The effect of prepared denture cleansers on some physical properties of stained acrylic resin denture base material cured by two different techniques

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ABSTRACT

Background: The debris in the denture cause many problem to the patient and the use of the denture cleanser is the solution for this problem but this denture cleanser may affect the properties of the denture. The aim of our study was to observe the effect of prepared denture cleansers on some physical properties (water sorption, water solubility and color stability) of the acrylic resin after their immersion in the tea solution and also to compare the effect of those denture cleansers on heat and microwave cure acrylic resin.

Materials and methods: Heat curing and Microwave acrylic denture was prepared and immersed in four types of denture Cleansers after their staining with tea then the water sorption, water solubility and color stability of acrylic resin was measured.

Results: There were no changes in the stained acrylic properties when the samples were immersed in the prepared denture cleansers and in the alkaline peroxide cleanser compared to that immersed in the distilled water. Furthermore no significant differences were observed between microwave and water bath cured specimens in respect to color stability, sorption and solubility of the testing groups.

Conclusions: The prepared denture cleanser solutions are good and satisfactory cleanser materials for the acrylic resin denture base cured by two different techniques.

Key words: Acrylic, denture cleanser, water sorption, water solubility.

INTRODUCTION

Acrylic plastic has been the most widely used and accepted among all denture base materials and it was estimated that they represent 95% of the plastics in prosthodontics (1,2).

The unclear denture may have undesirable effect on patient's health and ability to successful wear of the denture (3). If a patient's denture becomes unsanitary, the consequences may be bad breath, poor esthetic, denture stomatitis and angular cheilitis (4).

The efficient cleansing of the fitting surface of the denture is a key factor in the maintenance of healthy oral mucosa and important for the long term success of removable prosthodontics treatment (3,6).

Denture cleansers are a popular method used by denture wearers for cleaning (7). There are wide varieties of denture cleansers used to remove soft food and hard deposits of calculus and stains on denture base and teeth; the most common of them used immersion technique and marketed as powder, tablets or liquid. In spite of the large variety of these cleansers and their different mode of action each had its advantages and disadvantages.

Cleansers and cleaning methods used may have harmful effect on the plastic or metal component of the denture (8). Knowledge of constituents of denture cleansers, their efficiency, adverse effect and safety would aid in dispensing appropriate information to the patient (9), so the dentist must be able to recommend a denture cleanser that is effective, non deleterious to denture material and safe for patient use (10,11,3).

This study evaluated the effects of prepared denture cleanser solution (4% Oxalic acid, 4% tartaric acid and 4% citric acid) in addition to alkaline peroxide solution on the water sorption, water solubility and color stability of stained acrylic resin material that cured by two curing method.

MATERIALS AND METHODS

A disc of (50±1 mm in diameter and 0.5±0.1mm in thickens) were constructed from Heat cured acrylic resin (major base 2%;italy) and Microwave acrylic denture base resin (AcronTM MCGC 2AB) to measure water sorption, water solubility and color stability; the preparation of the acrylic samples was conducted according to the ADA specification.

Sample grouping

The specimen grouping was classified as follows:
Group 1: Specimens immersed in 4% citric acid denture cleanser solution.

Group 2: Specimens immersed in 4% tartaric acid denture cleanser solution.

Group 3: Specimens immersed in 4% oxalic acid denture cleanser solution.

Group 4: Specimens immersed in alkaline peroxide denture cleanser solution.

Group 5: Specimen immersed in distilled water (control group).

Preparation of the solutions
1. Tea solution: 4 grams of dry tea boiled in 500 ml of distilled water for 4 minutes, and allowed to cool at room temperature, and then the solution was decanted from tea leaves (12).

2. Alkaline peroxide solution: It's prepared according to the manufacturer’s instructions (1 tablet of alkaline peroxide added to 150 ml of warm distilled water (50°C)).

3. The experimental denture cleanser solutions: a fresh denture cleanser solutions was prepared by dissolving each of the oxalic acid, tartaric acid and citric acid in the isopropyl alcohol (the isopropyl alcohol was chosen as solvent to the acid powder due to its antiseptic effect) (13) as followed:

\[ 4 \text{ gm of acid powder} + 100 \text{ ml. alcohol} \rightarrow 4\% \text{ W/V of acid isopropyl denture cleanser solution} \]

Then, prior to the use each prepared denture cleanser solutions were diluted with an equivalent volume of distilled water as follow:-

\[ 25 \text{ ml. of } + 25 \text{ ml. of prepared } \rightarrow 100 \text{ ml. of distilled water. denture cleanser solutions. fresh diluted} \]

denture cleanser solutions.

Water sorption and water solubility test
The specimens' preparation and testing procedure were done according to the ADA specification No.12 for denture base resin (9).

The no. of the specimens used in this study were 50 specimens for the two curing methods (25 specimens from the water bath curing method and 25 from the microwave energy)) (5 samples for each group). The specimens were dried in a desiccator containing freshly dried silica gel. The desiccator was stored in an incubator at a 37°C ±2°C for 24 hours. After 24 hour, the specimens were removed to a similar desiccator at room temperature for one hour then weighed with a digital balance on a precision of 0.1mg. This cycle was repeated until a constant mass "conditioned mass" was reached (The weight loss at each disc was not more than 0.5mg in 24 hours period).

Then the discs of group (1,2,3,4) were immersed in fresh tea solution for 24 hours. Afterwards, they were immersed in the denture cleansing solution for another 24 hours, while the discs of group 5 were immersed in distilled water at 370°C ±20°C for 48 hours.

For all groups after which time the discs were removed from the solutions with tweezers wiped by a clean dry hand towel until free from moisture, waved in the air for 15 seconds and weighed one minute after removal from the solutions this mass was consider as mass after immersion.

After that to obtain the value of solubility test, the discs were reconditioned to a constant mass in the desiccator at 370°C ±20°C as done previously for sorption test and considered as the reconditioned mass.

The values for sorption were calculated for each disc from the following equation and the final value should be rounded to the nearest 0.1 mg/cm²:

\[ \text{Sorption (mg/cm²)} = \frac{\text{mass after immersion (mg)} - \text{condition mass (mg)}}{\text{Surface area (cm²)}} \]

The soluble matter lost during immersion was determined to the nearest 0.01 mg/cm² for each disk as follows:

\[ \text{Solubility (mg/cm²)} = \frac{\text{condition mass (mg)}}{\text{Surface area (cm²)}} - \text{reconditioned mass (mg)} \]

Color stability test:
The number of the specimens used in this study was 50 specimens for the two curing methods (25 specimens from the water bath curing method and 25 from the microwave energy)) (5 samples for each group). The color stability test was measured by two methods
a. Objective method (Spectroscopic study).

We used a spectrophotometer device to measure the light absorption of each specimen at two wavelengths at 400 λ and 500λ. For all groups the light absorption for each disc was measured before immersion of the discs in the solutions.

The discs of groups 1,2,3,4 were immersed first in the fresh tea solution then they were immersed in the denture cleansing solution while for the control group (group 5) the discs were immersed just in the distilled water. After the completion of immersion of the discs of all the groups the light absorption of the discs were measured as done before the immersion.
procedure by using a spectrophotometer at the same two wave length and the difference between the two readings were calculated.

The visual examination of staining removal was assessed by ten independent observers (dentist). Each observer read the samples after their removal from the solutions. The samples were evaluated visually for staining removal by comparing the tested samples with the control group by placing the specimens on a white background and they were graded for the amount of staining on a scale of (No, slight, mild, moderate, severe).

In the statistical analysis we used Descriptive statistics (Arithmetic mean, Standard deviation, Statistical tables) and Inferential statistics (t–test, one way analysis of variance test (ANOVA) and Multiple comparison tests utilizing the least significant differences (LSD)).

RESULTS

The mean and the standard deviation of sorption test for the experimental and the control groups that cured by the conventional water bath and microwave are listed in Table and Figure 1.

The sorption value for all the groups are nearly similar in both curing method they were all within the ADA specification limit. No.12 for denture base polymers (the uptake should not be more than 0.8mg/cm²).

One way analysis of variance test (ANOVA) demonstrated a no significant difference in the sorption between the 5 groups in both curing method (F = 0.117, P = 0.975 for water bath) and (F = 0.077, P = 0.988 for microwave) (P > 0.05).

The (t-test) show there is no significant difference between the microwave and water bath method for each group as shown in Table and Figure 1.

Similar methods of statistical analysis used for sorption test were applied to the results of solubility test. The mean and standard deviation of solubility for both curing method are presented in Table and Figure 2.

The solubility value for both curing methods was complied with the ADA specification limit (The loss in weight should not be more than 0.04 mg/cm2).

The ANOVA test of solubility demonstrated no significant difference between the investigating material (F = 0.229, P = 0.102, for water bath) and (F = 0.177, P = 0.948, for microwave). The results of the (t-test) show that there is no significant difference found between the microwave and water bath curing method for all tested groups as shown in Table and Figure 2.

For the color stability test the mean and standard deviation of the amount of absorption difference before and after immersion in the denture cleanser solution as well as in distilled water are presented in Table and Figure 3.

The ANOVA test revealed a highly significant difference between groups that cured by the microwave curing method for both wavelength 400 nm (F = 9.572, P = 0.000) and at 500nm (F = 21.739, p = 0.00) while for the samples that cured by the water bath method there is no significant difference between the groups at 500nm (F = 2.803, P = 0.054) but at 400nm there is a significant difference between the groups (F = 3.352, P = 0.030). Table 4 represent the results of the LSD test of the color stability.

There is no significant difference for all groups at the two wave length when compared between the two curing methods except the tartaric acid which showed a highly significant difference (P<0.01) at 400nm and a significant difference (P<0.05) at (500nm) by applying t–test (Table 4, and Figure 3).

The result of visual examination of staining removal of all groups for both curing methods show no difference in the color when compared with the control group as shown in Table 5.

Figure 1: Histogram of sorption test
Table 1: Descriptive statistics and t-test of sorption test (mg/cm²)

<table>
<thead>
<tr>
<th>Materials</th>
<th>Water bath</th>
<th>Microwave</th>
<th>P – value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Citric acid</td>
<td>0.8</td>
<td>0.069</td>
<td>0.8</td>
<td>0.068</td>
</tr>
<tr>
<td>Tartaric acid</td>
<td>0.8</td>
<td>0.053</td>
<td>0.8</td>
<td>0.063</td>
</tr>
<tr>
<td>Oxalic acid</td>
<td>0.8</td>
<td>0.086</td>
<td>0.8</td>
<td>0.075</td>
</tr>
<tr>
<td>Alkaline peroxide</td>
<td>0.8</td>
<td>0.029</td>
<td>0.8</td>
<td>0.041</td>
</tr>
<tr>
<td>Distilled water</td>
<td>0.8</td>
<td>0.010</td>
<td>0.8</td>
<td>0.031</td>
</tr>
</tbody>
</table>

Table 2: Descriptive statistics and t-test of solubility test (mg/cm²)

<table>
<thead>
<tr>
<th>Materials</th>
<th>Water bath</th>
<th>Microwave</th>
<th>P – value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Citric acid</td>
<td>0.004</td>
<td>0.004</td>
<td>0.046</td>
<td>0.04</td>
</tr>
<tr>
<td>Tartaric acid</td>
<td>0.005</td>
<td>0.002</td>
<td>0.044</td>
<td>0.01</td>
</tr>
<tr>
<td>Oxalic acid</td>
<td>0.006</td>
<td>0.006</td>
<td>0.044</td>
<td>0.02</td>
</tr>
<tr>
<td>Alkaline peroxide</td>
<td>0.013</td>
<td>0.006</td>
<td>0.024</td>
<td>0.01</td>
</tr>
<tr>
<td>Distilled water</td>
<td>0.010</td>
<td>0.005</td>
<td>0.044</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Figure 2: Histogram of solubility test

Figure 3: Histogram of color stability test

Table 3: Descriptive statistics and t-test of color stability test (nm)

<table>
<thead>
<tr>
<th>Materials</th>
<th>400 nm</th>
<th>500 nm</th>
<th>P – value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Citric acid</td>
<td>- 0.262</td>
<td>0.32</td>
<td>- 0.486</td>
<td>0.24</td>
</tr>
<tr>
<td>Tartaric acid</td>
<td>- 0.191</td>
<td>0.13</td>
<td>- 0.420</td>
<td>0.12</td>
</tr>
<tr>
<td>Oxalic acid</td>
<td>- 0.113</td>
<td>0.16</td>
<td>- 0.332</td>
<td>0.10</td>
</tr>
<tr>
<td>Alkaline peroxide</td>
<td>0.178</td>
<td>0.29</td>
<td>0.024</td>
<td>0.15</td>
</tr>
<tr>
<td>Distilled water</td>
<td>0.081</td>
<td>0.14</td>
<td>0.065</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Table 4: Multiple comparison test (LSD) of color stability test (Spectroscopic studies)

<table>
<thead>
<tr>
<th>Materials</th>
<th>400 nm</th>
<th>500 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water bath</td>
<td>Microwave</td>
</tr>
<tr>
<td></td>
<td>Mean D.F.</td>
<td>P- value</td>
</tr>
<tr>
<td>Distilled Water + citric acid</td>
<td>0.344</td>
<td>0.02</td>
</tr>
<tr>
<td>Distilled Water + tartaric acid</td>
<td>0.273</td>
<td>0.07</td>
</tr>
<tr>
<td>Distilled Water + oxalic acid</td>
<td>0.195</td>
<td>0.18</td>
</tr>
<tr>
<td>Distilled Water + alkaline peroxide</td>
<td>-0.096</td>
<td>0.50</td>
</tr>
<tr>
<td>Citric acid + Tartaric acid</td>
<td>-0.071</td>
<td>0.62</td>
</tr>
<tr>
<td>Citric acid + oxalic acid</td>
<td>-0.148</td>
<td>0.31</td>
</tr>
<tr>
<td>Citric acid + alkaline peroxide</td>
<td>-0.441</td>
<td>0.00</td>
</tr>
<tr>
<td>tartaric acid + oxalic acid</td>
<td>-0.077</td>
<td>0.59</td>
</tr>
<tr>
<td>tartaric acid + alkaline peroxide</td>
<td>-0.369</td>
<td>0.01</td>
</tr>
<tr>
<td>Oxalic acid + alkaline peroxide</td>
<td>-0.292</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Table 5: Visual examination of acrylic resin specimens

<table>
<thead>
<tr>
<th>Degree of staining</th>
<th>Materials</th>
<th>Water bath</th>
<th>Microwave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citric acid</td>
<td>0.42 (NO)</td>
<td>0.38 (NO)</td>
<td></td>
</tr>
<tr>
<td>tartaric acid</td>
<td>0.40 (NO)</td>
<td>0.08 (NO)</td>
<td></td>
</tr>
<tr>
<td>Oxalic acid</td>
<td>0.24 (NO)</td>
<td>0.14 (NO)</td>
<td></td>
</tr>
<tr>
<td>alkaline peroxide</td>
<td>0.30 (NO)</td>
<td>0.12 (NO)</td>
<td></td>
</tr>
</tbody>
</table>

Scale of staining {NO→ Slight → Mild → Moderate → Severe}
NO=0; Slight=1; Mild=2; Moderate=3; Severe=4

Figure 3: Histogram of color stability (Spectroscopic studies)
DISCUSSION

Sorption of the material represents the amount of water absorption on the surface and into the body of the material, the sorption of poly methyl methacrylate (PMMA) is facilitated by its polarity and the mechanism primary responsible for ingress of water is diffusion \(^{(14)}\); whereas solubility represents the mass of the soluble materials from polymer. The only soluble materials present in the denture base resins are initiator, plasticizers and free monomer \(^{(1,15,16)}\). The rate at which the materials absorbed water or lost soluble components varied considerably with the type of material, the amount of the plasticizer or filler content and the solution in which they were immersed \(^{(17)}\).

In the present study the sorption and solubility were measured according to ADA specification no.12 \(^{(9)}\). The result of immersion of acrylic resin in the denture cleanser as well as in the distilled water complied with ADA requirement; the results of sorption and solubility tests showed that there was no statistically difference between the two curing methods (water bath and microwave energy). Similar conclusion was reported by others authors \(^{(18-21)}\) while Al Doori and al Haydary disagreed with them where they found that the microwave group samples showed a lower sorption than the water bath group samples \(^{(22,23)}\).

The water molecules has affinity more than that of the chemical solution molecules to enter and get out from the acrylic resin (the water molecules has simple and small structure compared to the complex structure of the denture cleanser solutions), this might be the cause of the low solubility value of the water bath acrylic resin samples was lower when immersed in chemical solutions than when immersed in distilled water.

A change in appearance indicates reduction of the long term quality of a denture \(^{(24)}\), several denture base resins have been introduced that provide easier and faster processing, although these materials have adequate mechanical properties the color stability also of interest.

For both curing methods there was no color change observed visually after immersion of the acrylic samples in the denture cleanser solutions and in the distilled water this may be due to that human eyes are not sensitive like the apparatus used in our study.

The result of the spectrophotometer study showed that for all tested groups except the samples that immersed in tartaric acid there was no significant difference among the tested groups between the two curing methods this result agree with those done by an earlier studies \(^{(18,25-27)}\) who found that acrylic resin whether cured by microwave or by water bath methods showed adequate color stability when acrylic resin processed according to the manufacturers instructions, while May et al. found that there was a significant color difference between the two curing method \(^{(28)}\).

The tartaric acid had greater effect on the color of the acrylic resin this might be due to that the tartaric acid have 4 active groups in their structure that are available to molecular interacted with the acrylic polymer by formation of hydrogen bonds while the citric acid have 3 active groups ; the oxalic acid have 2 active groups and water molecules have only one active group in their structure; this could be used to explain the reason of that the microwave and water bath acrylic resin when immersed in the prepared cleanser solutions have significant color differences compared with that immersed in the distilled water (Figure 4).
The statistical analysis for both curing methods show a significant difference among the tested groups regarding the color stability test; the presence of the residual monomer could be one of the possible reasons that may be used to explain the color changes \((25, 28, 29)\), while Gross and Moser showed that the surface porosity resulting from a dissolution of slight soluble component of the material which cause the color changes \((30)\). On the other hand other authors saw that the high immersed temperature may be sufficient to cause decomposition of the resin leading to discoloration; or the oxidation of the un reacted \(\text{c} = \text{c}\) double bonds produced colored peroxide product \((30-33)\).

Although the spectrophotometer study showed a statically significant difference among the tested groups for both curing methods but the color difference was often clinically insignificant because many reporters demonstrated that when the value of color difference was less than \((1)\) it mean that the color difference was clinically insignificant \((34-37)\).

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