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Masticatory Efficiency and Perceived Masticatory Ability Evaluation in Completely Edentulous Patients Rehabilitated with A Thermoplastic Denture

Mostafa I. Fayada*[1,2], Ihab I Mahmoud[1], Ahmed A Shon[1]

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Aadj@azhar.edu.eg

ABSTRACT

Aim: This study was conducted to evaluate the masticatory efficiency and perceived masticatory ability among completely edentulous patients rehabilitated with a thermoplastic denture base **Subjects and methods**: This study was done in the Faculty of Dental Medicine, Al-Azhar University. The masticatory efficiency was evaluated in 60 completely edentulous patients. The patient received a complete thermoplastic denture. (Vertex™ ThermoSens, Vertex-Dental B.V. Netherlands). The masticatory efficiency and the perceived masticatory ability were evaluated at one month and after six months of denture use. Data were collected and statistically analyzed with SPSS@ V25 to evaluate the masticatory efficiency before and after the adaptation period for each patient to assess the association between both indices **Results:** Masticatory efficiency and the perceived masticatory ability increased considerably after six months of denture use, and they were significantly higher than values recorded one month after prosthesis placement. **Conclusions:** A significant association was also observed between masticatory efficiency and perceived masticatory ability, and both can be used to evaluate masticatory performance among complete denture wearers.

KEYWORDS

Masticatory efficiency;
Thermoplastic denture base,
Masticatory ability,
Edentulous patients,
Thermoplastic denture

INTRODUCTION

The effective masticatory function is one of the essential goals of prosthodontic rehabilitation[1]. The masticatory function can be described in terms of the objective capacity of a person to fragment solid food or as the subjective response of a person to questions concerning chewing food. Objective masticatory function (defined as masticatory performance) has often been measured by determining an individual's capacity to grind or pulverize a test food after a fixed number of chewing cycles. Self-assessed masticatory function (defined as masticatory ability) has been studied by interviewing subjects on their oral function [2].

Reduced masticatory efficiency is one of the major complaints of edentulous patients wearing conventional dentures. In addition, the

1. Department of Removable Prosthodontics, Faculty of Dental Medicine, Al-Azhar University, Cairo (Boys),Egypt.
2. Department Substitutive Dental Science, College of Dentistry, Taibah University, Saudi Arabia

* Corresponding Author e-mail: dr.mifayad@azhar.edu.eg

complex neuromuscular skills required to overcome the limitations of dentures diminish with aging. Although there has been an increase in rehabilitation with osseointegrated implants, treatment with conventional complete dentures still remains the most common treatment for edentulous patients, especially in low-developed countries [3].

The low masticatory efficiency of denture prostheses impairs the ability of wearers to consume high-fiber foods. Hence, dentures with high masticatory efficiency are required [4]. It also has consequences on both physical measures of general health and perceived general health status, as measured using generic health-related quality-of-life instruments [5].

Chewing function can be assessed using chewing tests and questionnaires or personal interviews[2,5]. Methods used for evaluating masticatory performance have been broadly divided into either subjective methods or objective methods. The former is implemented through various questionnaires, while the latter indicates the condition of the chewed mastication material with a numerical value [6].

Though a number of objective methods of evaluating masticatory performance have been attempted, they require specific instruments, materials, or complicated procedures [7-10].

Both natural foods, such as peanuts, almonds, and carrots, and synthetic materials have been used as test materials in experiments determining masticatory performance [2].

Another method to determine masticatory performance, which is now widely used, evaluates the ability to mix and knead a food bolus. Two-colored chewing gum and paraffin wax have been used as test foods for the quantification of the masticatory performance [2, 11].

Color-changeable chewing gum has been developed by a Japanese research group to allow for a simple measurement of masticatory performance through the color change of the chewing gum. The material is specially developed for that purpose (Masticatory Performance Evaluating Gum XYLITOL; Lotte Co., Ltd., Tokyo, Japan) [12].

Tarkowska et al.[13], mentioned that a measurement technique using color-changeable chewing gum seems most likely to fulfill masticatory efficiency test requirements due to its simplicity and reported superior differentiability.

Chewing gum that changes its color as it is chewed was chosen as a test food for evaluating masticatory performance as it is used efficiently by the dentist at the chair side in the clinic with better compliance from the patient [14]. Colorimetric methods using color scales are inexpensive and easy to use. Furthermore, this method offers the advantage that the subjects can evaluate their own masticatory performance at any location [6].

Color-changeable chewing gum can be used as a stand-alone instrument for perceived chewing ability evaluation because it is a valid and reliable method for the evaluation of masticatory function[6,13]. These tests have proven more accurate than subjective questionnaire-based methods that collect information on the opinions reported by both patients and professionals [15].

The gum base contains red, yellow, and blue dyes, citric acid, and xylitol. The red dye is pH-sensitive that loses its color under the acid condition. The pH inside the chewing gum is maintained low by the citric acid, while the chewing gum appears yellowish-green before mastication. However, when the chewing gum is mixed with saliva as mastication proceeds, the increase of pH inside the chewing gum as a result of elution of the citric acid makes the color of the chewing gum change from yellowish-green to red [14].

In complete denture wearers, the ability to comminute food during mastication is reduced compared to adults with natural dentition, depending on the individual's age and type of food chewed owing to the biomechanical characteristics of exclusively mucosa-supported dentures. Due to

their mucosa-supported nature, complete dentures require stability on the support zone to function effectively [15].

The chewing forces used by denture wearers may be limited by the discomfort and the pain that happens when one or both of the dentures lose their retention or even by the fear of such pain [16].

To improve the masticatory efficiency of complete denture wearers, three principal factors; retention, stability, and support should be considered for successful full dentures. Treatment alternatives that aid in increasing retention and stability for improving denture function should be considered when conventional denture therapy is inadequate. One of these alternatives is using thermoplastic denture base material [17].

Flexible dentures are more aesthetically pleasing and readily acceptable to the patient than conventional dentures. They can be given as a substitute to patients allergic to poly methyl methacrylate. As they are lightweight and flexible, they can be successfully given to patients with bony undercuts. The material's flexibility provided a certain degree of stress-breaking effect, and there was no denture associated with sore mouth.[18]

Up to our knowledge, ther was no study evaluating the masticatory ability (assessed subjectively) with masticatory efficiency using color changeable gums (quantified objectively), among completely edentulous patients rehabilitated with a thermoplastic denture.

PATIENTS AND METHODS

This cross-sectional, prospective study was conducted at the Faculty of Dental Medicine, Al-Azhar University, Egypt. The study was carried out over a period of eight months, from March 20022 to November 2022. The study group was randomly selected 60 completely edentulous patients reported to the Department of Prosthodontics. (27 males and 33 females) whose average age was 44-61 years (mean age 50.96 ± 4.68 years). The ethics committee at Al-Azhar University approved the study protocol. Informed consent was obtained from all subjects after an explanation of the methodology before enrolment in the study.

Patients selection

All the patients studied should have no psychiatric disease or movement disorders. Patients with a history of temporomandibular disorders such as Myofacial Pain Dysfunction Syndrome (MPDS), trismus, trauma, TMJ dislocation, and ankylosis were excluded. Also patients with compromised oral conditions, local lesions, and resorbed or flabby ridges were excluded.

Based on information from previous studies, it was found that 40 cases are enough for conducting the research at power 0.80, confidence interval 0.95, and alpha level. 0.05.[3, 16, 17, 19]

All patients received a complete thermoplastic denture. (Vertex™ ThermoSens, Vertex-Dental B.V. Netherlands). All patients received new complete dentures, with even occlusion, and free from discomfort.

Measurement of masticatory performance using color-changeable chewing gum

The test item used for this study was color-changeable chewing gum (XYLITOL; Lotte Co., Ltd., Tokyo, Japan) The gum was inside the packaging. (Fig. 1) The chewing gum (dimensions 70 × 20 × 1 mm; weight, 3.0 g) initially shows a yellowish-green color The color of the chewed gum was compared to the color scale provided by the manufacturer[14].

Fig. (1) Colour-changeable chewing gum(Masticatory Performance Evaluating Gum XYLITOL*).

The patients were instructed to "Please chew the chewing gum well", without being given any instructions with regard to the chewing side. Each subject was instructed to chew the gum, irrespective of chewing side, for the instructed number of strokes. The patients rinsed their mouths with water for 15 s before chewing the gum for 100 strokes on their preferred side at a rate of one stroke per second. And this sequence was repeated three times with 30 minutes intervals. A mean value of three trials was used in the analysis. After each trial, the subjects were asked to rinse their mouth with water. The chewing gum was picked immediately after chewing and compressed between two glasses to evaluate its color.[14, 20, 21]

The chewed bolus was assigned numeric scores according to the degree of color change; 0 % (green), 25 %(yellow), 50% (pale pink), 75% (pink), and 100% (red). All of the color reading was performed by the same examiner.

Measurement of the perceived masticatory ability

The perceived masticatory ability was used for masticatory ability evaluation (subjective method). It was measured by using an index developed by Khalifa et al,[22] where individuals were asked about the difficulty of masticating 15 common hard and soft foods. This index is scored on a 5-point Likert scale ranging from a score of 0 (very easy to chew) to a score of 5 (very difficult and avoided). A score of zero indicates acceptable conditions, and a score of 1 or more indicates unfavorable conditions.

Statistical tests were performed using statistical software (IBM SPSS Statistics v25 ; IBM Corp) (a=.05 for all tests). The Mann-Whitney U test was used for the association between both indices regarding patient sex.

Measurement time of masticatory performance and perceived masticatory ability

I- The first measurement was done using clor changeable chewing gum after one month of denture placement.

II- The second measurement was done after six months of denture insertion as Goiato[3] suggested that more than five months was needed to evaluate patient adaptation and functional capacity with new complete dentures.

RESULTS

The masticatory efficiency and perceived masticatory ability were evaluated among completely edentulous patients with a thermoplastic denture base at one month and six months after denture insertion.

Among 60 completely edentulous patients were randomly selected there were 27 male and 33 female patients Table (1). The mean age of the selected patients was 44 years ranging rom 44 years to 61 years.

Table (1) *Gender Frequency*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	27	45.0	45.0	45.0
	Female	33	55.0	55.0	100.0
	Total	60	100.0	100.0	

The masticatory efficiency evaluation was done using color scale scores. The mean value of color scale scores for masticatory efficiency evaluation was 32.5 ±11.55. At the time of one month after new denture placement. After six months of denture placement, the mean value of color scale scores was 55.0 ± 16.46 (Table 2)

The perceived masticatory index for each participant was obtained by collecting the perceived masticatory ability score (from 0 to 5) of each food. The mean value for perceived masticatory ability was 46.6 ±11.18. At the time of one month after the new denture placement. After six months of denture placement, the mean value of perceived masticatory ability was 35.1 ± 10.49.

Table (2) *Descriptive Statistics of the study sample*

	N	Minimum	Maximum	Mean	Std. Deviation
Age	60	44.00	61.00	50.96	4.68
Eff1	60	25.00	50.00	32.50	11.55
Eff6	60	25.00	75.00	55.00	16.46
Ind1	60	25.00	65.00	46.66	11.18
Ind6	60	17.00	55.00	35.16	10.49
Valid N (listwise)	60				

The data were checked for normal distribution using Kolmogorov-Smirnov and Shapiro-Wilk tests. The results of both tests showed that the date werenot normally distributed. Table (3)

Table (3) *Tests of Normality*

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Eff1	.442	60	.000	.576	60	.000
Eff6	.286	60	.000	.786	60	.000
Ind1	.234	60	.000	.872	60	.000
Ind6	.144	60	.003	.935	60	.003

a. Lilliefors Significance Correction

The nonparametric Wilcoxon Signed Ranks test was used to compare means of masticatory efficiency and perceived masticatory index at six months and six months after denture placements

The Wilcoxon Signed Ranks test showed that there were a **statistical significance difference** was found between the mean value of color scale scores recorded at one month and after six months after denture placement. (Table 3,4).

Table (3) *Wilcoxon Signed Ranks Test*

		N	Mean Rank	Sum of Ranks
Eff6 - Eff1	Negative Ranks	2[a]	16.50	33.00
	Positive Ranks	43[b]	23.30	1002.00
	Ties	15[c]		
	Total	60		
Ind6 - Ind1	Negative Ranks	60[d]	30.50	1830.00
	Positive Ranks	0[e]	.00	.00
	Ties	0[f]		
	Total	60		

a. Eff6 < Eff1 b. Eff6 > Eff1 c. Eff6 = Eff1

d. Ind6 < Ind1 e. Ind6 > Ind1 f. Ind6 = Ind1

Table (4) *Wilcoxon Signed Ranks Test Statistics[a]*

	Eff6 - Eff1	Ind6 - Ind1
Z	-5.741[b]	-6.885[c]
Asymp. Sig. (2-tailed)	.000	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

The Mann-Whitney U test (Table 5,6) was used for the association between both indices and participants' sex. The results of this study showed that no significant differences were found between men and women regarding either index.

Table (5) *Mann-Whitney test ranks*

	Gender	N	Mean Rank	Sum of Ranks
Eff1	Male	27	31.50	850.50
	Female	33	29.68	979.50
	Total	60		
Eff6	Male	27	30.72	829.50
	Female	33	30.32	1000.50
	Total	60		
Ind1	Male	27	29.30	791.00
	Female	33	31.48	1039.00
	Total	60		
Ind6	Male	27	28.19	761.00
	Female	33	32.39	1069.00
	Total	60		

Table (6) *Mann-Whitney test statisticsa*

	Eff1	Eff6	Ind1	Ind6
Mann-Whitney U	418.500	439.500	413.000	383.000
Wilcoxon W	979.500	1000.500	791.000	761.000
Z	-.505	-.099	-.496	-.939
Asymp. Sig. (2-tailed)	.613	.921	.620	.348

a. Grouping Variable: Gender

DISCUSSION

At first thought, natural test foods may be considered advantageous because of their consumption in daily life and familiarity with them. However, this issue can vary according to seasonal and geographical factors [23].

In order to avoid this kind of variability in assessing chewing function, some researchers report that the use of synthetic food is a good alternative [19, 24, 25].

Plesh et al. [26]preferred chewing gum as the test material because of the uniform density during the chewing cycle. Hayasaki et al.[27] and Shiga et al.[28] also used chewing gum in their studies. Tokmakci et al. [23] mentioned that chewing gum is a material with uniform properties, so it can be reliably reproduced and provide an ideal test bolus for the scientific study of masticatory effectiveness. In some previous studies, Blissett et al.[29]; Mazari et al.[30] used chewing gum to simplify and standardize the test procedures.

Tokmakci et al. [23] offered sugar-free chewing gum to participants, as it can be applied easily and being sugar- and/or sweetener-free, it will not cause salivary stimulation that can influence the mastication function. Further, with its uniform properties in terms of weight and shape, this type of test food has also helped us standardize masticatory efficiency measurements.

The present study found a statistically significant difference in the masticatory efficiency and perceived masticatory ability between the measurements recorded at one month and six months after denture placement.

The studies of Slagter and Fontijn-Tekamp could explain the result of the present study; they found that the masticatory function of the complete-denture wearers is relatively poor in comparison with that of healthy dentate subjects[31,32]. Complete-denture wearers need up to 7 times more chewing strokes than subjects with a complete natural dentition to reduce the food to half of the original particle size. Oral function significantly improves after mandibular implant overdenture treatment. Most studies on implant treatment and oral function showed a significant improvement of the objective masticatory performance in the mandibular overdenture.[33]

The significantly lower masticatory efficiency in patients rehabilitated with complete dentures after denture placement has been reported in other studies.[34]

A significant improvement was observed in the masticatory function with a complete thermoplastic denture after six months, and this may be attributed to increasing adaptation and subsequent stability of the denture after six months of denture use.

A statistically significant difference was found after six months in both measurements. These results were in accordance with the study conducted by Hazari et al.[35]. These findings may be attributed to the basic nature of the thermoplastic denture base materials. This result is extremely important since complete thermoplastic dentures are a simpler and cheaper treatment option when compared with other treatment options as implant-supported dentures. Furthermore, they provide a significant improvement in terms of stability and retention for patients with severe adaptation problems to conventional mandibular dentures. These results were in accordance with the study conducted by Berretin-Felix et al.[36] who mentioned that the type

of dental treatment used has a direct relationship with masticatory efficiency.

The perceived masticatory index for each participant was obtained by collecting the perceived masticatory ability score (from 0 to 5) of each food, and the mean for all participants was 46.6 ±11.18 after one month of denture placement. After six months of denture placement, the mean value of perceived masticatory ability was 35.1 ± 10.49. No significant differences were found between men and women regarding either index. This study's results are in accordance with the results of Elmoula et. al.[37].

It is also important to emphasize the diagnostic factor and previous planning before denture construction. The human factor in planning and technical performance are decisive for the success of rehabilitation.

CONCLUSION

Within the limitations of the present study, A significant association was observed between perceived masticatory ability and masticatory efficiency, and both can be used to evaluate masticatory performance among complete denture wearers.

Competing interests

The authors declare that they have no competing interests.

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كفاءة المضغ وتقييم القدرة المتوقعه للمضغ في المرضى الذين يعانون من فقد تمامًا والذين أعيد تأهيلهم باستخدام اطقم أسنان معلجة بالحرارة

مصطفى ابراهيم فياض,1,2 ,ايهاب اسماعيل محمود 1 ,احمد عاطف شون 1

1. قسم الاستعاضة الصناعية المتحركة. كلية طب الاسنان - جامعة الأزهر (بنين -القاهرة) ، مصر
2. قسم علوم الاسنان التعويضية. كلية طب الاسنان - جامعة طيبه , المدينة , المملكة العربية السعودية

* البريد الإلكتروني: DR.MIFAYAD@AZHAR.EDU.EG

الملخص:

الهدف: جريت هذه الدراسة لتقييم كفاءة المضغ وقدرة المضغ المتصورة بين المرضى الذين يعانون من ضعف الأسنان تمامًا والذين أعيد تأهيلهم باستخدام قاعدة أسنان بلاستيكية حرارية.

المواد والاساليب :تمت هذه الدراسة في كلية طب الأسنان جامعة الأزهر. تم تقييم كفاءة المضغ في 60 مريضا عديم الأسنان تماما. تلقى المريض طقم أسنان بلاستيك حراري كامل. (VERTEX-DENTAL B.V ، VERTEX ™ THERMOSENS هولندا). تم تقييم كفاءة المضغ والقدرة المتصورة للمضغ في شهر واحد وبعد ستة أشهر من استخدام طقم الأسنان. تم جمع البيانات وتحليلها إحصائيًا باستخدام SPSS @ V25 لتقييم كفاءة المضغ قبل وبعد فترة التكيف لكل مريض لتقييم الارتباط بين كلا المؤشرين.

النتائج: زادت كفاءة المضغ وقدرة المضغ المتصورة بشكل كبير بعد ستة أشهر من استخدام أطقم الأسنان ، وكانت أعلى بكثير من القيم المسجلة بعد شهر واحد من وضع الطرف الاصطناعي.

الخلاصة: ولوحظ أيضًا ارتباط كبير بين كفاءة المضغ والقدرة المتصورة للمضغ ، ويمكن استخدام كليهما لتقييم أداء المضغ بين مرتدي أطقم الأسنان الكاملة.

الكلمات المفتاحية: كفاءة المضغ قاعدة أسنان بلاستيكية حرارية ، قدرة مضغ ، مرضى عديمو الأسنان ، طقم أسنان بلاستيك حراري ،