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Evaluation of Surface Roughness of Heat Cured PMMA after Immersion in Artificial Saliva and Different Solutions

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Abstract

Objective: The aim of this in vitro study was to evaluate the surface roughness of heat-cured acrylic resin after immersion in artificial saliva and different solutions**. Material and Methods**: 70-disc shaped specimens 10mm in diameter and 2 mm in thickness were prepared from heat-cured acrylic resin. Then, divided into 2 groups. First group consist of 4 groups as follow: (control) immersion in distilled water, immersion in Zamzam water, immersion in diluted thyme oil and immersion in mouth wash (Listerine ®) with 10 samples each. The samples were immersed in their respective solution for 8 h per day for one month. The second group consist of 3 groups as follow distilled water, artificial saliva normal and acidic with 10 samples each. The samples kept in artificial saliva for 16h per day for one month. Profilometer was used to evaluate the surface roughness (µm). For analyzing statistically, the obtained data, one-way ANOVA and LSD test were used. P-value<0.05 was considered significant. **Results**: All solutions showed no statistically significant difference on surface roughness of specimens at 8h and 16h for one month. However, the Zamzam water group showed positively significant difference when immerse 8h for one month. **Conclusion**: The six solutions used in this study none produced increased in surface roughness compared to control group for two times of immersion Nevertheless, the best result as denture cleanser was obtained in Zamzam water which was showed the less value in surface roughness (µm).

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Introduction

Acrylic resin has been recommended as a denture base material for several years. In addition to having outstanding mechanical qualities, denture base material should ideally gain some important physical characteristics, such as biocompatibility and a strong link with prosthetic teeth [1]. Most denture users have poor oral hygiene and struggle to keep their dentures clean. The primary cause of disorders affecting the oral mucosal tissues is unclean dentures. Denture wearers were found to have a significant correlation between denture stomatitis and inadequate denture hygiene. For better health, especially in elderly people, edentulous individuals must maintain proper dental hygiene and keep their dentures clean [2]. Dentures can be cleaned mechanically, chemically, or by combining the two [3].The mechanical cleaning procedure is usually used by patients, and it is insufficient for cleaning undercut sections of dentures, which might harbor bacteria. Furthermore, aged patients with weak motor coordination and handicapped patients with low physical ability and a lack of cooperation may not clear the accumulated biofilm appropriately [4]. The most popular chemical cleaning techniques that have been proposed for prosthesis disinfection are denture cleansers. In addition to being biocompatible, bactericidal, and fungicidal, the best cleaner should also be easy to use and not change the prosthesis's structure in any way. Most importantly, it should effectively remove both organic and inorganic deposits [3]. Long-term use of denture cleaners can make PMMA surfaces rougher [5]. The rough, pitted surfaces of acrylic dentures serve as a breeding ground for bacteria to colonize and build biofilms [3]. The presented in vitro study was conducted to evaluate the effect of artificial saliva and different solutions(distilled water, Zamzam water, diluted thyme oil and mouth

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wash) on surface roughness of heat-cured acrylic resin material. The null hypothesis tested was that no significant differences would be found after immersion in different solutions.

Material and Methods

Preparation of specimens
Metal patterns were constructed [10mm in diameter and 2mm in thickness] [6] .
The metal patterns were covered with separating media and let to dry after the lower part of the dental flask was filled with dental die stone mixed in accordance with the manufacturer's instructions. A layer of separating material was then applied to the whole surface of the stone and the metal patterns after they had been carefully placed to half of their depth and allowed to set. Then, the upper part of the flask was placed on top of the lower part and filled with stone. A dental vibrator was used to remove the trapped air. Following the stone's full setting, the flask was opened (see Figure 1), and the metal designs were taken out to create a mold for packing heat-cured acrylic resin. Following a 15-minute hydraulic pressure test, the clamped flask was placed in a water bath to cure it. It was heated to 74°C for 1.5 hours and then raised to boiling, 100°C, for 30 minutes (ADA, 1999). After the curing process was finished, the flask was submerged in water for 15 minutes and allowed to cool gradually at room temperature for 30 minutes [2]. A tungsten steel bur put in a handpiece at low speed was then used to trim only the superfluous acrylic after the acrylic specimens had been carefully removed from the stone mold. The specimens' surfaces are left unfinished [1].

Figure 1. Opening the flask.

Immersion Procedure
The specimens were divided into two groups:
First group: 40 specimens were distributed into the following: (Control) group of Distal Water, Zamzam water, thyme oil diluted using a 1:1 mixture of thyme essential oil (allin and polysorbate) and distilled water at a concentration of 0.5µl/ml [7], and group of mouth wash (Listerine) each of these solutions contained 10 specimens, and 200 ml of the solution were immersed in closed containers [1] once a day for 8 hours to simulate overnight use [8,9]. None of the solutions was replaced during this period [10] for 30 days [11] .
Second group: 30 specimens were distributed into the following:
Artificial saliva normal and acidic: (Control) 10 specimens were immersed in distilled water,10 specimens were immersed in normal saliva and 10 specimens were immersed in acidic saliva up to 200 ml once a day for 16 hours for 30 days [11] to simulate the time of denture wearing.

Surface Roughness Test
Each disc-shaped specimen's surface roughness was measured to within 0.01 µm using a Time Group Inc. hand-held roughness measurement equipment profilometer (TR200). The analyzer's stylus traveled 0.5 mm/second across the specimen surface. The recorded data had a resolution of 0.01µm, a cut of value of 0.8mm, and a tracing length of 2.4 mm. Each specimen had three readings taken, and the specimen's mean roughness (Ra) was determined [2,12].

Statistical Analysis
Statistical package for social science, version 21 (SPSS) was used to gather and analyze the research's data. Surface roughness change was summarized using descriptive statistics, and a one-way analysis of variance (ANOVA) was conducted on surface roughness (µm) and followed by an LSD test for group comparison. A P value <0.05 was deemed statistically significant.

Results

The result of surface roughness(µm) showed that all group nearly the same mean value for groups control (distil water), diluted thyme oil, mouth wash (2. 5809±.53136 µm), (2.6199±.70094 µm) and (2.8566±.37206 µm) respectively and the lower mean value of surface roughness was for Zamzam water group (1.8930± .26521 µm) after immersion in 8 hours a day for one month as shown in Table 1 and Figure 2. To compare the mean values among groups, least significant difference (LSD) test was implied Table 3. The test showed significant difference when compared Zamzam water group with control group (distil water), diluted thyme oil group and mouth wash group, and the test revealed non- significant difference between groups of diluted thyme oil and mouth wash when compared with control group (distil water) also non- significant difference between groups of diluted thyme oil and mouth wash. The surface roughness (µm) for the second group showed nearly the same mean value for all groups control (distil water), Artificial saliva (normal), Artificial saliva (acidic) (2.5809±0.53136 µm), (2.3243±0.40270 µm) and (2.4948±0.63629 µm) respectively after immersion 16 hours a day as shown in Table 4 and Figure 3. Statistical analysis using one-way ANOVA test showed a statistically non- significant difference among the mean values of the study groups as shown in Table 5.

Discussion

For the acrylic surface to be free of microorganisms, surface roughness is crucial [13]. An increase in surface roughness may make biofilm removal more challenging [14].
In this study, the duration of immersion in the denture cleanser was selected to mimic the 8-hour overnight immersion, which is a typical scenario in which dentists advise patients to take out their dentures while they are asleep and submerge themselves in solutions to relieve the underlying tissues and clean the dentures [8]. Based on the results of surface roughness of this study the null hypothesis was accepted.
The present study's findings demonstrated that, except for the Zamzam water group, which had greater smoothness or less surface roughness, overnight immersion produced surface roughness values that were almost identical (µm). Figure 1 and Table 1.The current study's findings concur with Ural C et al. and found no difference in the impact of sodium hypochlorite and commercial cleansers on surface roughness [15] agreement with Salem et al., who demonstrated that there is no discernible change in the surface roughness of acrylic resin samples immersed in various denture cleaning solutions as opposed to samples immersed in distilled water [16].
The PH of Listerin® is 4.11. It is reasonable to believe that the increased acidity led to the breakdown of the acrylic resin's outermost layer, which raised the roughness values. A subsurface area of the acrylic resin was revealed as a result of the material's ongoing exposure to these mouthwashes, which encouraged the loss of this outer layer [13].
The plant extract denture cleaner of choice was thyme essential oil. This was consistent with research by Liu et al., which found that thyme essential oil had the lowest inhibitory concentration values and was the best antifungal and antimicrobial [17]. Comparing

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the fittydent to other commercially available denture cleansers, Sharam et al. found that it had the least impact on the surface properties of denture resins. However, when compared to the thyme essential oil denture cleanse, it significantly increased the surface roughness [18]. In an acrylic resin denture foundation subjected to glutaraldehyde for ten minutes, Carvalho et al. observed surface pitting and the development of polymer beads [19]. Although there was no significant difference between the groups in this study, there was a significant difference between the Zamzam water group and other solutions.

According to Al-Ansy et al., bottled Zamzam is ozonated [20]. When ozonated water, an environmentally friendly disinfection solution, was examined for its impact on PMMA's surface roughness and surface less, it was discovered to have no effect [21]. The patient's time wearing the denture is represented by the samples of heat-cured acrylic resin submerged in artificial saliva (both normal and acidic) for 16 hours. Resin's characteristics may be compromised by its susceptibility to various environmental conditions. Saliva, humidity, and temperature variations are some of these variables. One of the primary issues in the field of removable dental prosthesis has been alterations in salivary pH [22]. Alfadda et al. discovered that soaking in neutral and basic PH values considerably increased the heat-cured acrylic material's surface roughness [12]. The results of this study disagree with Alfadda et al.

Limitation

It is well known that depending on the patient's dietary intake, the salivary PH value in the oral cavity continuously fluctuates between acidic and basic. The same acrylic material may therefore need to be exposed to different salivary PH levels to examine how it affects surface roughness or other mechanical and physical characteristics. Along with other limitations, the current study only examined the effects of various chemical cleaners on a single type of denture base resin, and the immersion period was only one month.

Conclusion

Within the limitations and based on the results of this study, it was found that Zamzam water showed less or no negative effect on surface roughness and the mouth wash listerin® showed slight increase in surface roughness but a statistically no significant difference when compared with control. In addition, both two types of artificial saliva had no effect in increasing of surface roughness.

Author's Contribution

SFA: Methodology, Writing – RMZ: Original Draft Preparation. NH: Supervision.

Conflict of Interest

We have no conflicts of interest to disclose regarding this article. The opinions expressed are solely those of the authors and have not been influenced by any financial or personal relationships.

Regulatory Statement

This article did not involve the use of any hazardous materials, living organisms, or any procedures that could harm the environment. There was no need to comply with any specific regulatory laws or regulations regarding occupational health and safety or the environment. All necessary measures were taken to ensure compliance with ethical research practices and laboratory safety.

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Table 1. Descriptive statistics of surface roughness (µm) after immersion in different solutions 8 hours a day for one month for all studied groups.

Groups	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Control (distil water)	10	2.5809	0.53136	0.16803	1.82	3.65
Zam zam water	10	1.8930	0.26521	0.08387	1.60	2.24
Diluted thyme oil	10	2.6199	0.70094	0.22166	1.64	3.89
Mouthwash	10	2.8566	0.37206	0.11766	2.44	3.64
Total	40	2.4876	0.59917	0.09474	1.60	3.89

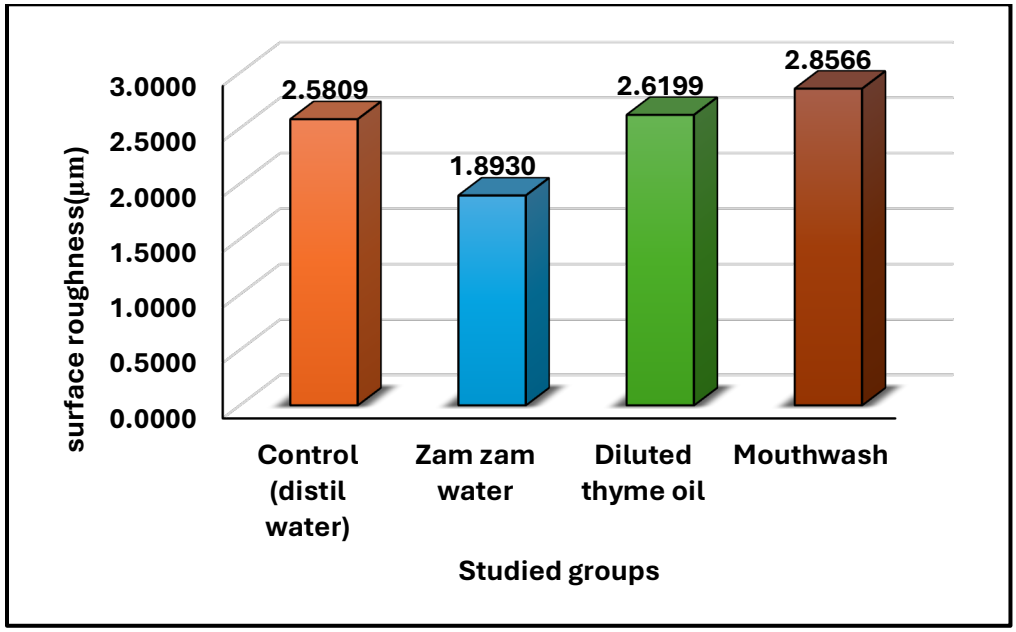

Figure 2. Bar chart showing the mean value of surface roughness (µm) after immersion in different solutions 8 hours a day for all studied groups.

Table 2. One-way ANOVA to compare the surface roughness (µm) after immersion in different solutions 8 hours a day between control and experimental groups.

ANOVA	Sum of Squares	df	Mean Square	F	p-value
Between Groups	**5.159**	**3**	**1.720**	**7.002**	**0.001***
Within Groups	**8.842**	**36**	**0.246**		
Total	**14.001**	**39**			

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Table 3. Least significant difference for surface roughness(μm) after immersion in different solutions 8 hours a day to compare between all studied groups.

(I) Group	(J) Groups	Mean Difference (I-J)	P-value	95% Confidence Interval	
				Lower Bound	Upper Bound
Control (distil water)	Zam zam water	0.68790*	0.004	0.2384	1.1374
	Diluted thyme oil	-0.03900	0.861	-0.4885	0.4105
	Mouthwash	-0.27570	0.222	-0.7252	0.1738
Zam zam water	Diluted thyme oil	-0.72690*	0.002	-1.1764	-0.2774
	Mouthwash	-0.96360*	0.000	-1.4131	-0.5141
Diluted thyme oil	Mouthwash	-0.23670	0.293	-0.6862	0.2128

Table 4. Descriptive statistics of surface roughness(μm) after immersion in different solutions 16 hours a day for one month for all studied groups.

Groups	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Control (distil water)	10	2.5809	0.53136	0.16803	1.82	3.65
Artificial saliva (normal)	10	2.3243	0.40270	0.12734	1.84	2.92
Artificial saliva(acidic)	10	2.4948	0.63629	0.20121	1.92	3.69
Total	30	2.4667	0.52475	0.09581	1.82	3.69

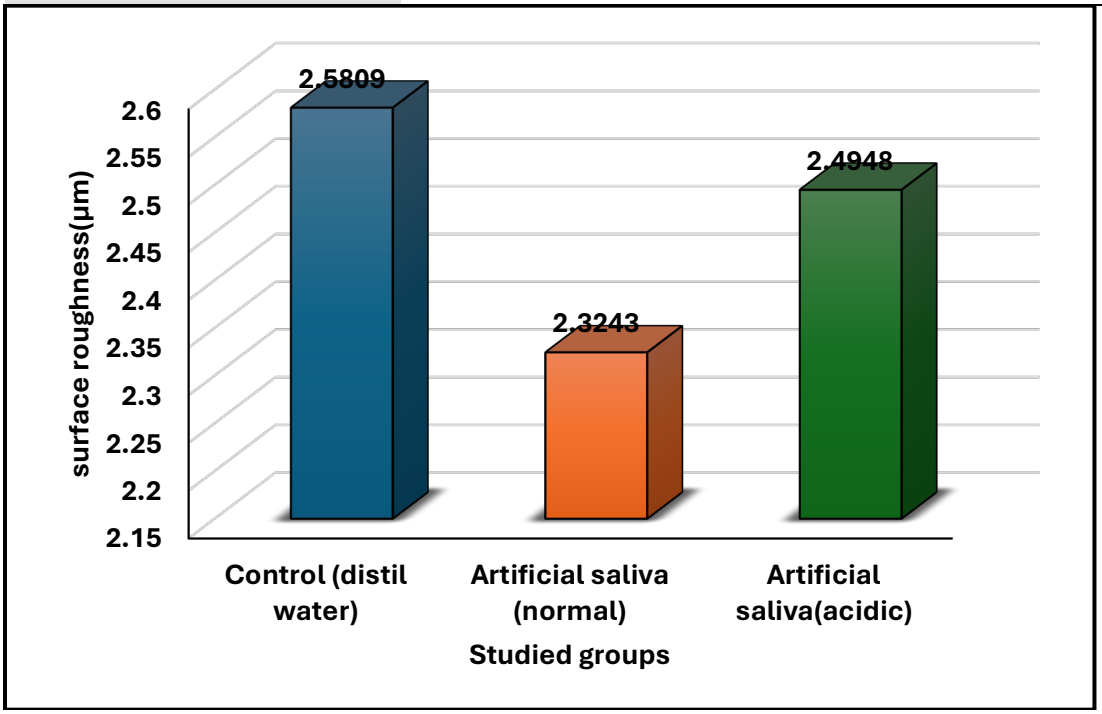

Figure 3. Bar chart showing the mean value for surface roughness(μm) after immersion in different solutions 16 hours a day for all studied groups.

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Table 5. One-way ANOVA to compare the surface roughness(μm) after immersion in different solutions 16 hours a day between control and experimental groups.

ANOVA	Sum of Squares	df	Mean Square	F	p-value
Between Groups	0.341	2	0.171	0.602	0.555
Within Groups	7.644	27	0.283		
Total	7.985	29			