

MASTICATORY PERFORMANCE AND BITE FORCE EVALUATION IN COMPLETELY EDENTULOUS PATIENTS REHABILITATED WITH DIFFERENT THERMOPLASTIC DENTURE BASE MATERIALS

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ABSTRACT

Objective: This study was conducted to evaluate the masticatory performance and bite force in complete denture wearer rehabilitated with thermoplastic nylon and thermoplastic acrylic resin denture base.

Methods: This study was done in out patients clinics, Faculty of Dental Medicine, Al- Azhar University. Masticatory performance and maximum bite force were evaluated in randomly selected forty completely edentulous patients. The patients were randomly allocated into two equal groups. Group I: Patient received a thermoplastic acrylic complete denture. (Polyan IC™ bredent GmbH & Co.KG, Germany). Group II: Patient received a thermoplastic nylon complete denture. (Vertex™ ThermoSens, Vertex-Dental B.V. Netherlands). Masticatory performance and maximum bite force measurements were taken one week after new denture placement and after six months of denture use. Statistics were analyzed using Independent t-test to compare the masticatory performance and maximum bite force measurements between both groups.

Results: After one week of new denture placement, there were no significance differences in masticatory performance and maximum bite force measurements between both groups. Masticatory performance and maximum bite force were increased considerably after six months of denture use. The masticatory performance and maximum bite force values were considerably higher in patients with a thermoplastic nylon denture than patients with thermoplastic acrylic denture with statistical significant difference after six months of denture use.

Conclusion: After six months of denture use, patients with a thermoplastic nylon denture have a higher masticatory performance and biting force than patients with a thermoplastic acrylic denture. Therefore, thermoplastic nylon denture could be used in management of completely edentulous patients with diminished masticatory performance bite force.

KEYWORDS: Masticatory performance; bite force; denture base materials; thermoplastic denture base.

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INTRODUCTION

Many people have been affected by teeth loss which causes physiological and functional disorders, so rehabilitation treatments with an adequate prosthesis are indicated.^[1]

30% of Patients with complete dentures have complaints. They suffer from various problems with their dentures, particularly regarding the mandibular denture, such as decreased stability, retention, and pain during mastication.^[2]

Studies have shown that when compared with natural dentition subjects, denture wearers suffer from a decline in masticatory performance.^[3-5] When people age, their muscles undergo functional changes, mainly through atrophy and tooth loss.^[6]

Effective masticatory function is one of the important goals of prosthodontic rehabilitation.^[7]

Reduced masticatory performance is one of major complaints of edentulous patients wearing conventional dentures. In addition, the 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.^[8]

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.^[9]

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.^[6]

The low masticatory performance of denture prostheses impairs the ability of wearers to consume high-fiber foods. Hence, dentures with high masticatory performance are required.^[10] 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.^[11]

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 a test food after a fixed number of chewing cycles or indicate the condition of the chewed mastication material with a numerical value. The subjective methods are implemented through various questionnaires or interviewing subjects about their oral function to self-assessed masticatory function (defined as masticatory ability).^[11, 12]

Though several objective methods of evaluating masticatory performance have been attempted, they require specific instruments, materials, or complicated procedures.^[13-16]

Both natural foods, such as peanuts, almonds and carrots, and synthetic materials have been used as test materials in experiments determining the masticatory performance.^[12]

Another method to determine masticatory performance, which is now widely used, evaluates the ability to mix and knead a food bolus. Two-coloured chewing gum and paraffin wax have been used as test foods for the quantification of the masticatory performance.^[12, 17]

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).^[18]

Tarkowska et al.^[19], mentioned that a measurement technique by means of a color-changeable chewing gum seems most likely to fulfill masticatory performance test requirements due to its simplicity and its reported superior differentiability.

Chewing gums that changes its color as it is chewed were chosen as a test food for evaluating masticatory performance as it is used easily by the dentist at the chair side in the clinic with better compliance from patient.^[20] Colorimetric methods using color scales are inexpensive and simple to use. Furthermore, this method offers the advantage that the subjects can evaluate their own masticatory performance at any location.^[21]

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.^[19,21] These tests have proven more accurate than subjective questionnaire-based methods that collect information on the opinions reported by both patient and professional.^[9]

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 to change from yellowish-green to red.^[20]

Bite force is an important variable to investigate oral function.^[1] Maximum bite force (MBF) also

directly influences diet choice, which has an important role in the maintenance of masticatory function.^[22] The old people with fewer or no teeth avoid fibrous foods resulting in reduced food intake and leaving out various sources of proteins, fibers, minerals and vitamins.^[23, 24]

Selecting less nutritious food leading to high risk of malnutrition and consequently the potential for cardiovascular disease and cancer.^[25, 26]

In fact, the masticatory force of completely edentulous patients is 20% to 40% of that of healthy dentate persons. Therefore, complete denture wearers need up to seven times more chewing strokes to reduce food particle than do dentulous subjects.^[27, 28]

To improve the masticatory performance of complete denture wearers, three principal factors; retention, stability, and support should be considered for successful complete 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.^[5]

The flexible dentures are more aesthetically pleasing and easily 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 flexibility of the material provided a certain degree of stress-breaking effect and there was no denture sore-mouth.^[29]

Even though retention and alveolar ridge height, which could influence the results, were not evaluated, the present study is one of the few studies comparing masticatory performance and bite force in complete denture wearers with different thermoplastic denture base materials.

PATIENTS AND METHODS

Patients selection

The study group comprised of randomly selected 40 completely edentulous patients with average age 52 years. Based on standard deviation from previous studies, it was found that 26 cases are enough for conducting the research at power 0.80, confidence interval 0.95 and alpha level. 0.05.^[1, 4, 22, 27]

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

Informed consent was obtained from all patients after an explanation of the methodology prior to enrolment in the study.

The patients were randomly allocated into two groups (Each group consisted of 20 individuals) according to line of treatment:

- a) Group I: Patients received a thermoplastic acrylic complete denture. (Polyan IC™ bredent GmbH & Co.KG, Germany)
- b) Group II: Patients received a thermoplastic nylon complete denture. (Vertex™ ThermoSens, Vertex-Dental B.V. Netherlands)

All patients received new complete dentures, with even occlusion and free from discomfort.

First measurements

For each patient in both groups masticatory performance and maximum bite force were evaluated after two subsequent clinical follow-up sessions, spanning around 7 days.

Masticatory performance evaluation

The test item used for this study was a colour-changeable chewing gum (XYLITOL; Lotte Co.,

Ltd., Tokyo, Japan) The gum inside the packaging. (Fig. 1) The chewing gum (dimensions, 70 × 20 × 1 mm; weight, 3.0 g) initially shows a yellowish-green colour The color of chewed gum was compared to the color scale provided by the manufacturer.^[20].



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 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 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. All of color reading was performed by a same examiner.^[20, 30, 31]

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).

Bite force recordings

Measurements were made with the patient in an upright position one week after new prosthesis placement.

The maximum bite force was measured bilaterally at the first molars region by an occlusal

force meter. (GM10, Nagano Keiki, Tokyo, Japan) [Fig.2]. The instrument was placed such that all bite forces were directed to the center.

The patients were instructed to bite as powerfully as possible three times per side at maximum intercuspation, with a rest time of 2 min in between. The maximum occlusal force recorded in Newtons (N) was recorded. The highest of the three records was considered to be the patient’s MBF.



Fig. (2) Occlusal force meter.

Second measurements

For each patient in both groups, masticatory performance and maximum bite force were evaluated was done after six months of denture insertion as Goiato^[8] suggested that more than five months was needed to evaluate patient adaptation and functional capacity with new complete dentures.

The difference in masticatory performance and bite force after six months was calculated and the mean of two groups was compared. Statistical analysis was completed using SPSS software V.20.

RESULTS

The masticatory performance and maximum bite force were evaluated in completely edentulous patients rehabilitated with thermoplastic nylon and thermoplastic acrylic resin denture base .

Masticatory performance evaluation

After one week of new denture placement: The mean value of color scale scores with thermoplastic acrylic complete denture was 32.50±11.60. The mean value of color scale scores with thermoplastic nylon complete denture was 33.12±11.85. The independent t-test revealed that there was **no**

statistical difference was found between both groups (p>0.05), after one week of new denture placement. (Table 1, Fig. 3)

After six months of new denture placement: The mean value of color scale scores with thermoplastic acrylic complete denture was 40.62±17.62. The mean value of color scale scores with thermoplastic nylon complete denture was 48.75±13.80. After six months, the independent t-test revealed that a **statistical difference** was found between both groups (p<0.05). (Table 1, Fig. 3)

TABLE (1) Masticatory performance evaluation after one week and six months of new denture placement.

Grouping		Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Mast_1w	G1	32.50	11.60	1.83	.812
	G2	33.12	11.85	1.87	
Mast_6M	G1	40.62	17.62	2.78	.024*
	G2	48.75	13.80	2.18	

G1: Thermoplastic acrylic complete denture.

G2: Thermoplastic nylon complete denture.

Mast_1W Masticatory performance Force after one week of new denture placement.

Mast_6M Masticatory performance after 6 months of denture placement.

**Statistical significant different.*

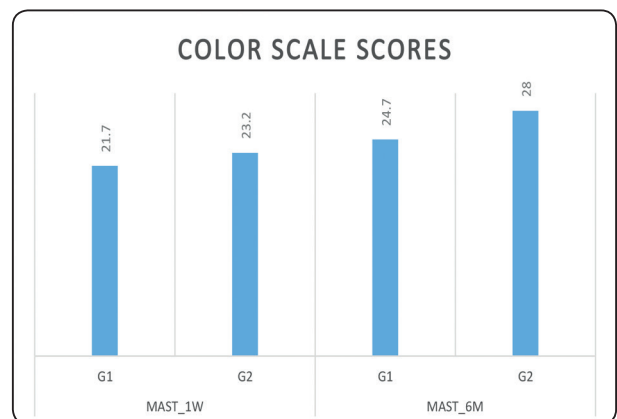


Fig. (3) Mean value of color scale scores for both groups after one week and after six months of denture insertion.

Bite force evaluation

After one week of new denture placement, the mean value of maximum bite force with thermoplastic acrylic complete denture was 21.70 ±2.45 N. The mean value of maximum bite force with thermoplastic nylon complete denture was 23.20 ±1.47 N. The independent t-test revealed that there was no statistical difference was found in maximum bite force values between both groups (p>0.05). (Table 2, Fig. 4)

After six months, for each group maximum bite force increased considerably after six months of denture use and it was higher than MBF recorded at the time of new prosthesis placement in the same group. When comparing both groups, Patient received a thermoplastic acrylic complete denture recorded lower MPF values 24.70±2.21N than patients received a thermoplastic nylon complete denture 28.0±1.56 N. The independent t-test revealed that there was statistically significant difference in maximum bite force (p < 0.05). (Table 2, Fig. 4)

TABLE (2) Maximum bite force evaluation after one week and six months of new denture placement.

Grouping		Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
MBF_1W	G1	21.70	2.45	.77	.115
	G2	23.20	1.47	.46	
MBF_6M	G1	24.70	2.21	.70	.001*
	G2	28.0	1.56	.49	

G1: Thermoplastic acrylic complete denture.

G2: Thermoplastic nylon complete denture.

MBF_1W Maximum bite force after one week of new denture placement.

MBF_6M Maximum bite force after 6 months of denture placement.

**Statistical significant different.*

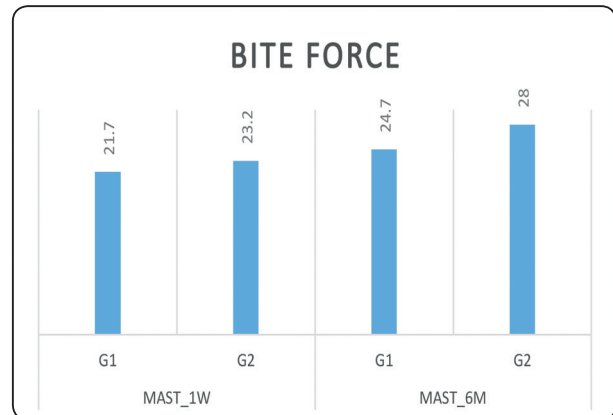


Fig. (4) Mean bite force comparison after one week and after six months of denture insertion.

DISCUSSION

Masticatory performance was evaluated by colour-changeable chewing gum (XYLITOL; Lotte Co., Ltd., Tokyo, Japan). At the first thought, natural test foods may be considered advantageous because of their consumption in daily lives and familiarity with them. However, this issue can vary according to seasonal and geographical factors.^[32]

To avoid this kind of variability in assessing chewing function, some researchers report that the use of synthetic food is a good alternative.^[33-35]

Plesh et al. ^[36] preferred chewing gum as the test material because of the uniform density during chewing cycle. Hayasaki et al.^[37] and Shiga et al.^[38] also used chewing gum in their studies. Tokmakci et al.^[32] 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.^[39]; Mazari et al.^[40] used chewing gum to simplify and standardize the test procedures.

Tokmakci et al. ^[32] 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 performance measurements.

Second measurement was done after six months of denture insertion as Goiato^[8] suggested that more than five months was needed to evaluate patient adaptation and functional capacity with new complete dentures.

The result of the present study found that there was statistical significant difference of the masticatory performance between thermoplastic acrylic complete denture and thermoplastic nylon complete denture on using color changeable gum (at six months after denture placement). while after one week of new denture insertion there was no statistical significant difference between the two groups.

The result of the present study could be explained by the studies of *Slagter and Fontijn-Tekamp* they found that masticatory function of the complete-denture wearers is quite poor in comparison with that of healthy dentate subjects ^[27, 28]. 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.^[41]

The significant lower masticatory performance in patients rehabilitated with acrylic complete dentures has been reported in other studies.^[42]

At the time of denture insertion, there was no significance difference in masticatory performance between patients with a thermoplastic acrylic denture and patients with a thermoplastic nylon denture. It measures 32.50 ± 11.60 for patients with thermoplastic acrylic denture while it measures 33.12 ± 11.85 for patients with a thermoplastic nylon denture.

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

A statistically significant difference in masticatory performance was found after six months between the two groups. These results were in accordance with the study conducted by Hazari et al.^[43].

Bite force is increasing considerably after six months of denture use in both groups. One week after denture insertion, bite force measured 21.70 ± 2.45 N, 23.20 ± 1.47 N for group I and group II respectively.

The MBF values were considerably higher in patients with a thermoplastic nylon denture than patients with thermoplastic acrylic denture after six months of denture use. It measures 24.70 ± 2.21 N for patients received thermoplastic acrylic complete denture while in patients received thermoplastic nylon denture it measures 28.0 ± 1.56 N. The higher values observed in patients with a thermoplastic denture may be directly related to better stability and retention obtained with a thermoplastic nylon denture base.

These results match the findings of Roldan^[44], It is important to mention that although there were only six months between measurements, significant differences were observed and may be explained by the adaptation period to the new prosthesis.^[45, 46] this in agreement with the finding of Borie^[22] who found that MBF was found to increase significantly after one month of use.

These findings may be attributed to the basic nature of the thermoplastic nylon denture base material. This result is extremely important since thermoplastic nylon complete denture are a simpler treatment option when compared with other

treatment option as implant-supported dentures. Furthermore, they provide a significant improvement in terms of stability and retention for patients with severe adaptation problems. It is also important to emphasize the importance of diagnosis and previous planning before denture construction. The human factor in planning and technical performance are decisive for the success of rehabilitations.

CONCLUSION

The rehabilitation of orofacial structures requires the restoration of esthetic and function irrespective of the structure left. Within the limitations of the present study, there were statistically significant difference in masticatory performance and bite force between thermoplastic acrylic complete dentures and thermoplastic nylon complete denture after six months of denture placement. However, further long-term studies are recommended to evaluate the overall usefulness of the material.

Competing interests

The author declare that they have no competing interests.

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