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Effect of tea tree oil on heat cure Acrylic resin properties

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Abstract

Purpose: Investigate the effect of long-term 90-time immersion in tea tree oil denture cleanser solution on the roughness, hardness, UV absorption, water sorption, and solubility of a heat-cured acrylic resin.

Material and Methods: One-hundred twenty specimens of heat cured acrylic resin were performed and divided into four sets . Each set consist of 30 specimens that distributed into three groups (Group 1: distilled water , Group 2 : 0.75% tea tree oil and Group 3: 1% tea tree oil) , totaling with 10 specimens per group. The specimen were immersed for ten minutes in accordance to its groups 90 time to simulate six months. After periods of immersion the specimens were tested for surface roughness , hardness, UV- absorption, water sorption, and solubility. One-way analysis of variance ANOVA and Tukey HSD were used to assess the data at a significant level α=0.05.

Results: Tea tree oil solutions had a statistically non-significant differences ($P > 0.05$) on acrylic resin hardness property and UV- absorption test ($P > 0.05$) and statistically significant effect of acrylic properties in surface roughness ($P < 0.05$), with significant decrease in water sorption and solubility ($P < 0.05$), after 90 time immersions.

Conclusion: Immersion of heat cured acrylic resin specimens in tea tree oil result in statistically significant increase in the surface roughness, significant decrease in water sorption and solubility after immersion, while the hardness and UV-absorption properties had not affected.

Keyword: Acrylic Resin, Tea Tree Oil, Roughness, Hardness, UV-absorption, Water Sorption

1. Introduction

Poly (methyl methacrylate or PMMA), which has high aesthetic attributes, a low water absorption rate, and low toxicity, is the most often used material for manufacturing denture resin. But this material has a drawback, which is that it's porous, which makes it easy for food to stick there and for microorganisms to grow, which might lead to oral illness [1]. Dentures can be chemically cleaned to prevent this problem. The requirement to clean prostheses has prompted a worldwide search for disinfectants that are safe for the prosthesis surface [2]. However, it has been noted that the characteristics of different prostheses might be adversely affected by chemical cleansers [3].

The roughness of the PMMA surfaces is crucial because microbe adherence to a surface is a need for that surface to get colonized [4]. The hardness of the denture base resin constitutes an indicator for both the material's simplicity of finishing and its ability to withstand in-service scratches during cleaning operations [5]. The alteration in color is a sign of dental materials that are getting older or being damaged. Denture base resins' color stability may offer crucial information about the materials' durability [6]. The water sorption study also has therapeutic importance since the water that acrylic resins absorb when wearing prosthetics works as a plasticizer and might cause volume alterations. Furthermore, it is preferable that these substances have low solubility's since, if released into the oral cavity, the residual monomers and other water-soluble residues, might irritate tissue. The performance of any prosthesis over time depends on these characteristics [7].

So, there has been investigation into potential natural denture cleaners [8]. Natural plant extracts' safety and biocompatibility with minimal side effects, in addition to their affordability, are the main advantages of employing them as disinfectants [9].

Melaleuca alternifolia, an Australian native plant from which tea tree oil (TTO) was derived, could be steam-distilled to produce the oil from its leaves. TTO was made up of a variety of substances, mostly monoterpene and sesquiterpene hydrocarbons and their alcohols. Several studies showed that TTO had antiseptic, antibacterial [10], anti-inflammatory, and anti-fungal characteristics, particularly those that had anti-candidal properties [11]. Moreover, phytoconstituents were chemical substances found in natural agents that had a

specific target effect for treating and preventing biofilm-related disorders [12]. A few of these compounds were α-terpineol which came from Melaleuca alternifolia [13]. These phytoconstituents displayed antifungal activity against C. albicans [14]. In spite of the beneficial disinfectant effect of TTO, there was no studies on its effect on heat cure acrylic properties for using TTO as a denture cleanser. Therefore, the aim of the current study was to evaluate how long-term (90-time) immersion in TTO solution affected physicomechanical properties (surface roughness, hardness, UV-absorption, water sorption and solubility) of heat cured acrylic resin.

2. Material and Method:

2.1. Specimen preparation

A total of 120 specimens of heat-cured acrylic resin (SR Triplex Hot, Ivoclar Vivadent, Liechtenstein) were fabricated following the guidelines provided by the manufacturer. Then, the resin was poured into a master mold [15]. The plastic models were made using a laser cutting machine according to the specified dimensions for each test. For the surface roughness and hardness test, a master mould created with size of (30×15×2.5 mm) length, width and thickness, respectively [16]. For UV-absorption test and water sorption and solubility test a turning machine used to cut aluminum foil into a disc shape pattern 50 mm in diameter and 0.5 mm in thickness according to ADA No 12, 1999 [17,18]. The excess material was removed from all acrylic specimens (aside from those that were being prepared for surface roughness testing) using a prosthetic engine equipped with stone and acrylic burs, which were continuously cooled by water to prevent overheating that could cause the specimens' distortion. In order to get a glossy surface on the specimens, the polishing technique was conducted by employing rouge, which was positioned within a dental lathe machine and rotated at a speed of 1500 revolutions per minute (rpm), while ensuring a constant flow of water for cooling purposes [19].

2.2. Specimen grouping

A total of 120 specimens were performed and distributed into four sets:

1. Surface roughness test,
2. Hardness test,
3. UV-absorption test.
4. Water sorption and solubility tests.

Each set consist of thirty specimens distributed into three groups with ten specimens in each groups:

Group 1: immersed in distilled water (DW),

Group 2: immersed in 0.75% TTO,

Group 3: immersed in 1% TTO

2.3. Preparation of TTO solution:

Pure Tea Tree Essential Oil (Now foods; Bloomingdale, IL 60108, USA): TTO solution prepared by mixing it (according the specimen groups) with 1% tween 80 as an emulsifying agent and DW by using magnetic stirrer.

2.4. Immersion Technique

Each specimen was immersed in TTO concentration (0.75%, 1%) according to specimen groups and the control group immersed in DW on-site as for 10 minutes. The specimen would be removed from each immersion, cleaned with DW, wiped with absorbent paper, and the immersion process would be repeated 90 times [20].

2.5. Surface roughness test

The surface roughness of the specimen was precisely (0.001) measured using the stylus-type electronic roughness tester contacts surface roughness measuring equipment (profilometer, VTSYIQI, China).

The digital scale's reading automatically appeared when the pointer was permitted to contact the sample's starting region while it was on a stable, rigid surface [21]. It had a diamond tip moves physically in 5 access and 2.5mm length while still retaining contact with the surface and give the average reading.

2.6. Surface hardness test

In this investigation, a Shore D hardness tester was employed since acrylic resin materials are best suited for it [22]. The device has an end-mounted 1.6 mm cylinder and a pointed indenter with a 0.8 mm diameter. A digital scale is connected with an indenter. Each specimen was exposed to five indentations, and the average of the five readings was computed [23].

2.7. UV-absorption test

A UV spectrophotometer was used to evaluate how much UV light was absorbed. To determine how much UV light the specimens absorbed, the UV light spectra was examined between 200 and 400 nm. The spectrophotometer's computer screen was connected to the disk-shaped specimens, which were placed above the light source and subjected to the light [24].

2.8. Sorption and solubility test:

According to ADA 1999, A desiccator containing recently dried silica gel was used to store 30 samples. For 24 hours, the discs were kept at 37 °C + 2 °C in an incubator. After th The samples were then taken out and maintained at room temperature for (60 ± 10) minutes in another desiccator with newly dried silica gel before being weighed using a digital balance that had a (0.000lg) accuracy. This cycle was repeated every day at the same time until a constant mass "conditioned mass" (M1) was established, where each specimen's loss in mass was no more than 0.2 mg (0.0002g) in a 24-hour period. According to the immersion procedure used in this study, which is ten minutes for 90 times, the specimens were then submerged in cleaning solution for the tested groups and distilled water for the control group at 37°C ± 2 °C. The discs for each group were removed from the liquids using tweezers and afterward dried with a clean, dry hand towel until they reached a state of moisture absence. Subsequently, a period of 15 seconds was allocated for the waving process, followed by a subsequent weighing that occurred one minute later. Upon removal of the discs from the liquids, the resulting mass was marked as (M2). In order to determine the solubility test value, the discs were subjected to reconditioning in a desiccator at a temperature of 37°C ± 2°C, which had been previously utilized for the sorption test. The reconditioned mass (M3) was determined.

The following equation 1 was used to get the values for sorption for each disc, and the result should be rounded to the nearest 0.1 mg/cm^2.

Where: $WSP = \frac{M2-M1}{S}$ (1) (ADA 1999)

For each specimen, in equation 2, the amount of soluble materials lost during immersion was calculated to the closest 0.01 mg/cm^2 as follows:

Where: $WSL = \frac{M1-M3}{S}$ (2) (ADA 1999)

WSP = sorption mg/cm2

WSL= solubility (mg/cm2)

S= surface areas of the disc (cm^2).

In the statistical analysis, both descriptive statistics (such as mean, standard deviation, and statistical tables) and inferential statistics (such as one-way analysis of variance test [ANOVA] and multiple comparison tests using Tukey HSD for the significant findings) were used.

3. Results

Tables 1–10 include a summary of the study's findings and statistical analysis.

3.1. Surface roughness:

Based on the surface roughness data provided in table 1-2 it can be observed that all of the denture base resin specimens used in the experiment exhibited a statistically significant difference between group 2 and group 3 (P<0.05) as compared to group 1, following 90 immersions in TTO.

Table 1: Descriptive statistics and one-way ANOVA for surface roughness test

Groups	N	Mean	Std.	F	P	Sig.
Group 1	10	1.42360	0.013970	496.687	0.000	S
Group 2	10	1.53720	0.017087			
Group 3	10	1.66290	0.019451			

Level of significance $P \leq 0.05$. Std: Standard deviation

Table 2: Multiple comparison of surface roughness test

Groups	Mean difference (I-J)	S.E	P
Group 1-2	0.113600	0.007596	0.000
Group 1-3	0.239300	0.007596	0.000
Group 2-3	0.125700	0.007596	0.000

Level of significance $P \leq 0.05$. SE: Standard error

3.2. Hardness test:

Table 3 showed the mean value of group 2 and group 3 lower than that of group 1 and the least values showed in group 3 in 90, while *P* value revealed a non-significant differences (P>0.05) for long term immersion .

Table 3: Descriptive statistics and one way ANOVA test of hardness test

Groups	N	Mean	Std.	F	P	Sig.
Group 1	10	85.6380	0.16864	1.258	0.300	N.S
Group 2	10	85.5660	0.17709			
Group 3	10	85.5310	0.10577			

Level of significance $P \leq 0.05$. Std: Standard deviation

3.3. UV-absorption test:

Table 4 displayed descriptive statistics data demonstrating the mean value decreasing with increasing TTO concentration in, compared to group 1, and one way ANOVA test P value demonstrating a non-significant differences (P >0.05) between groups.

Table 4: Descriptive statistics and one way ANOVA test of UV-absorption test

Groups	N	Mean	Std.	F	P	Sig.
Group 1	10	2.389030	0.1189832	1.650	0.211	N.S
Group 2	10	2.379750	0.1702108			
Group 3	10	2.288220	0.1153325			

Level of significance $P \leq 0.05$. Std: Standard deviation

3.4. Water Sorption

In relation to the water sorption test of the control and experimental groups in Table 5, it was discovered that group 2-3's mean was lower than group 1's, which indicated that the experimental groups' water absorption decreased. In the data on water sorption, a one-way analysis of variance (ANOVA) resulted in a statistically significant difference (P<0.05) between the groups. In the test for water sorption, Tukey HSD of multiple comparisons between the study groups was performed in Table 6, which demonstrated a non-significant difference between groups 1-2 (P>0.05) and a significant difference between groups 1-3 (P<0.05) in the same table.

Table 5: Descriptive statistics and one way ANOVA test of water sorption test

Groups	N	Mean	Std.	F	P	Sig.
Group 1	10	0.760	0.0516	10.688	0.000	S
Group 2	10	0.720	0.0422			
Group 3	10	0.660	0.0516			

Level of significance $P \leq 0.05$. Std: Standard deviation

Table 6: Multiple comparisons of water sorption test

Groups	Mean difference (I-J)	S.E	P	Sig.
Group 1-2	0.0400	0.0218	0.177	N.S
Group 1-3	0.1000	0.0218	0.000	S
Group 2-3	0.0600	0.0218	0.027	S

Level of significance $P \leq 0.05$. SE: Standard error

3.5. Solubility test:

The results in table 7 represent descriptive statistics of the solubility test after 90 time immersion in the tested groups. The ratio of the experimental groups were lower than that of the group 1, the P value was significant (P<0.05) as shown also in the table 7.

Table 7: Descriptive statistics and one way ANOVA test of solubility test

Groups	N	Mean	Std.	F	P	Sig.
Group 1	10	0.067	0.00483	59.459	0.000	S
Group 2	10	0.048	0.00422			
Group 3	10	0.046	0.00516			

Level of significance $P \leq 0.05$. Std: Standard deviation

A multiple comparison test in table 8 showed a statistically significant difference group 1-2, group 1-3 ($P<0.05$), while group 2 had a non-significant difference from group 3 ($P>0.05$).

Table 8: Multiple comparison of solubility test

Groups	Mean difference (I-J)	S.E	P	Sig.
Group 1-2	0.01900	0.00213	0.003	S
Group 1-3	0.02100	0.00213	0.000	S
Group 2-3	0.00200	0.00213	0.620	N.S

Level of significance $P \leq 0.05$. SE: Standard error

4. Discussion

Cross contamination may be avoided with the help of denture washing, which also benefits the patient's health, the durability of their dentures, and their general quality of life. The key step for ensuring proper denture hygiene has been suggested as denture disinfection. There are a number of chemical and mechanical treatments that are recommended for cleaning and preserving the health of dentures. A cleaning technique should ideally be efficient without impairing the characteristics of the materials used to make denture bases. The physical and mechanical qualities of denture base material might be influenced by daily usage of denture cleaners. It is possible to clean the denture using a variety of chemical cleaners [3].

Water is the most common component of denture cleaners since it is used to prepare and dissolve them [25]. Water molecules may be rapidly absorbed by resin materials because of their nature and polarity, enabling the release of monomers and/or additives from the resin network as well as the ease with which the resin network may be accessed [26]. With time, this process worsens since water molecules serve as a plasticizer and change how the resins behave mechanically [25].

In this study, there is a statistically significant increase ($P<0.05$) in surface roughness in 90 time immersion. This might occur as consequence of the polymer being exposed to a solution, which causes hydrolytic breakdown as a result of the chemical reaction between the solution and the organic matrix in the gaps between the polymer chains; this may be in agreement with Kanno et al. who studied denture cleaning by hydrogen peroxide disinfectant [27]. The hardness of the acrylic resin showed a statistically non-significant difference ($P>0.05$) after long term immersion. So that, TTO was not cause major deterioration or softening in surface hardness of heat cure acrylic resin. This may be in agreement with Heidrich et al. who found no significant alteration in hardness test until 12 months immersion in 8% rosemary oil, 2% castor oil, an12% propolis glycolic extract liquid tested [28]. Also, Pereira et al. obtained the same result after immersion the heat cure acrylic for 150 and 300 hours in different denture cleansers [29] and AL-Dwairi et al. showed a statistically non-significant difference after immersion heat cure acrylic in fluconazole and nystatin [30].

Regarding the UV-absorption test, there was a statistically non-significant change ($P>0.05$) seen at 90 time immersion interval in TTO. The findings of the current investigation are consistent with previous research by Pisani et al. wherein they observed non-significant difference after immersion microwaves and heat cure acrylic

resin in ricinus communis for long period simulating three years [31]. Also, this result in agreement with Lohitha et al. who found the same result after immersion in polident, Fixodent scope plus, and stain away plus denture cleansers solution for 90 time [32].

Regarding the water sorption, after 90 time immersion, group 1 had a statistically insignificant difference(P>0.05) compared to group 2 and highly significant difference (P<0.05) compared to group 3 . Due to the presence of polar carbonyl groups, acrylic resins have an affinity for water molecules [33]. Consequently, water molecules permeate via the intermolecular gaps within the polymers, which are slightly spaced apart [34], and gradually penetrate the resin [33]. The most significant impact of water sorption is a change in dimension [34], which alters the previously calculated vertical dimension of occlusion. The shrinkage caused by the polymerization of heat-polymerized acrylic resin has, however, been reported to be partially compensated by water sorption. As a result, once saturation is reached, the prosthesis should fit more comfortably than it did when it was first made [35], while the solubility test, Groups 2 and 3 differed statistically significantly from group 1 (P<0.05). There is a suggestion that a potential association exists between residual monomer and the weight reduction observed in the solubility test since it is commonly observed that the highest quantity of residual monomer is released from acrylate within the initial days of water storage [36]. Additionally, water molecules can enter and exit acrylic resin more readily than chemical solution molecules can because they are simpler and smaller than the complex molecules found in denture-cleaning solutions. This might be responsible for the acrylic resin samples' low water sorption and solubility values, which were lower when immersed in chemical solutions than when immersed in distilled water [37].

This study's limitations include the use of in vitro rather than clinical testing, the evaluation of only one of the several denture base resins that are now available, and the narrow focus.

5. Conclusion

Heat-cured acrylic resin immersed for 90 times revealed that 0.75% TTO concentration improved the solubility of the resin and increase the surface roughness property while having no effect on surface hardness, UV absorption and water sorption property. In contrast, hardness and UV- absorption qualities were unaffected by 1% TTO concentration, while water sorption and solubility properties improved with increasing surface roughness.

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