

Evaluating Masticatory Performance of Removable Partial Denture Wearers Using Color-Changeable Chewing Gum and Gummy Jelly

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Abstract

Tooth loss decreases stomatognathic system function, including masticatory performance. Dental prostheses restore masticatory performance, which affects stomatognathic function and general health. We analyzed mastication performance between removable partial denture (RPD) wearers and dentate subjects using gummy jelly and color-changeable chewing gum and discovered correlation between both methods and factors affecting masticatory performance. We measured masticatory performance and factors affecting it in 40 RPD wearers and 40 dentate subjects using color-changeable chewing gum (30, 45, and 60 strokes) and gummy jelly (10, 20, and 30 strokes). RPD wearers were classified using the Eichner index.

Correlations were compared statistically. Masticatory performance was significantly higher in dentate subject than in RPD wearers using both chewing materials ($P < 0.05$). RPD wearers showed a strong correlation between color-changeable chewing gum 60 strokes and gummy jelly 30 strokes and a negative relationship between gummy jelly and Eichner index ($P < 0.05$).

Masticatory performance in RPD patients decreased 20.84% using gummy jelly and 11.77% with color-changeable chewing gum compared with that in dentate patients.

The optimal number of strokes in RPD wearers is 60 using color-changing gum and 30 using gummy jelly.

The Eichner index is related to masticatory performance in RPD wearers using gummy jelly.

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Introduction

Tooth loss can decrease mastication, speech, and emotional impact due to loss of confidence.¹ Rehabilitation using removable partial dentures (RPDs) can increase masticatory performance by approximately 70% of that in dentate subjects depending on the type of denture and amount and distribution of the original tooth remaining.²⁻⁴

Several different methods can be performed to evaluate masticatory performance, for instance, using an artificial test food (gummy

jelly and Optocal), paraffin wax, or two-color and color-changeable chewing gum. The material can be examined either using an instrument or visually. Instrument examination is done mostly at the research institution, whereas visual inspection may be used more generally to facilitate evaluation of prosthetic treatment and patient condition.⁵

Gummy jelly containing β -carotene includes manual measuring methods and a fully automatic system developed to evaluate masticatory performance, in which the concentration of glucose or β -carotene is measured to calculate the increase in surface area of the comminuted gummy jelly. It serves as the measurement index, dissolved in water from the surface of the comminuted gummy jelly after a specified time. Nokubi et al.⁶ developed an easy visual scoring method that did not require equipment. In this method, a visual score of 1–10 is determined on the basis of the level of masticatory performance.⁶⁻⁸

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Kamiyama et al.⁹ found a new color-changeable chewing gum, Masticatory Performance Evaluating Gum XYLITOL (70 × 20 × 1 mm, 3.0 g; Lotte Co., Ltd., Saitama, Japan), which is measured using a colorimeter and did not stick to denture materials.⁹

Hama et al.¹⁰ suggested that measurement of masticatory performance requires an easy and effective method that is practical to use. Chewing gum has the advantage of simulating natural and stable chewing. They found a color scale that has been tested for validity and reliability, so that everyone can evaluate masticatory performance anywhere.¹⁰

The masticatory process consists of crushing, tearing, and mixing food. Gummy jelly can be used as an instrument to measure mastication in the crushing (comminuting) phase and chewing gum to check the degree of mixing, but to our knowledge, no single method can evaluate both aspects simultaneously.¹⁰⁻¹² Therefore, several methods are needed to evaluate masticatory performance comprehensively. Masticatory performance may be influenced by several factors, such as age,⁸ sex,¹³ body mass index (BMI),¹⁴ and numbers of tooth loss (Eichner index).¹⁵

We analyzed mastication performance between RPD wearers and dentate subjects using gummy jelly and color-changeable chewing gum and discovered correlation between both methods and factors that affect masticatory performance.

Materials and methods

This cross-sectional study was done at the Dental Hospital Faculty of Dentistry, Universitas Indonesia and Klinik Gigi Ajiwaras and was approved by the ethical committee of the Faculty of Dentistry, Universitas Indonesia

(No. 27/Ethical Approval/FGUI/VII/2016). The subjects were obtained by consecutive sampling and classified into two groups, dentate ($n = 40$) and RPD ($n = 40$) groups. Inclusion criteria were willingness to participate in the research, non-Muslim, patients used RPDs or were fully dentate without loss of teeth except the third molar, patients wore an RPD who have no subjective complaints about the dentures and can chew gummy jelly, and patients did not use an RPD overdenture or implant support. Masticatory performance was assessed using color-changeable chewing gum and gummy jelly and measured by asking the subject to chew the gum (Fig. 1) with 30, 45, and 60 strokes as well as gummy jelly (Fig. 2) with 10, 20, and 30 strokes. Immediately after chewing, the gum was flattened by compression between two glass plates until 1.5 mm thickness (Fig. 3) and measured using a color chart (Fig. 4). For gummy jelly, after chewing, the subject was asked to spit the jelly onto a paper cup covered by gauze (Fig. 5) and measured using a visual chart (Fig. 6). Body weight and height of the subjects were measured, and Eichner index was examined.

SPSS software version 22 was used to perform statistical analyses. Statistical significance was set at $P < 0.05$. The Kolmogorov–Smirnov test with 95% confidence level was used to calculate normality and variance homogeneity of the data. Data were analyzed by the Mann–Whitney U test to compare masticatory performance of the dentate and RPD groups using gummy jelly and color-changeable chewing gum. Spearman's rank correlation coefficients (r) were used to analyze the correlation between gummy jelly and chewing gum measurements and factors that affect masticatory performance.



Figure 1. Color-changeable chewing gum (masticatory performance evaluating gum Xylitol; Lotte Co., Ltd. Saitama, Japan).

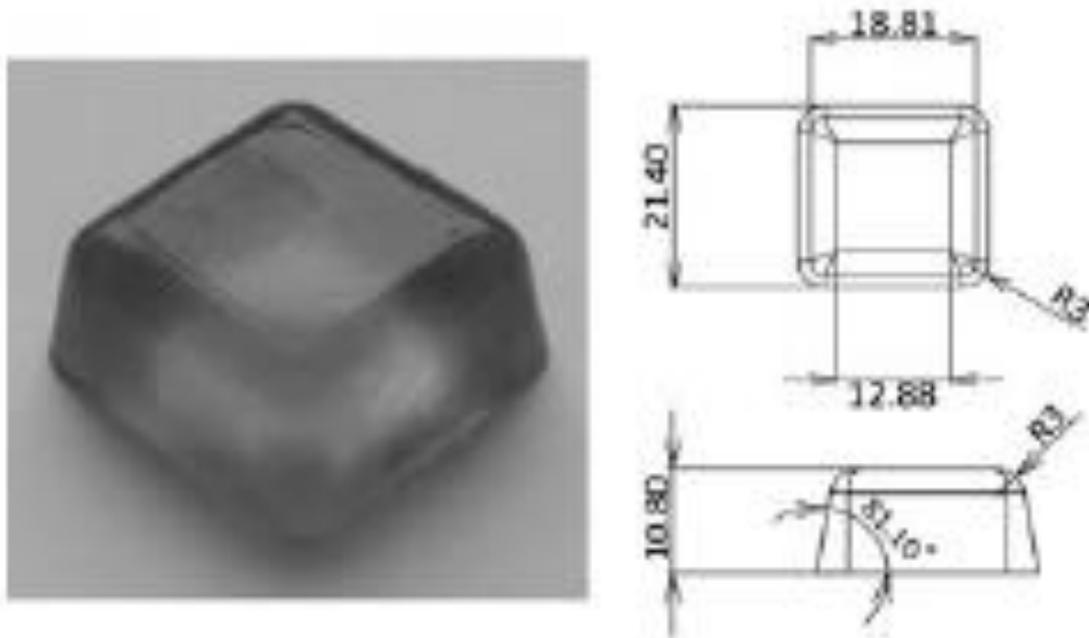


Figure 2. Gummy jelly.

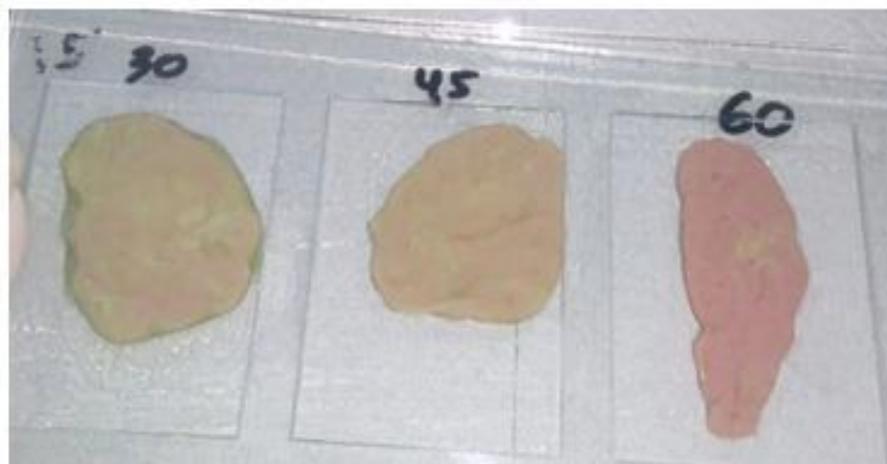


Figure 3. Sample of chewing gum after chewing

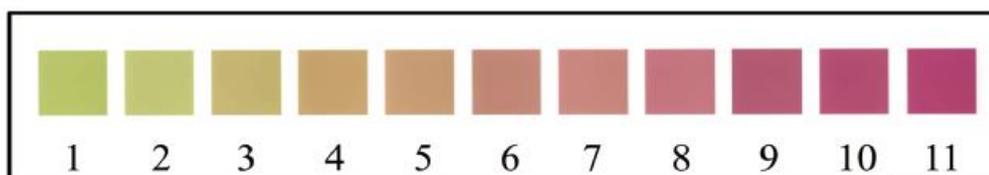


Figure 4. Color scale of color-changeable chewing gum that has 11 gradation colors between 1 and 11.



Figure 5. Sample of gummy jelly after chewing.

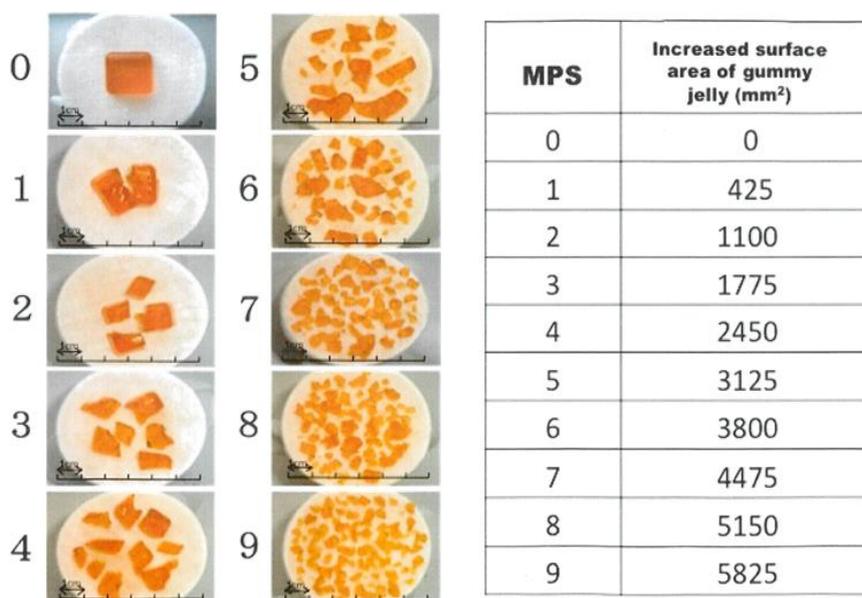


Figure 6. Visual scale shows 10 categories of gummy jelly.

Results

The 80 recruited study subjects were divided into two groups, dentate (age 21–38 years, majority 26–35 years old) and RPD (age 28–76, majority 56–65 years old) groups. Most subjects in both groups were women. BMI in both groups was normal, but three in the dentate group had a BMI >30 (obese). Most patients in the RPD group had an Eichner index class B, where there were 1–3 support zones in the premolar and molar areas. The frequency distributions of age, sex, BMI, and Eichner index are shown in Table 1.

There was a significant difference in masticatory performance between the dentate

and RPD groups using gummy jelly and color-changeable chewing gum ($P < 0.05$). Masticatory performance was lower in the RPD than in the dentate groups (Table 2).

The correlation between color-changeable chewing gum (30 strokes) and gummy jelly (10 strokes) in the dentate group was statistically significant ($P < 0.05$). Meanwhile, in the RPD group, a correlation was found between 30, 45, and 60 strokes of chewing gum and 20 and 30 strokes of gummy jelly (Table 3). Greater masticatory performance was noted using gummy jelly according to the lower Eichner index class in RPD wearers ($P < 0.05$ for all gummy strokes, with Eichner index $r = -0.314, -0.487, -0.486$) (Table 4).

Variable	RPD (n = 40)	(%)	Dentate (n = 40)	(%)
Age				
a. 15–25	–	–	17	42.5
b. 26–35	1	2.5	22	55
c. 36–45	1	2.5	1	2.5
d. 46–55	10	22.5	–	–
e. 56–65	21	52.5	–	–
f. > 65	8	20	–	–
Sex				
a. Male	13	32.5	15	37.5
b. Female	27	67.5	25	62.5
BMI				
a. <18.5	–	–	–	–
b. 18.5–22.9	16	40	22	55
c. 23–24.9	9	22.5	8	20
d. 25–29.9	15	37.5	7	17.5
e. >30	–	–	3	7.5
Eichner Index				
a. Class A	4	10		
b. Class B (B1, B2, B3 = 23; B4 = 9)	32	80		
c. Class C	4	10		

Table 1. Frequencies Distribution of Age, Sex, BMI, and Eichner Index

		Median (Min–Max)	P value
CG 30	Dentate	3 (2–4)	0.005*
	RPD	3 (2–4)	
CG 45	Dentate	6 (3–8)	0.005*
	RPD	5 (3–8)	
CG 60	Dentate	8 (5–9)	0.000*
	RPD	7 (5–8)	
GJ 10	Dentate	3 (0–5)	0.005*
	RPD	2 (1–4)	
GJ 20	Dentate	6 (3–7)	0.000*
	RPD	4 (2–6)	
GJ 30	Dentate	8 (4–9)	0.000*
	RPD	6 (4–8)	

Table 2. Mann–Whitney U test of Color-changeable Chewing Gum and Gummy Jelly between Dentate and RPD Groups

	Group	GJ 10 (r)	GJ 20 (r)	GJ 30 (r)
CG 30	RPD	0.285	0.431*	0.455*
	Dentate	0.347*	0.240	0.379*
CG 45	RPD	0.221	0.454*	0.573*
	Dentate	0.151	0.171	0.258
CG 60	RPD	0.241	0.522*	0.584*
	Dentate	0.166	0.113	0.293

CG, chewing gum; GJ, gummy jelly.

*Significant ($P < 0.05$).

Table 3. Spearman's Correlation Coefficient between Color-changeable Chewing Gum and Gummy Jelly.

	Group	Age	Sex	BMI	Eichner Index
CG 30	RPD	0.149	-0.053	0.059	-0.537*
	Dentate	-0.078	0.119	-0.084	
CG 45	RPD	-0.212	-0.029	0.139	-0.205
	Dentate	0.033	0.230	0.366*	
CG 60	RPD	-0.162	-0.024	-0.034	-0.241
	Dentate	0.047	0.247	-0.261	
GJ 10	RPD	-0.178	-0.111	-0.109	-0.314*
	Dentate	0.440	-0.107	0.088	
GJ 20	RPD	-0.129	-0.011	-0.165	-0.487*
	Dentate	0.038	0.113	-0.046	
GJ 30	RPD	-0.182	-0.073	-0.143	-0.486*
	Dentate	-0.004	0.141	-0.058	

CG, chewing gum; GJ, gummy jelly.

*Significant ($P < 0.05$).

Table 4. Spearman's Correlation Coefficient between Masticatory Performance with Age, Sex, BMI, and Eichner Index

Discussion

Teeth are the main indicator of decreased masticatory performance, so that oral health care is of primary importance. Rehabilitation using RPD is performed to improve masticatory function, but the remaining teeth are the main indicator of decreased masticatory performance.¹⁶ From our results, statistically there was a significant different in masticatory performance between dentate subjects and RPD wearers, with masticatory performance in RPD wearers having decreased by 20.84% by using gummy jelly and 11.77% with color-changeable chewing gum compared with dentate subjects. Feedback controls are needed for formation of a food bolus that will modulate muscle activity. This feedback control function decrease due to loss of functional teeth cannot be compensated by mucosal sensitivity achieved when using dentures.¹⁷

There was a correlation between gummy jelly 10 and 30 strokes and color-changeable chewing gum 30 strokes, which indicated that the comminuting test was suitable for dentate subjects with good masticatory performance. In contrast, in RPD wearers, there was a relationship between all strokes of color-changeable chewing gum and gummy jelly 20 and 30 strokes ($P < 0.05$), indicating that the mixing test can be used either on subjects with good or compromised (like RPD wearers) masticatory performance.

Comminuting and mixing tests measure different aspects of the mastication process. Gummy jelly requires precise manipulation between molar teeth and specimens during the chewing cycle that has proved difficult for denture wearers. Gummy jelly particles may be tucked beneath the lower denture, which can make mastication difficult or the subject stop chewing.¹⁸ Subjects with compromised masticatory performance cannot break the specimen because their maximum bite force is lower than that required to break food particles. Chewing gum forms a bolus that is easier to manipulate and, therefore, a better choice for denture wearers.¹⁹ Due to the hardness of gummy jelly, wax, and peanut tested by varying degrees of pressure, gummy jelly has the highest pressure because it is elastic and must be broken with teeth during mastication, whereas waxes are softer and cohesive and may a form bolus during mastication. Mixing ability has a weak correlation with elastic food and a strong correlation with brittle food.²⁰

The strongest correlation seen with 30 strokes of gummy jelly and 60 strokes of color-changeable chewing gum indicated that the optimal stroke number that can be used in RPD wearers is 30 when using gummy jelly and 60 when using color-changeable chewing gum.

Age, sex, and BMI are not related to masticatory performance in dentate or RPD wearers using gummy jelly and color-changeable chewing gum. The theory says that as the

subject's age increases, the ability of mastication will decrease. However, in our study, age is not directly related to masticatory performance; if posterior occlusal contact is maintained, the masticatory performance will not decrease. The influence of age is more associated with orofacial structure and function.^{4,11} Regarding mastication, women may have less muscle strength than men, but women can improve the coordination of other motor and sensory functions.²¹ According to Shaikh et al.,²² there was no significant difference in BMI before and after denture rehabilitation.

There is a correlation between masticatory performance and Eichner index in RPD wearers using gummy jelly. Eichner index is more related to the comminuting than the mixing process, because Eichner index records the posterior occlusal contact, which is classified on the basis of tooth contact between the upper and lower jaws in the premolar and molar areas. A support zone at least has one contact across the entire region.²³

Conclusions

Masticatory performance in RPD patients decreased 20.84% using gummy jelly and 11.77% with color-changeable chewing gum compared with that in dentate patients. The optimal number of strokes in RPD wearers is 60 strokes using color-changing gum and 30 strokes using gummy jelly. The Eichner index is related to masticatory performance in RPD wearers using gummy jelly.

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Conflict of Interest

The authors state that there were no conflicts of interest related to this study.

References

1. Riadiani B, Dewi RS, Ariani N, Gita F. Tooth Loss and Perceived Masticatory Ability in Post-Menopausal Women. *J Dent Indones* 2014;21(1):11-5.
2. Okada K, Enoki H, Izawa S, Iguchi A, Kuzuya M. Association between masticatory performance and anthropometric measurements and nutritional. *Geriatr Gerontol Int* 2010;10:56-63.
3. Soboleva U, Laurina L, Slaidina A. The masticatory System- An Overview. *Stomatol Balt Dent Maxillofac J* 2005;7:77-80.
4. Tumrasvin W, Fueki K, Yanagawa M, Asakawa A, Yoshimura M. Original Article Masticatory function after unilateral distal extension removable partial denture treatment: intra-individual comparison with opposite dentulous side. *J Med Dent Sci* 2005:35-41.
5. Oliveira NM, Shaddox LM, Toda C, Paleari AG, Pero AC, Compagnoni MA. Methods for Evaluation of Masticatory Efficiency in Conventional Complete Denture Wearers: A Systematized Review. *Oral Health Dent Manag* 2013;13:757-62
6. Nokubi T, Yoshimuta Y, Nokubi F, et al. Validity and Reliability of a Visual Scoring Method for Masticatory Ability using Test Gummy Jelly. *Gerodontology Soc John Wiley Sons A/S*. 2013:76-83.
7. Ikebe K, Furuya-yoshinaka M. Association of Masticatory Performance with Age, Posterior Occlusal Contacts, Occlusal Force, and Salivary Flow in. *Int J Prosthodont* 2006;19(5):475-82.
8. Ikebe K, Matsuda K, Kagawa R, et al. Association of Masticatory Performance with Age, Gender, Number of Teeth, Occlusal Force and Salivary Flow in Japanese Older Adults : Is Ageing a Risk Factor for Masticatory Dysfunction? *Arch Oral Biol* 2011;56(10):991-6.
9. Kamiyama M, Kanazawa M, Fujinami Y, Minakuchi S. Validity and Reliability of a Self-Implementable Method to Evaluate Masticatory Performance : Use of Color-Changeable Chewing Gum and a Color Scale. *J Prosthodont Res* 2010;54:24-8.
10. Hama Y, Dds MK, Dds SM, Dds TU. Properties of a Color-Changeable Chewing Gum used to Evaluate Masticatory Performance. *J Prosthodont Res* 2014;58(2):102-6.
11. Tarkowska A, Katzer L, Oliver M, Priv A, Lecturer S. Assessment of Masticatory Performance by Means of a Color-Changeable Chewing Gum. *J Prosthodont Res* 2016;88(CiM):1-11
12. Endo T, Komatsuzaki A. A Two-Colored Chewing Gum Test for Assessing Masticatory Performance : A Preliminary Study. *Odontology* 2014:68-75.
13. Shiga H, Dds YK, Katsuyama H. Gender Difference in masticatory performance in dentate adults. *J Prosthodont Res* 2012;56(3):166-9.
14. Indrasari M, Shakina T, Masulii C. Association Between Masticatory Performance and Body Mass Index (BMI). *J Int Dent Med Res* 2016:293-8.
15. Nakatsuka Y, Yamashita S, Nimura H, Mizoue S, Tsuchiya S, Hashii K. Location of Main Occluding Areas and Masticatory Ability in Patients with Reduced Occlusal Support. *Aust Dent J* 2010;55:45-50.
16. Yoshino K, Kikukawa I, Yoda Y, et al. Relationship between Eichner Index and Number of Present Teeth. *Bull Tokyo Dent Coll*. 2012;53:37-40.
17. Bessadet M, Nicolas E, Sochat M, Hennequin M, Veyrune J. Impact of Removable Partial Denture Prosthesis on Chewing Efficiency. *J Appl Oral Sci* 2013;21(5):392-6.
18. Bilt van der, Mojet J, Tekamp FA, Abbink JH. Comparing masticatory performance and mixing ability. *J Oral Rehabil*. 2010;37(25):79-84.
19. Speksnijder CM, Abbink JH, Van Der Glas HW, Janssen NG, Andries VDB. Mixing Ability Test Compared with a Comminution Test in Persons with Normal and Compromised Masticatory Performance. *Eur J Oral Sci* 2009;117:580-6.
20. Sugiura T, Fueki K, Igarashi Y. Comparisons Between a Mixing Ability Test and Masticatory Performance Tests using a Brittle or an Elastic Test Food. *J Oral Rehabil* 2009.
21. Tamura K, Shiga H. Gender Differences in Masticatory Movement Path and Rhythm in Dentate Adults. *J Prosthodont Res* 2014;58(4):237-42.

22. Shaikh S, Aziz F, Umerjaved M, Sharif M, Aliazad A. Body Mass Index Before and After Provision of Complete Dentures. *Pakistan Oral Dent J* 2012;32(2):335-9.
23. Ikebe K, Maeda Y, Nokubi T, Matsuda K, Murai S. Validation of the Eichner Index in Relation to Occlusal Force and Masticatory Performance. *Int J Prosthodont* 2010;23(6):521-5.