EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 69, 505:513, JANUARY, 2023
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
FIXED PROSTHODONTICS AND DENTAL MATERIALS
Submit Date : 02-09-2022 • Accept Date : 05-11-2022 • Available online: 1-1-2023 • DOI : 10.21608/edj.2022.160262.2239

FLEXURAL STRENGTH OF THREE DIFFERENT DENTURE BASE MATERIALS AFTER IMMERSION IN A THYME EXTRACT AND A CHEMICAL CLEANSER: AN IN VITRO COMPARATIVE STUDY

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ABSTRACT

Statement of problem: Polymethyl-methacrylate is still a widely used material for complete and partial denture fabrication. Candida biofilm adherence to PMMA denture base has been studied, and ways to control its adherence by using different ways of cleaning, natural and chemical herbal cleanser-based methods have been introduced as an alternative to chemical methods. Using any type of cleanser may affect the flexure strength of denture bases.

Purpose: This study aimed to compare the effect of herbal extract cleanser and chemical cleanser on the flexure strength of three different denture base materials: heat polymerized acrylic resin, thermoplastic polyamide (Nylon), and thermoplastic monomer-free microcrystalline polymer (Karadent).

Materials and methods: A total of 90 samples were divided into three equal groups (Heat cured processed acrylic resin, Karadent, Nylon) Samples were immersed in the cleansing solution and distilled water as a control group for 15 days.

Results: Flexure strength was measured using a universal testing machine, and the results were collected, tabulated, and statistically analyzed using ANOVA. There was a significant difference between thyme-immersed specimens and specimens immersed in sodium hypochlorite (NaoCl). The Karadent specimens showed the least flexure strength measures among the three groups.

Conclusion: immersing in different cleanser affected the flexure strength of denture base materials, using thyme as a cleanser has less effect on denture base flexure strength in comparison to NaoCl.

KEYWORDS: Denture cleanser – thyme extract cleanser – Thermoplastic monomer free microcrystalline polymer – Thermoplastic polyamide – flexure strength

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INTRODUCTION

Poly-methyl-methacrylate (PMMA) is considered the conventional denture base material[1]. New materials have been developed over the years to improve the qualities of denture bases. Oral microorganism accumulation could aggravate and induce soft tissue diseases because of the daily use of dentures without proper cleaning and disinfection[2]. Acrylic resin denture base stains and accumulates organic and inorganic deposition.[3]

Denture stomatitis is a pathogenic erythematous disease of denture-bearing mucosa caused mostly by microbial causes. Candida albicans is the most common species, accounting for 50% to 98% of all cases [4]. The tissue surface of maxillary complete dentures is the primary reservoir of Candida albicans and related Candida species. Most denture wearer saliva contains these yeasts, which have a propensity for adhesion to denture materials. It was indicated that therapy should be oriented on the denture rather than the mucosa[5,6] and denture cleaners should be used to remove, kill the microorganism, and prevent reinfection of denture surfaces. [7] That is why home care recommendations are provided to patients during denture placement sessions to help them maintain a healthy mucosa. Denture care is an essential component of overall health, especially in elderly patients who are unable to clean their dentures due to illness or dementia. [8]

Mechanical and chemical cleaning has been recommended as an approach for regular denture biofilm removal. The chemical approach is the most successful in preventing C. Albicans infection and the production of denture biofilms. [9]

The immersion approach is used by most commercial denture cleaners, which is appropriate for many elderly patients in long-term care institutions due to illness and poor dexterity. The two main chemical types of immersion denture cleansers are sodium hypochlorite and alkaline peroxides. Sodium hypochlorite is inexpensive, presents bactericidal and fungicidal action as well as stain removal capabilities, requires a short period of disinfection, and has been recommended as an effective denture cleanser. Furthermore, alkaline hypochlorite cleansers containing 5% sodium hypochlorite work directly on the organic matrix of plaque, causing the polymer structure to dissolve. They can convert the chromophores and remove stains. [10,11]

On the other hand, many plant species provide extracts that might be used to prevent different implant extracts were found to be efficient against the microbes that cause denture-related oral mucosal disorders such as Origanum syriacum and Ocimum basilicum extracts have antifungal activity against candida flora identified in denture stomatitis if used as immersion method for denture cleanning.[12,] also using triphala as a denture cleanser had a better antifungal property on the heat cure denture base material. Its availability in the rural setup, cost-effectiveness, and tremendous advantages makes this herb one of the the alternatives to the current antimicrobials that are being used for denture disinfection.[13] Disinfecting using thyme showed acceptable results on a long cycle, short cycle heat-cured acrylic resin, and thermoplastic monomer-free microcrystalline polymer from C. albicans. [12,14]

Ideally, denture cleansers should minimize or eliminate the biofilm without altering the physical and mechanical properties of the denture base material. Several studies: however, claim that the prolonged use of denture cleansers can have a negative impact on the physical and mechanical properties, including the flexural strength, color, surface roughness, and hardness, of denture base resins.[10] Flexural strength is a combination of tensile, compressive, and shear bond strengths. The loading that occurs on the denture in the mouth during the masticatory process is represented by this flexural strength. [11,15]

Flexural strength is of particular importance among the different physical attributes that might

be impacted by cleansers since denture base resins can fail clinically owing to flexural fatigue.[16,17]

Several studies investigated the effect of chemical and herbal cleansers on the flexural strength of conventional heat cured denture base materials. However studies that investigated the effect of these cleanserson different thermoplastic denture base materials are very scarce. . Hence, this study aimed to compare the effect of using a herbal (thyme) extract and Naocl as a chemical cleanser on denture bases fabricated from two different thermoplastic materials (Nylon and Karadent) as compared to the conventional Heat cured acrylic resin.

Null hypothesis

There would be no significant differences between the chemical cleanser (sodium hypochlorite) and the essential oil cleanser (thyme extract) on the flexure strengths of all tested materials

MATERIALS AND METHODS

The materials used are represented in Table I.

TABLE (I): The materials used in the study

Product	Manufacturer
Heat cure resin / poly methyl methacrylate (PMMA)	(Acrostone, manf. &co, Egypt)
Flexible thermoplastic resin (Polyamide resin-based material (nylon)	(TCS, Inc., USA)
Thermoplastic monomer free microcrystalline polymer (Karadent)	(TCS, Inc., USA)
Alkaline hypochlorite Sodium hypochlorite	JK Dental, Egypt
Thyme extract	Nawah-Scientific Center, Cairo, Egypt

A total of 90 (N=90) rectangular specimens, 30 heat cure polymerized acrylic resin denture bases, 30 flexible thermoplastic resins, and 30 thermoplastic monomer-free microcrystalline polymers were made. All specimens measured 65 × 13 × 5 mm.

Specimens were fabricated using a stainless-steel mold of the desired dimension and were invested in a Type III gypsum product (Dental Stone-Zhermack elite rock type 4 extra hard stone, ITALY) in a metallic flask. A wax pattern with dimensions of 65x13x5 mm was constructed to create the mould into which the resin was injected (Figure 1). Heat polymerized acrylic resin was mixed according to the manufacturer's instructions. Molds were packed with dough acrylic resin. Processing was carried out with a long curing cycle of polymerization (73°C for 90 minutes followed by 94°C for 30 minutes). The flexible thermoplastic resin and the thermoplastic monomer-free microcrystalline polymer (Figure 2a &2b) were prepared according to the manufacturer's

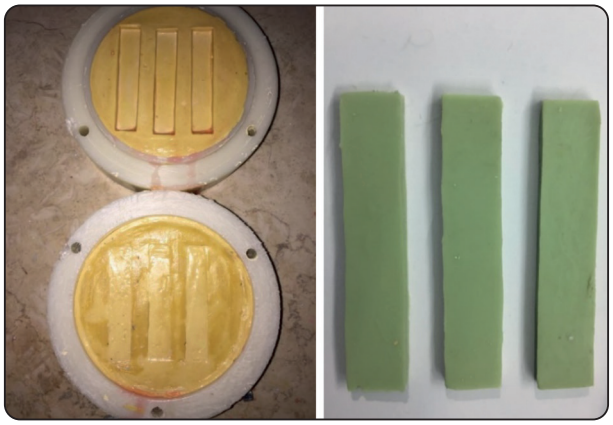

Fig. (1) (left) Stainless steel mold of the desired dimension and invested in the Type III gypsum product (Right): The wax patterns

Fig. (2): a) microinjection machine for karadent, b) karadent crystals

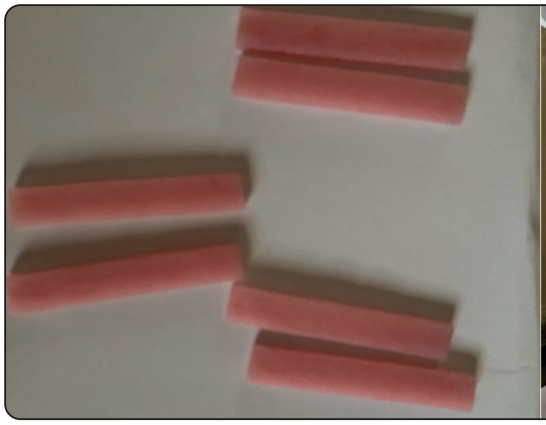

Fig. (3) Specimens after preparation ready for immersion

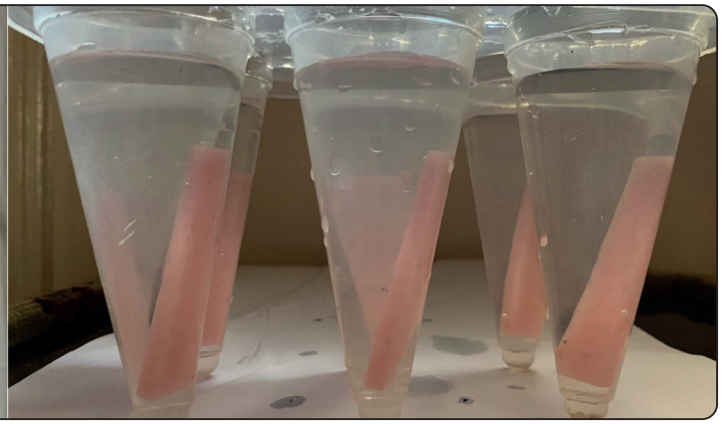

Fig. (4) Immersion of specimens in different cleansing solutions

instructions. The material was injected by the injection molding technique. The injection cartridge was carried out by Sabilex (microinjection machine, Argentina). The temperature was kept at 280°C, and the pressure was kept at seven bars for 20 minutes, according to the manufacturer's instructions for fabrication.

Plant extract: Extraction of plant extract was carried out in Nawah Scientific Center, Cairo, Egypt. Thyme was collected, dried, and ground using experimental distillation at room temperature and ethyl alcohol as a solvent. The steamed and extracted volatiles were collected in a condenser. An evaporator was then used for the evaporation of the excess solvent.

Cleansing protocol: Specimens (Figure 3) were subjected to daily cleansing by (Figure 4) immersing 10 specimens from each group in each of the three solutions for 15 days continuously, which simulated 3 years of use according to the subgroup they belonged to at room temperature. The calculation of these immersion periods was performed by the following method. One hour represented 3 immersions of 20 min, and each 24 h (one day) corresponded to 72 immersions of 20 min per day. Therefore, to complete a 3-year immersion simulation (1095 days), 15 days were required. [18]

a) Immersing in diluted thyme essential oil by diluting 1 ml of thyme essential oil, 1 ml of ethanol, and 7 ml of distilled water [19]

b) Immersing in 5% NaoCl cleanser

c) Immersing in distilled water as a control group

Flexural strength testing:

5 specimens from each material group was tested for flexure strength before immersion in any cleanser or water.

Fig. (5) Instron universal testing machine

The flexural strength was tested by using a universal testing machine (Model 3345; Instron Industrial Products, Norwood, MA, USA) with a load cell of 5000 N (Figure 5) and the data were recorded using computer software (Instron Bluehill Lite Software). A total of 30 specimens from each group were used for flexural strength determination (n= 90). All the specimens were marked in the center. The load was applied at the center of the specimen crosshead speed of 5 mm/min until it fractured. The machine has a digital monitor that indicates the amount of force being applied to the test specimen. When the specimen breaks, the reading on the digital scale automatically stops, thus indicating the fracture load.

Statistical analysis:

Data were collected, tabulated, and statistically analyzed using SPSS program version 21. A one-way between subjects ANOVA was conducted to compare the effect of different cleansers on the flexure strength, for Acrylic, Polyamide and Karadent denture base specimens. This was followed by Post hoc comparisons using the Tukey HSD.

RESULTS

Means and standard deviations within each group are presented in Figures (6) and table 2

TABLE (2) Descriptive statistics of flexure strength of acrylic resin, Polyamide and Karadent before and after immersion of water, thyme and Naocl

Groups	Flexure strength Before immersion	Cleanser	Mean	SD
Acrylic	83.96 ±1.21	**Water**	83.80	1.33
		Thyme	82.66	1.31
		Naocl	69.39	2.10
Naylon	84.01±1.01	**Water**	82.45	1.25
		Thyme	81.27	1.25
		NaoCl	66.41	1.03
Karadent	83.71±1.79	**Water**	83.12	2.86
		Thyme	82.08	1.38
		NaoCl	60.94	1.36

Immersion of the three different denture base materials (heat cured acrylic resin, naylon and karadent) in water did not show a significant difference in flexural strength before and after immersion (P value 0.129), also immersion of the three denture base materials in thyme extract showed no significant difference (P value 0.129) and it was compared to water. While immersion in NaoCl showed a significant difference between before and after the immersion (P value 0.00) in the three material groups.

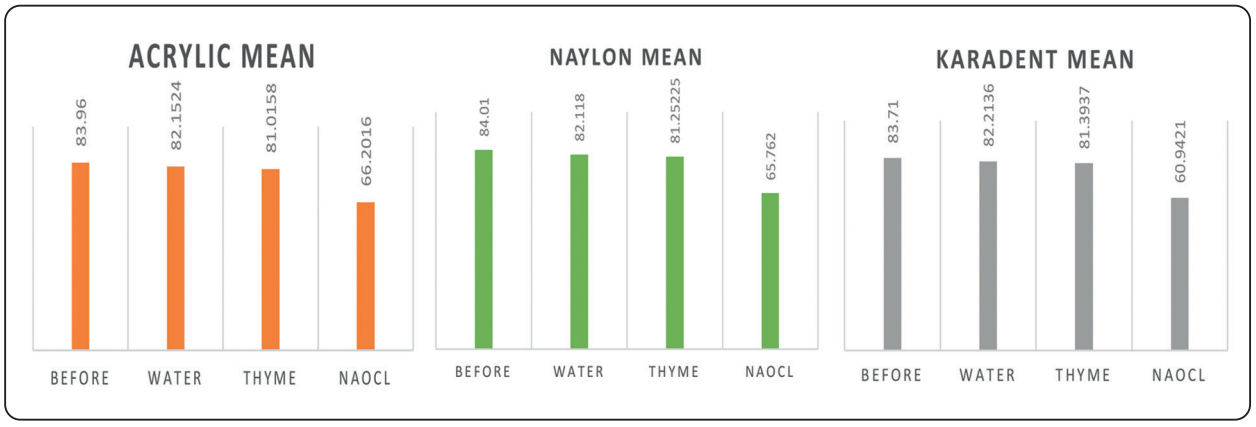

Fig. (6) Mean of fracture strengths of each denture base materials before and after immersion in three different solutions

Comparison of means and standard deviations between the three denture base materials after immersion in the different denture cleansers are presented in Figure (7) and table (3)

For all three tested denture base materials, Naocl showed significantly lower flexural strength values than the control (water) and the Thyme extract p-value (p value ≤ 0.05) however there were no significant differences in the flexural strength of all tested materials when thyme extract and water were used as denture cleansers. (Table 3)

TABLE (3) Flexure strength of the tested materials after immersion in the three cleansing materials: Within group and between group comparison

Cleanser	Acrylic Mean± SD	Naylon Mean± SD	Karadent Mean± SD	P Value (Between Group Comparison)
Water	83.80 ±1.33 ^{Aa}	82.45± 1.25 ^{Aa}	83.12± 1.38 ^{Aa}	P-value = 0.129
Thyme extract	82.66± 1.31^{Aa}	81.27±1.03^{Aa}	82.08±1.36^{Aa}	P-value =0.129
NaoCl	69.39 ±2.10^{Bb}	66.41±2.86^{Bb}	60.94±1.20^{Bc}	P-value = 0.00
P Value (Within Group Comparison)	< 0.001	< 0.001	< 0.001	

Different superscript capital letters (in each column) indicate significant differences P<0.05 within each group

Different superscript small letters (in each row) indicate significant differences P<0.05 between groups

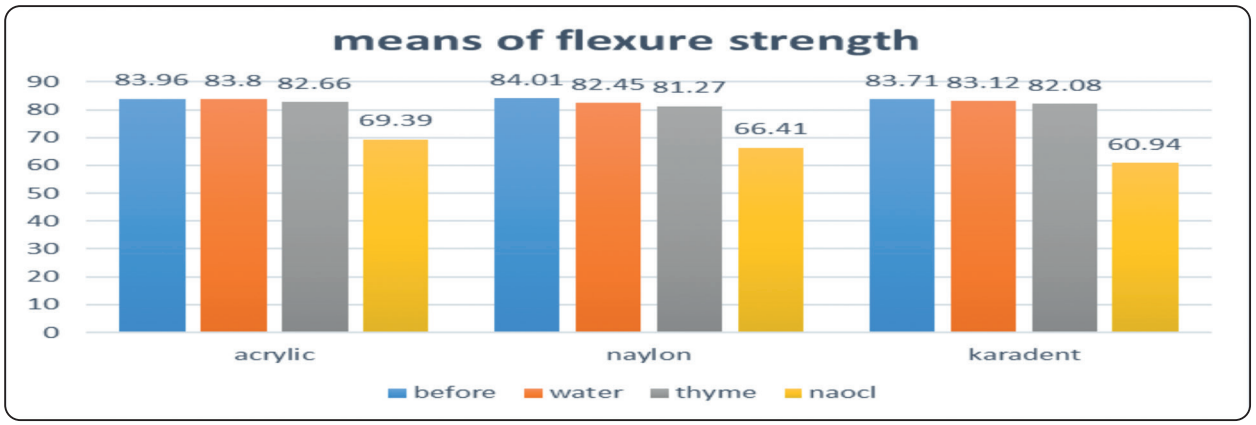

Fig. (7) Comparison of means between different groups.

DISCUSSION

The null hypothesis was rejected as the results showed significant difference between the chemical cleanser (sodium hypochlorite) and an essential oil cleanser (thyme extract) on the flexure strengths of all tested materials.

Denture hygiene and the health of oral mucosa are critical in patients who use complete and partial removable dentures, and denture hygiene maintains the health of oral mucosa. Bacterial endocarditis, aspiration pneumonia, chronic obstructive pulmonary disease, generalized respiratory infections, and other systemic disorders have all been linked to oral bacteria. [19]

According to Furukawa, Immersion for 20 minutes every day for three years was the denture hygiene routine adopted, these times might

result in cleaner penetration into the acrylic resin pores, which is responsible for microorganism elimination.[10] Immersion in 1% sodium hypochlorite for 10 minutes has been shown to be efficient in removing bacteria from both the superficial and interior surfaces of materials.[17,20]

The results reported unfavorable alterations of the flexural strength negatively before and after immersion in chemical cleanser (NaoCl), Thyme cleaning showed less effect on flexure strength in comparison with the NaoCl group and a non-significant difference concerning water control group cleaning group, while karadent denture base specimen resin recorded significantly lower flexural strength than nylon and heat cure acrylic resin values when immersed in NaoCL.

This outcome could be attributed to the nature of the resin material; Naylon is a thermoplastic polyamide resin-based material and is a general term for a family of synthetic polymers known as aliphatic or semiaromatic polyamides. Nylons absorb moisture in proportion to the relative humidity of their immediate surroundings. This observation is consistent with Ragain et al., who suggested that a decrease in flexural strength may be due to water sorption [20]. Hamanaka et al. reported that polyamide (nylon) denture base material showed lower flexural strength values before and after using the cleansers in comparison to PMMA denture bases [21]. Furthermore, these findings follow a study by Salman and Saleem, which revealed that denture cleansers reduced the flexural strength of nylon denture base materials.[11,22]

For all groups (heat polymerized acrylic denture base resin, Nylon denture resin groups, and Karadent denture base), NaoCL recorded the statistically significant lowest flexural strength values. This was linked to the possibility that chlorine radicals from denture cleanser might attack the polymer chain backbone, resulting in polymer breakdown and a decrease in strength.[23]

Among the three groups, karadent showed the least flexural strength results with NaoCl, and significantly lower n comparison to acrylic resin and insufficient studies about karadent properties and decreased strength may be due to an increased number of pits, which allow more invasion of chlorine, leading to weakening of the material. [24]

Alkaline hypochlorite denture cleanser solutions work basically by removing light stains and food debris with a bleaching action. While multiple studies have confirmed that these products improved plaque ability, flexure strength after cleansing was questionable. Similar results were found by Robinson et al., who conducted a series of studies designed to investigate the effect of subjecting acrylic resin denture materials to denture cleanser at recommended and elevated level of cleanser concentrations.[17,25,26.] The results corresponded with those of another study used polymides and PMMa as denture base materials, which found that immersion in 1% NaOCl resulted in a significant drop ($p<0.05$) in flexural strength[27]

The reduction in strength was attributed by Pisani MX et al. to the modification of the polymer resin chain by NaOCl. [28] Other studies, in contrast to ours, indicated no change in flexural strength (flexure strength above 65 MPa) with the use of NaOCl, possibly because the concentration of disinfectant, duration of immersion and type of acrylic resin were different from those in the present study. [29]

Thyme essential oil was chosen as the plant extract denture cleanser used in this study as studies conducted by Liu et al and Hammer et al., reported that thyme essential oil has the best antifungal and antimicrobial properties with the lowest minimum inhibitory concentration (MIC) values.[29,30]

Thyme extract did not negatively influence the flexural strengths of the materials tested and had a comparable effect to the control cleanser (water). These results agree with results obtained by Sidhant Sudan et al. who reported that Thyme essential oil

showed better flexural strength than the combination method with chemicals and can be effectively used as a denture cleaner.[31]

Studies involving thyme as a denture cleanser revealed that thyme essential oil denture cleanser was superior to commercially available denture cleanser in preserving the surface properties of heat cure and self-cure denture base. [32]

The influence of denture cleansers on the characteristics of acrylic resin, thermoplastic polyamide resin-based material, and thermoplastic monomer-free microcrystalline polymer after a prolonged time of immersion in essential oil extraction (thyme) has not been widely studied.

CONCLUSION:

Within the limitations of this study, flexural strength of all materials (heat cure acrylic resin, naylon and karadent) after immersion in thyme essential oil extract as a denture cleanser was significantly better than immersion in NaoCl and was comparable to immersion in water (control)

Clinical significance: Thyme essential oil extract can be used as a long-term denture cleanser.

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