Evaluating the Effect of Four Chemical Disinfectants on Surface Roughness of Acrylic Resin Denture Base Material (in vitro evaluation)

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ABSTRACT

Background and Aim: Using disinfectants for cleansing dentures is inevitable. Despite their favorable effect on reducing microorganisms, these chemical materials can cause undesirable effects on the surface of dentures. The aim of this study is to determine the effect of chemical disinfectant solutions on surface roughness of denture base materials.

Materials and Methods: In this experimental in-vitro study, 50 acrylic resin specimens were fabricated from 2 different brands of Meliodent and Acropars. Samples were placed in 4 groups of solutions (sodium hypochlorite 0.5%, vinegar 2.5%, sodium bicarbonate 5%, corega tabs) control group was placed in normal tap water. Samples were evaluated for the initial and secondary surface roughness. 1 specimen from each group was coated in PVD procedure and was assessed with SEM. Data were analyzed using ANOVA and Post-hoc tests and multiple comparisons.

Results: The initial measurements revealed no significant difference between two acrylic materials regarding the studied features (P<0.4). The highest surface roughness in Meliodent group was observed in 0.5% sodium hypochlorite, which was significantly higher than other solutions (P<0.05). In Acropars group, the highest surface roughness was caused by 2.5% vinegar, which was significantly higher than other solutions (P<0.05). Corega tabs presented the least amount of surface roughness on both acrylic resin specimens (P<0.01).

Conclusion: Results showed that the effect of disinfectant solutions on surface roughness of Meliodent acrylic is higher than Acropars; and the least destructive effect was for Corega tabs. Usage of chlorinated solutions for disinfecting Meliodent acrylic and acidic solutions for Acropars is not recommended.

Key words: Acrylic resin; Meliodent; Acropars TR; Surface roughness; SEM, Disinfectants

INTRODUCTION

Among the concerns about removable prostheses made of acrylic resin are the mechanical and physical changes in acrylic resin denture base. On the other side, health care and disinfecting is essential and inevitable in any stage of dental procedure. Based on ADA’s infection control protocol, it is suggested that dental prosthesis be disinfected prior to transferring to laboratory and also before being handed to the patient. The enrolled studies show that these solutions have a noticeable role in elimination of microorganisms and microbial plaques; however, they cause physical and mechanical changes in acrylic resins including discoloration, change in flexural strength and surface roughness. Increased surface roughness gradually raise the adhesion of microbes and food particles to the surface of the acrylic, which would lead to irritation and inflammation of the...
oral mucosa. One of the causes of surface roughness is chemical disinfectant solutions. Several researches have been performed focusing on the effect of chemical disinfectants on the surface properties of acrylic resins, in which microwave-polymerized acrylic and heat-polymerized acrylic etc. were used, and the results of some studies revealed the destructive effect of microwave to be lower. In some cases, the chemical disinfectant solutions were detected to have destructive effect lower than microwave; generally they both increase the surface roughness. On the other side, chemical solutions such as chlorhexidine, peracetic acid and sodium hypochlorite, as well as alkaline peroxide tabs, all increased the surface roughness of acrylic resins. But a different study reported the disinfectant solutions including sodium hypochlorite and Corega tabs to have no destructive effect on the acrylic surface by not increasing surface roughness. With respect to the controversies present in various studies and the prevalence of using chemical compounds by patients for cleansing dentures, the current study was enrolled to evaluate 4 types of chemical solutions including 0.5% sodium hypochlorite, 5% vinegar, 2.5% sodium bicarbonate, and Corega tabs for disinfecting acrylic samples, beside tap water (as control group) on one Iranian and one German thermosetting acrylic resin.

### Materials and Methods:

In this in-vitro study, the surface roughness of two thermosetting acrylic resins was assessed based on Ra (mean surface Roughness) and Rz (surface roughness depth), after one month of immersion in disinfectant solutions. The acrylics used in this study were German Meliodent and Acropars acrylics which are widely used in Europe and in Iran respectively. In order to prepare fully smooth samples with no need for polishing, 50 samples were made of the two acrylics through accurate flasking using a glass slab. After flasking, wax elimination (Densplay GmbH, Modeling wax, England) and rinsing the flasks, acrylic was invested. After applying the acrylic and packing the flasks followed by final packing, the flask was placed in curing device (Kavo EWL 556, Germany) and was polymerized with a relatively slow method in 70 °C for 9 hours. Samples were immersed in distilled water at 37±1°C for 50±2 minutes so that the free monomers would be released. samples were cut into 6 equal pieces of 20×20mm using cutting machine or a disk, while the cutting area was being cooled with the aid of air or water (to keep the temperature <30°C throughout the cutting procedure). They were then polished by metallographic sandpaper with approximate roughness of 30micron (500P), 18micron (1000P), and 15micron (1200P). Samples were all prepared at room temperature (23±2°C) and in relative humidity (50±10). A total of 25 samples were made of Acropars acrylic resin (A) and 25 were made of Meliodent (B).

First, 5 samples of each acrylic type were assessed for surface roughness (prior to being immersed in disinfectant solutions). Then they were placed among other samples (the remaining 40 samples) and each of these 25 samples were allocated to one of the 5 groups of E, F, G, H, I. For encoding, each single sample was given a number, and they were randomly delivered to an operator. Group AE and BE were stored in 2.5% vinegar, AF and BF in 0.5% sodium hypochlorite, AG and BG in 5% sodium bicarbonate, and AH and BH in a solution of disinfectant Corega tabs, AI and BI in normal tap water (as control group). The volume of disinfectant agent was 100cc for all samples. Each sample was immersed in the related disinfectant solution for 8 hours at the room temperature. Next they were removed out of the solution and were rinsed. At that time, the samples were stored in distilled water for 16 hours. The solutions were replaced daily and this procedure was repeated for 1month. The surface roughness of samples was measured and evaluated using Profilimeter (Pocket-sized, MAHR). ANOVA and Post-hoc tests were used to analyze data. In the next stage, one sample was taken from
each group and was dried. Using a gold coating machine, these samples were gold-coated with a thickness of 10nm through PVD (Physical Vaporization Deposition). They were then photographed at various sections in 500×, 1000×, 2000× and 5000× magnifications. At least two pictures were taken of the samples in each magnification.

Results:
Prior to immersion in disinfectant solutions, 5 samples of the two acrylic types (Meliodent and Acropars) were assessed for surface roughness divided based on the acrylic type. The results are presented in table 1. According to the figures mentioned in this table, the surface roughness of Acropars and Meliodent were the same in Rz and Ra parameters and their difference was not statistically significant.

Table 1: Initial surface roughness of the samples in Ra and Rz (n=5)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Rz (mean±SD)</th>
<th>Ra (mean±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meliodent</td>
<td>0.1±0.05</td>
<td>0.92±0.3</td>
</tr>
<tr>
<td>Acropars</td>
<td>0.07±0.05</td>
<td>0.06±0.08</td>
</tr>
</tbody>
</table>

Table 2: Surface roughness of Meliodent acrylic resin based on the chemical disinfectant material (n=5)

<table>
<thead>
<tr>
<th>Surface roughness</th>
<th>Rz (μm)</th>
<th>Ra (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal water (control)</td>
<td>0.13±0.038</td>
<td>1.13±0.13</td>
</tr>
<tr>
<td>Sodium hypochlorite</td>
<td>0.30±0.086</td>
<td>1.92±0.0376</td>
</tr>
<tr>
<td>Vinegar</td>
<td>0.26±0.056</td>
<td>1.88±0.44</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>0.19±0.024</td>
<td>1.32±0.22</td>
</tr>
<tr>
<td>Corega tabs</td>
<td>0.19±0.033</td>
<td>1.3±0.5</td>
</tr>
</tbody>
</table>

The value of surface roughness of Acropars acrylic resin based on the surface roughness features (Rz and Ra) showed that the most surface roughness of this acrylic was detected in vinegar (0.342±0.06), followed by sodium bicarbonate (0.156±0.0814) and sodium hypochlorite (0.15±0.035). Also the least surface roughness was found in the samples immersed in Corega (0.058±0.078) and normal water (0.057±0.0273). According to the multiple comparisons test, significant difference was found between vinegar and all other samples; although there was no difference between sodium hypochlorite and sodium bicarbonate. Also normal water and Corega were similar. In the figures obtained from Rz, the highest surface roughness value was again seen in vinegar (2.7±0.122) and to a much lower extent in sodium bicarbonate (1.62±0.63), respectively. The least amount was found in the samples immersed in Corega tabs (1.3±0.5).
The post-hoc (LCD) analysis proved that differences exist between vinegar and other solutions; while no difference was found between sodium hypochlorite and sodium bicarbonate; nor did between Corega tabs and water.

With respect to the investigations performed by SEM, the corrosive environments like sodium hypochlorite (figure B Meliodent) and vinegar (figure A Meliodent and C Acropars) can cause Uncoordinated, uneven and asymmetric indentations on the acrylic surface, which had not been observed in other cases. SEM detected no influence on surface porosity of control group (figure D Acropars), the figures indicating constitution of no new layer on the water surface. On the other side, the least influence on the surface porosity was observed in Corega, which was supported by the measurements performed by Profilometer.

**Discussion:**
This study assessed the effects of four types of disinfectant materials (0.5% sodium hypochlorite, 2.5% vinegar, 5% sodium bicarbonate, and Corega tabs) on the surface roughness of thermosetting acrylic resins. The cumulative effect of disinfectant materials can negatively influence the surface and the mechanical properties of acrylic over time. Hence, with respect to the mean duration of former studies, the current study was designed to be carried out within 30 days. The results of this study revealed that using these four chemical solutions for disinfecting the acrylic resins denture base (Meliodent and Acropars) would increase the surface roughness. According to the current study, hypochlorite created significant difference in Meliodent acrylic, indicating the highest surface roughness among all groups. In other words, corrosiveness of this solution on the physical structure of Meliodent acrylic has been higher than other solutions.

Ebadian studied the effects of sodium hypochlorite and glutaraldehyde on Acropars and Meliodent acrylics, showing that hypochlorite sodium caused more changes than glutaraldehyde. This finding is in line with the study by Pinto that evaluated the effects of 3 types of disinfectants on surface roughness and surface hardness of 3 acrylics. All these studies were in agreement with the current one that assessed the destructive effects of sodium hypochlorite on acrylic. The results of another study reported the solutions of sodium hypochlorite and Corega tabs to have no considerable influence on the surface roughness of acrylic over 180 days, which did not conform to the present study. In mentioned study microwave-polymerized acrylic was used that is a more novel method; but still can affect other physical properties of the acrylic. Aside from oldness, thermosetting acrylics are more common and have less negative effects. This difference can be due to the type of acrylic and polymerization.

The results of another study which claimed no alteration in surface roughness of acrylics by solutions was also against the current study. Mentioned study was done over one week and reliable results are not expected in such a short span. The least destructive effect was observed
in water (control group) among all solutions; and the least negative effect was detected in Corega tabs. In the study by Pinto et al., no significant difference was detected between the initial surface roughness and the measured value after immersion in solutions, while one of the solutions was Corega tabs; that study supports the current one.

In a study performed by Peracini et al., the surface roughness caused by Corega was similar to that created by water, with a considerably slight difference with the other material (bony plus); this confirms the above mentioned conclusion. Another study reported that the surface roughness created by Corega over 250 minutes was more than Close Up toothpaste and denture care material; which contradicts the conclusion of the present study. The difference can be due to the different type of acrylics used and the measurement devices; the brush was also a variable which was not considered in the current study. The device that was used in mentioned study was Surface SJ-201P, but the one used in present study was EZ Pocket Surface Analyzer. Regarding the duration, the current study is more reliable; while the other study considered the toothbrush used by a group of patients as the intervener, and this makes the mentioned study superior in this regard. Vinegar has severe destructive effect on Acropars acrylics and creates large and deep indentations, and it was the only acidic agent used in this study. The effective material in vinegar is acetic acid.

A study was carried out by Fernandez et al. and evaluated the effects of two disinfectants on 2 types of acrylic in terms of color stability and surface roughness. Compared to sodium hypochlorite, more surface roughness was observed in the majority of samples immersed in acetic acid in 60 minutes, which invigorates the above mentioned result. Based on the study by Da Silva et al., among the solutions of 3.8% sodium perborate, 2% chlorhexidine gluconate, 100% vinegar and disinfectant tabs, the highest surface roughness was caused by sodium perborate; this contradicts the above mentioned result.

The difference can be attributed to the inconsistency of the solutions concentration. The surface roughness caused in Meliodent acrylic by Corega and sodium bicarbonate is similar and is the least value among other solutions. The chemical structure of these two substances is similar, Corega contains sodium bicarbonate and they are both subgroups of peroxides which remove the debris via releasing oxygen. Like chlorinated groups, this group causes dissolving and removing large molecules and plasticizers; thus, they have very little impact in terms of creating roughness on the acrylic surface.

Similar results were reported by Ural et al. between the groups containing sodium bicarbonate, i.e. the lowest surface roughness was observed in these groups and it approves the above mentioned conclusion. In another study about the effects of a number of disinfectants and toothpastes on the amount of wear and surface roughness, the conclusion was drawn that there exists a significant difference between the amount of surface roughness created by Corega tabs and Colgate and Sorriso toothpastes, the major ingredient of which is sodium bicarbonate.

This difference can be justified by the countless ingredients in toothpastes, in addition to the method adopted. Using a substance in pure form demonstrates its impacts more precisely; sodium bicarbonate was used in pure form in the current study. Furthermore, in that study toothbrush was considered, believing that some patients use it to clean their denture while some others only immerse it in solution. Generally, this study showed the initial surface roughness and the indentation depth of Acropars acrylic to be less than Meliodent; approving Acropars to have better surface features. In the secondary measurements (after being immersed in the disinfecting solutions and water), the smaller numbers in terms of Ra were related to Acropars acrylic (except for vinegar). But in terms of Rz in vinegar and sodium bicarbonate solutions, the numbers achieved from Acropars were greater than Meliodent; indicating deeper indentations of Acropars in these two solutions;
but the indentations created in the other two solutions (sodium hypochlorite and Corega) were less deep. The results of this study demonstrated the impacts of disinfectant solutions on surface roughness to be higher on Acropars acrylic than Meliodent and that the lowest destructive effect was created by Corega tabs among other solutions. Regarding the composition of this disinfectant, it can be concluded that if used improperly, the alkaline peroxide solutions can cause alterations in the properties of acrylic.\textsuperscript{23} This solution was also found to have the lowest destructive effects in this study.

**Conclusion:**
The final conclusion can be that chlorinated compounds are not recommended for disinfecting Meliodent acrylics and acidic solutions are not recommended for disinfecting Acropars acrylics.

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