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Analyzing the Effects of Polident and Thyme Extract Oil on Denture Base

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Abstract

Objective: Dentures are the most common remedy for edentulous human population. Natural products and essential oils provide promising therapeutic agents for the treatment of oral infections. The increasing understanding of the diverse applications of natural resources has made them a favored substitute for manufactured materials. therefore, the goal of this study was to find out how different immersion solutions [thyme oil, Polident denture clean] changed the roughness, hardness, and transverse strength of 3D-printed PMMA denture base. **Materials and Methods**: The current study produced ninety 3D-printed resin samples, each measuring [65mm ×10mm×2.5mm] and classified them into three groups including 30 samples, each group were submerged into three groups depending on immersion solutions [control, thyme essential oil, and Polident denture cleaner] for a duration of 15 days. After that the samples were tested for surface roughness, hardness, and transverse strength. **Results**: The Polident immersion group had the highest surface roughness values followed by thyme essential oil, whereas the control group was demonstrated the lowest mean values. Likewise, the surface hardness test findings demonstrated that the Polident immersion group exhibited the greatest mean values, while the thyme immersion group had the lowest mean values but statistically was not significant. Furthermore, the transverse strength test indicated the lowest average transverse strength for the thyme essential oil group. **Conclusion**: Thyme essential oil as a denture cleaner better preserves surface roughness but has a lesser influence on the hardness and transverse strength of the 3D Print denture base compared to Polident denture cleanser.

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Introduction

An increasing number of older people are regularly using dentures as a result of the rising prevalence of edentulism and aging [1,2]. People who wear dentures for a long time have more mutans, streptococci, lactobacilli, staphylococci, microorganisms, and yeasts in their mouths than people who do not wear them [3,4]. Throughout the denture placement appointment, home care instructions are essential to help maintain healthy oral mucosa, especially for elderly patients with disease, dementia, and poor dexterity of who cannot brush their dentures adequately [5,6]. Alqanas et al. have proposed denture cleansers for denture cleaning and maintenance protocols, emphasizing the importance of keeping excellent denture hygiene for healthy oral mucosa. Denture cleaners should get rid of biofilm without changing the properties of the denture base material. Long-term use can change the color, hardness, and surface roughness of denture base resins [7]. An ideal denture cleaning should be biocompatible, bactericidal, fungicidal, non-harmful to the denture structure, effective in removing both organic and inorganic deposits, and user-friendly [8]. Almost all cleaners' dentures contain oxidizing agents, reducing agents, effervescent compounds, detergents, enzymes, and disinfectants [9]. The most frequently used alkaline peroxides, but denture cleansers are breaking down the physical characteristics of denture base resins and pathogenic microorganisms were becoming more resistant to these chemicals. This has encouraged people to look at plant extracts as novel antibacterial and antifungal drugs. Natural products and essential oils give excellent therapeutic agents for oral infections [10,11]. Research comparing plant extracts indicates that thyme essential oil is an effective antibacterial agent against Candida albicans, rendering it appropriate for denture cleaning [12]. Despite its recognized antibacterial capabilities, there is limited research on how thyme essential oil affects the physical qualities of

denture base materials when used as a denture cleaning agent. The hypothesis of present study is that the solution of thyme essential oil and Polident will not change the properties of the 3D printed resin. So, this study oriented to assess the effects of two distinct denture cleansers on surface roughness, hardness, and transverse strength of three-dimensional printed denture base.

Materials and Methods

Fabrication of 3D Printing Design CAD Specimens

The specimens were constructed of 3D printed resin denture base (Flexo Denture Base, V2, SENERTEK, Turkey) by using 3D printing CAD device (Phrozen, Thailand), before printing the specimens designed with bar-shaped dimensions (65mm, 10mm, and 2.5mm) for length, width, and thickness, respectively using Chitobox software according to ADA No. 12, 1999.

The sample plan was saved as an STL file, which was then loaded into 3D printing software for the planned denture base [13]. They exported the 3D printer software at a 90- degree angle [14]. Then added an appropriate quantity of resin to the print tank. Following the printing process by three-dimensional printing with a specified 50 µm layer thickness , removed the denture base specimen from the platform and trimmed off any excess materials, After that immersed them in to isopropyl ethyl alcohol in two steps: first for 2 minutes in one container, followed by another 3 minutes in a second container using an ultrasonic instrument (Bella Gusto, China) [15].

The UV Light Post-Curing Process for 3D Printed Specimens

The samples were subsequently subjected to UV light at an intensity of 405 nm for polymerization, which took place over a duration of 10 minutes [16]. The support structures were then separated by exerting light pressure at the junction where the support was attached to the printed component. After the removal of the support structures, finished and polished the external surface only of the denture bases specimens using the same tools and techniques used for finishing and polishing conventional heat cured denture base [15].

Specimen Grouping

The study used ninety specimens made of 3D printed denture base resin. Three tests, which included the surface roughness, surface hardness, and transverse strength tests. Each one involved thirty specimens. The immersion procedure divided the 30 specimens into three groups, each including 10 specimens, as shown below.

Group I: the specimens immersed in 100ml of distilled water, which was considered a control.

Group II: the specimens were immersed in 100ml of thyme essential oil solution for denture cleaning.

Group III: the specimens were immersed in 100ml of Polident denture cleanser tablet.

Prepare a denture cleanser solution

Preparation of thyme essential oil

To create 1000 ml of a diluted mixture for immersion treatments, blend 5ml of thyme essential oil, 5ml of 0.5% tween, 80ml of ethanol, and 910 ml of distilled water [11].

Preparation of polident denture cleanser

To prepare the denture cleanser, dissolve one Polydent tablets[Stafford-miller, Ireland] in 100ml of distilled water. After manufacturing denture cleanser solutions, perform the immersion process by immersing the specimens in each corresponding solution for a continuous duration of 15 days [17].

Cleansing method

Specimens experienced daily washing by dipping 10specimens from each group. Among the three different solutions, continuously for period 15 days, which replicated three years of usage based on their respective subgroups at room temperature. The determination of these immersion durations was executed using the subsequent procedure. One hour comprised three immersions of 20 minutes each, while a 24-hour period equated to 72 immersions of 20 minutes daily. Consequently, to fulfill a three-year immersion simulation [1095 days], fifty days were necessary [18].

Testing the specimens

Surface roughness test

The profilometer device (Time Group Inc., TR220, China) uses a sharp, sensitive diamond-crafted needle (stylus) as a surface analyzer to outline the profile of surface imperfections. The test was conducted according to the instructions provided by the profilometer. Then divided each sample into three equal portions, and the stylus contacted these three standardized portions to obtain three readings for each one. The stylus makes contact at 5mm in each area of the sample, and positioned the sample on a firm and stable surface, allowed the stylus to contact the first region and the digital scale automatically displayed the reading. The mean of the three measurements was regarded as the roughness value (ΔRa), represented by µm.

Surface Hardness Test

The Shore D durometer was employed to assess the hardness of 3D printed acrylic samples. The testing value was determined by calculating the mean of three distinct readings from the durometer scale. After established a twenty-millimeter distance between the surface of each sample and the indenter in three time (right, center, and left)] for the hardness test, and recorded the average values for each specimen.

Transverse Strength Test

The universal Instron testing equipment (JIANQIAO Testing Equipment, China) was used for the transverse strength test. The three-point bending technique was used to examine the transverse strength of acrylic samples. The prepared thirty samples were positioned them on a bending setup, which featured two parallel supporting arms spaced about 50mm apart. A maximum load of 50 kg was applied at a cross-head speed of 1 mm/min via a rod positioned at the center of the sample until fracture initiation occurred. Subsequently, calculated the transverse strength values by employing the following equation:

$T=3PL /2bd2$

T represents transverse strength (N/mm2).

P denotes the greatest load exerted on samples (Newton).

L indicates the space between the supporting arms(mm).

The ADA specification defines b as the width and d as the depth of samples (mm) (ADA specification No.12, 1999).

Statistical analysis

The data study computerized by using SPSS (Statistical Package for the Social Sciences). To compare the mean values of the different groups, One-way ANOVA and Tukey-HSD test post hoc test were utilized. All statistical calculations were conducted at a 0.05 significance level.

Results

Surface Roughness Test

Table 1 showed the mean and standard deviation for all the groups of 3 D-polymerized resins that were tested after being soaked in different denture cleaners. The Polident cleaner group III had the highest surface roughness (ΔRa) of the 3 D-polymerized resins, measuring 1.4348 µm. The Thyme essential oil group II came next, with a measurement of 1.0961 µm, whereas the control group I had the lowest roughness (ΔRa). An ANOVA-test was applied to evaluate the data, indicating a significance difference of statistics among these groups ($P<0.05$). As seen in Table 2, The Tukey-test revealed, after all examined groups, a significant difference in surface roughness between each two groups.

Surface hardness test

Table 3 compares the mean values for surface hardness test after soaking in various denture cleaning methods. The surface hardness findings of the groups indicate that the

Polident immersion group III exhibits the greatest mean values, while the thyme immersion group II displays the lowest mean values. However, the ANOVA-test result revealed no differences statistically among all groups.

Transverse strength test

The data were evaluated utilizing descriptive statistics. The specimens in Group III that were immersed in Polident solution had the highest mean transverse strength (17.14250 N/mm^2). The specimens in control group had the lowest mean value (14.22690 N/mm^2). Further analysis was need for comparison among the three groups by the ANOVA test that was revealed extremely significant differences (Table 4). The Tukey HSD-test was utilized for multiple comparisons among all groups (Table 5). The Tukey test findings demonstrated a highly significant difference within the groups.

Discussion

Physical cleaning procedures frequently combine with chemical denture cleansing techniques to ensure the cleanliness and hygiene of dentures. Older patients with severe diseases, such as disabling illnesses, diminished manual dexterity, and neuromuscular dysfunction, sometimes are unable to clean dentures. So that allows for the growth of bacterial and candida, leading to severe resources for disseminating infection [19]. Some research indicates that denture cleanser usage greatly reduces the amount of bacteria on dentures, particularly in older adults [20]. Traditional chemical denture cleaners are good at killing microbes, but natural plant extracts will soon be used instead because microbes are becoming more resistant to them. Mouth rinses, toothpastes, and similar products utilize these plant extracts for their effective antibacterial and antifungal activities [8].

Gutierrez et al. [21] had proved that thyme essential oil was selected as the botanical extract for the denture cleaning since it completely inhibits microorganisms. Gonçalves et al. [19] described that thyme essential oil was the most useful for killing *Streptococcus mutans*. Several studies have investigated the beneficial properties of thyme essential oil, but less research has focused on its impact on denture base resin.

Researchers like Peracini et al. [5] and Sharma et al. [22] found that Polident was better than other commercially available denture cleaners, especially when compared to hypochlorite and alkaline peroxides. It also didn't change the strength or roughness properties of denture base resins in a big way. Thus, it was utilized for comparison with the denture cleaner derived from the Thyme vulgaris plant extract.

In this study, the null hypothesis was thrown out due to significant differences seen between the chemical cleanser [Polident] and the essential oil cleanser (thyme extract) regarding the roughness, hardness, and flexural strengths of all examined material.

The surface roughness test evaluates the imperfections of denture surfaces, especially the fitting surface, which might harbor microorganisms and facilitate persistent reinfection of the palate. Several factors affect the surface texture of acrylic dentures. These include the amount of residual methyl methacrylate monomer, the polymerization process and cycle, the amount of time the dentures are stored in water, and how often they are washed [23].

Research indicates that the quantity of microbes on smooth surfaces is comparatively lower than on rough surfaces and the removal of biofilm becomes more difficult as the surface roughness increases [24]. When exposed to denture cleaners, the texture of denture foundation acrylic resin undergoes extensive surface morphological alterations [6].

Surface roughness, characterized by Ra values, is an acknowledged means of analyzing surface textures in research [25]. The results presented in Table 2 indicate that the Polident denture cleanser group had a greater mean roughness value (1.4348 µm) compared to the Thymes essential oil group (1.0961 µm) and the control group (0.3321 µm). This led to a rise in the roughness of the acrylic specimens. These results may be due to the perborate used in Polident denture cleaning, which might cause surface degradation, resulting in enhanced surface roughness.

The present study's results align with those of Mossa et al. [26]. Also, these findings were similar to those of Namala and Hedge [8], they concluded that the surface roughness in the thyme oil group increased less than that of the Polident denture cleanser group.

Alqanas et al. [6], they demonstrated that soaking 3D-printed acrylic in Polident denture cleanser increased surface roughness. The findings of this study agreed with our observations.

The findings of Panariello et al. [27], were different from this study's result because the surface roughness did not get better in the Polident denture cleaning group; but it stayed the same as in the untreated group.

Khandelwal et al., showed that the thymes oil group had a lower average value than both the untreated group and the Polident denture cleanser group. They explained their results by stating that the variation in surface roughness is attributable to their composition and the immersion solution. Thymol, which (2-isopropyl-5-methylphenol) and carvacrol (5-isopropyl-2-methylphenol) have the principal antibacterial constituents found in thyme oil. Thyme essential oil was utilized as an extract from plants as a denture cleanser due to its low minimum inhibitory concentration (MIC) values and its antifungal and antibacterial properties [28].

Conversely, the outcomes of the surface hardness test showing no significant variances within these groups. Following 15 days of immersion, Table 3 indicates that the Thymes oil group exhibited a lower mean surface hardness value (39.4000 MPa) related to the control group (41.1000 MPa), but the Polident group recorded a value of (41.7000 MPa). These findings agreed with those reported by Hatim et al. [29], they concluded that when thyme oil and nigella oil were added at concentrations of 1%, 1.5%, and 2%, the denture base became harder, but there were no big differences between the concentrations. The interaction between the unreacted monomer and the oil-coated polymer explains this alteration.

Panariello et al. [27], demonstrated that the application of this protocol had no impact on hardness, which was partially accepted. Similar results to this study were found by Neppelenbroek et al. [30], who also discovered that denture base resins that were treated with sodium hypochlorite and perborate mixture exhibited a significant decrease in average hardness values. The explanation of this result by stating that the thymol oil exerts its solvent effect on the surface of acrylic and other thermoplastic resins, the saturated salt solution results in increased water absorption within the acrylic, as sodium chloride, an ionic compound, forms an infinite repeating lattice of ions when dissolved in water. The polar nature of resin molecules makes it easier for water to dissolve due to electrostatic interactions. This makes the material's surface less hard. This investigation aligns with the conclusions of the current research.

Moussa et al. [26], contest our results, saying that the mean surface hardness of the Polident denture cleaner group is lower than that of the control group. The hardness values significantly diminished among all groups, contradicting the findings of Alqanace et al. [6].

A study by Khandelwal et al. [28], they found that the control group had a harder surface than both the thyme essential oil group and the Polident denture cleanser group. This varies from our studies; these differences may be attributed to several reasons, like immersion duration, the polymerization method of PMMA, and polishing denture procedures.

The current study demonstrates that the transverse strength of the PMMA denture

base resin affects the longevity of the prosthesis. Inadequate flexural strength leads to a higher frequency of denture fractures, occurring both intraorally and extraorally. This study revealed that the thyme essential oil group had a superior mean transverse strength value compared to the control group following 15 days of immersion. The results were similarly to those of Anjum et al. [11], who discovered that following 30 days of immersion. The thyme essential oil group had better results than the control group. This study's results contradicted those of Namala and Hedge[8], who reported that the transverse strength mean value of the control group exceeded that of the thyme oil group. In this study, the results showed that the mean transverse strength of the Polident denture cleaner group exceeded that of both the control and Polident groups.

Namala and Hedge [8] also found that the mean transverse strength of Polident denture cleaner was above than that of the un treated control group. They found that the Polident denture cleaner group had the same flexural strength as Sharma et al. and Anjum et al. [11,31].

The mean transverse strength value of the Polident denture cleaner exceeded that of the control group. Mohammed et al.'s research [17], they revealed that the thyme essential oil group had a greater mean transverse strength value compared to the control group. The difference between the Polident denture cleanser group and the control group was significant, as the control group had a greater mean value of transverse strength than the Polident denture cleanser group.

Thyme extract did not negatively affect the flexural strengths of the investigated material. The results were the same as those of Sidhant et al. [20] reported that Thyme essential oil exhibited superior flexural strength compared to the chemical combination approach and may be utilized successfully as a denture cleanser.

Conclusion

The present investigation demonstrated that the denture cleaner Polident and essential oil of thyme influence surface roughness. However, they can be safely used to clean denture base material without affecting its surface hardness or transverse strength.

Conflict of Interest

None.

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Table 1. Descriptive of data and ANOVA analysis for surface roughness assessments among all immersion groups.

	N	Mean	Standard Deviation	Standard Error	Minimum Value	Maximum Value	ANOVA test p-value
Group I	10	0.3321	0.06723	0.02126	0.25	0.47	0.000
Group II	10	1.0961	0.09803	0.031	0.92	0.18	
Group III	10	1.4348	0.09063	0.02866	0.34	0.58	

Table 2. Comparative Analysis Tukey HSD analysis of surface roughness test.

Groups		Mean Difference	Standard Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Group I	Group II	0.764	0.0386	0.000	0.8597	0.6683
	Group III	1.1027	0.0386	0.000	1.1984	1.007
Group II	Group III	0.3387	0.0386	0.000	0.243	0.4344

Table 3. The descriptive statistics and ANOVA test results for the surface hardness test among all immersion groups.

Groups	N	Mean	Standard Deviation	Standard Error	Minimum Value	Maximum Value	ANOVA test p-value
Group I	10	41.1	1.59513	0.50442	39	44	0.071
Group II	10	39.4	2.75681	0.87178	32	41	
Group III	10	41.7	2.11082	0.6675	37	45	

Table 4. Descriptive statistics and the ANOVA test for the transverse strength among all immersion groups.

Groups	N	Mean	Standard Deviation	Standard Error	Minimum Value	Maximum Value	ANOVA test p-value
Group I	10	14.2269	0.220758	0.06981	13.944	14.532	0.000
Group II	10	15.0306	0.786233	0.248629	14.314	16.945	
Group III	10	17.1425	0.344856	0.109053	16.827	17.88	

Table 5. Tukey HSD analysis of transverse strength tests for all immersion groups.

Groups		Mean Difference	Standard Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Group I	Group II	0.8037	0.228885	0.004	1.3712	0.2362
	Group III	2.9156	0.228885	0.000	3.4831	2.3481
Group II	Group III	2.1119	0.228885	0.000	1.5444	2.6794