationship to tissue irritation and bone resorption. Compend Cont Educ Dent 1984;4(Supplement):22-25.
8. Karlsson S, Swartz B. Effect of a denture adhesive on mandibular denture dislodgment. Quintessence Int 1990;21:625-627.
9. Niedermeier W, Kraft J, Land D. Denture retention by adhesives. A clinical-experimental study. Dtsch Zahnärztl 1984;39:858-861.
10. Chew CL, Boone ME, Swartz ML, et al. Denture Adhesives: Their effects on denture retention and stability. J Dent 1985;13:152-159.
11. Taebet WJ, Boone M, Schmidt NF. Effect of a denture adhesive on complete denture dislodgment during mastication. J Prosthet Dent 1980;44:374-378.
12. Grasso JE, Rendell J, Gay T. Effect of denture adhesive on the retention and stability of maxillary dentures. J Prosthet Dent 1994;72:399-405.
13. Grasso J, Gay T, Rendell J, Baker R, et al. Effect of denture adhesive on retention of the mandibular and maxillary dentures during function. J Clinical Dent 2000;11:98-103.
14. Grasso JE. Denture adhesives: Changing attitudes. J Am Dent Assoc 1996;127:90-96.
15. Kapur KK. A clinical evaluation of denture adhesives. J Prosthet Dent 1967;18:550-558.
16. Neil DJ, Roberts BJ. The effect of denture fixatives on masticatory performance in complete denture patients. J Dent 1976;1:219-222.
17. Tarbet WJ, Silverman G, Schmidt NF. Maximum incisal biting force in denture wearers as influenced by adequacy of denture-bearing tissues and the use of an adhesive. J Dent Res 1981;60:115-119.
18. Carlsson GE. Bite Force and Chewing Efficiency. Front.Oral Physiol 1974;1:265-292.
19. Karkazis HC, Kossioni AE. Surface EMG activity of the masseter muscle in denture wearers during chewing of hard and soft food. J Oral Rehabil 1998;25:8-14.
20. Manly RS, Braley LC. Masticatory performance and efficiency. J Dent Res 1950;29:448-462.
21. Shikano Y. Clinical study of evaluation on masticatory function in complete denture wearers. (in Japanese, English abstruct). J Jpn Prosthodont Soc 1990;34:318-332.
22. Endo Y. Clinical study of masticatory funciton in complete denture wearers-the effect of mechanical stimulation to the denture supporting mucosa on masticatory muscle activity-. (in Japanese, English abstruct). J Jpn Prosthodont Soc 1991;35:316-340.
23. Yamamoto N. Evaluation of masticatory function in complete denture wearers by masticatory efficiency, electromyographic activities and mandibular movement. (in Japanese, English abstruct). J Osaka Univ Dent Soc 1993;38:303-331.
24. Ellis B, Al-Nakash S, Lamb DJ The composition and rheology of denture adhesives. J Dent 1980;8:109-118.
25. Stafford GD. Denture adhesives-a review of their uses and composition. Dent Practit 1970;21:17-19.
26. Stafford GD, Russell C. Efficiency of denture adhesives and their possble influence on oral microorganisum. J Dent Res 1971;50:832-836.
27. Adisman K. The use of denture adhesive as an aid to denture treatment. J Prosthet dent 1989;62:711-715.
28. Sasaki H. Effects of the complete denture base forms on masticatory function. (in Japanese, English abstruct). J Jpn Prosthodont Soc 1978;22:844-864.
29. Jemt T, Stalblad PA. The effect of chewing movements on changing mandibular complete dentures to osseointegrated overdentures. J Prosthet Dent 1986;55:357-361.