Effect of Different Disinfecting Agents on Surface Roughness and Color Stability of Heat-cure Acrylic Denture Material: An In Vitro Study

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ABSTRACT

Aim: The current study aimed to determine the impact of three different disinfectants on the surface roughness and color stability of heat-cure acrylic denture material.

Materials and methods: Using a stainless-steel mold, disc-shaped wax patterns with dimensions of 10 mm in diameter and 2 mm thick (in accordance with ADA Specification No. 12) were created and prepared for a total of 75 acrylic samples. Dimensions of all 75 acrylic samples were checked with a digital Vernier caliper. About 25 samples of denture base material were immersed in three different chemical disinfectants: Group I: immersed in chlorhexidine gluconate solution, group II: immersed in sodium hypochlorite solution, and group III: immersed in glutaraldehyde solution. All samples were scrubbed daily for 1 minute with the appropriate disinfectant and submerged for 10 minutes in the same disinfectant. Between disinfection cycles, samples were kept in distilled water at 37°C. Color stability was measured using a reflection spectrophotometer. Surface roughness values were measured by a profilometer at baseline following 15 days and 30 days.

Results: After 15 days, the color stability was better in chlorhexidine gluconate solution group (4.88 ± 0.24) than sodium hypochlorite solution (4.74 ± 0.18) and glutaraldehyde solution group (4.46 ± 0.16). The mean surface roughness was less in glutaraldehyde solution group (2.10 ± 0.19), followed by chlorhexidine gluconate solution group (2.48 ± 0.09) and sodium hypochlorite solution group (2.64 ± 0.03). After 30 days, the color stability was significantly better in chlorhexidine gluconate solution group (4.40 ± 0.02), followed by sodium hypochlorite solution (4.06 ± 0.16) and glutaraldehyde solution group (3.87 ± 0.17). The mean surface roughness was significantly lesser in glutaraldehyde solution group (2.41 ± 0.14), followed by chlorhexidine gluconate solution group (2.94 ± 0.08) and sodium hypochlorite solution group (3.02 ± 0.13).

Conclusion: In conclusion, the color stability was significantly better in chlorhexidine gluconate solution group than sodium hypochlorite solution and glutaraldehyde solution group. But the surface roughness was significantly lesser in the glutaraldehyde solution group, followed by the chlorhexidine gluconate and sodium hypochlorite solution group.

Clinical significance: The maintenance of the prosthesis requires the use of a denture disinfectant; therefore, it is crucial to select one that is effective but would not have a negative impact on the denture base resin's inherent characteristics over time.

Keywords: Color stability, Disinfecting agents, Heat-cure acrylic material, Surface roughness.

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INTRODUCTION

An oral rehabilitation procedure’s major goals are to preserve the remaining oral tissue, maintain oral health, and enable patients to wear prostheses comfortably. Complete dentures should not be worn for an extended period of time since this may harm the supporting tissue, causing pathologic changes, bone loss, and persistent pain.1

The fundamental concern in preventing dental and general health issues for people is maintaining the hygiene of acrylic dentures. The lifetime of partial removable dentures and the preservation of oral mucosal health depend on regular denture cleaning. Denture stomatitis, angular cheilitis, and poor oral health can all be brought on by bacterial and fungal colonization on dentures. Halitosis and denture stomatitis have been linked to health issues for people is maintaining the hygiene of acrylic denture material.

Denture bases are most frequently made of heat-cured acrylic resin because it has a number of benefits, including good color stability, low residual monomer, minor porosity, as well as processing, manufacturing, and easy repair.2 At various stages of trial and insertion, when prostheses are removed from patients’ mouth, denture bases are subjected to biofilm.3

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mouths, pathogenic organisms that can spread through direct contact with the aerosol created during trimming, finishing, and polishing procedures may be present. Prosthetics must be cleaned regularly, which has prompted a large search for disinfectants that are safe for the prosthesis surface. Chlorine, iodophors, and aldehyde compounds are only a few of the chemical agents employed in the actual disinfection of prosthetics. Chlorhexidine is a broad-spectrum antiseptic that destroys bacteria and fungus like Candida albicans. A sodium hypochlorite solution is an efficient method for removing adhering microorganisms. Glutaraldehyde is an organic chemical with nonpolar molecules. This disinfectant’s action is better appropriate against Mycobacterium species.

The acrylic resin surfaces’ surface roughness is crucial since the attachment of microorganisms to a surface is a requirement for that surface’s colonization. The simplicity of finishing off material, as well as its resistance to in-service scratching during cleaning processes, are both influenced by the hardness of the denture base resin. The dental materials’ color may have changed as a result of deterioration or use. Denture base resins’ color stability might reveal crucial details about how well the materials will hold up over time, and very limited evidence regarding these disinfectants is available. Therefore, this study was carried out to evaluate the impact of three different disinfection agents on the surface roughness and color stability of heat-cure acrylic denture material.

**Materials and Methods**

**Samples Preparation**

The present in vitro study was conducted in the Department of Prosthodontics, Sri Rajiv Gandhi College of Dental Science and Hospital, during the year of 2019. A total of 75 acrylic samples were prepared. According to ADA Specification No. 12, disc-shaped wax patterns (10 mm in diameter and 2-mm-thick dimension) were created using a stainless-steel mold and then invested in type-III gypsum material (Dental Stone- Gypstone, Prevest DenPro Ltd., Jammu, India) in a metallic flask. Dewaxing was done once the stone was set, and then separating medium (Cold Mould Seal, Jammu, India) in a metallic flask. Dewaxing was done once the stone was set, and then separating medium (Cold Mould Seal, Dental Products of India, Mumbai, India) was applied. Molds were prepared as directed by the manufacturer using heat-polymerized acrylic resin (DPI Heat Cure, Dental Products of India, India). A lengthy polymerization cure cycle was carried out (73°C for 90 minutes, followed by 94°C for 30 minutes). The samples were taken out of the molds, trimmed using a tungsten steel bur mounted in a handpiece at low speed, finished with 120-, 220-, and 320-grit sandpaper, and then polished with a damp cloth and pumice slurry. All samples’ dimensions were measured using a digital Vernier caliper, and those not accurate were replaced with new samples. For the purpose of removing any remaining monomer, all samples prepared in this manner were submerged in distilled water for 24 hours at 37°C. Baseline readings were taken prior to the immersion of denture base resins in different disinfectants.

**Immersion of Denture Base Resins in Disinfectants**

About 25 samples of denture base material were exposed to three different chemical disinfectants:

Group I: Immersed in chlorhexidine gluconate solution: Samples were daily scrubbed with 0.5% chlorhexidine gluconate (CURASEPT) for 1 minute and then submerged in the same disinfectant for 10 minutes.

Group II: Immersed in sodium hypochlorite solution: Samples were daily scrubbed with 1% sodium hypochlorite solution (3D Fine-Chem Ltd.) for 1 minute and then submerged in the same disinfectant for 10 minutes.

Group III: Immersed in glutaraldehyde solution: Samples were daily scrubbed with 2% alkaline glutaraldehyde (Cidex, Jalagaon Chemical Pvt. Ltd.) for 1 minute and then submerged in the same disinfectant for 10 minutes.

Following the respective disinfectant agents, the samples were stored in distilled water at 37°C in-between disinfection cycles.

**Measurement of Color Stability of Denture Base Material**

At baseline, 15 days, and 30 days later, color stability was evaluated. Each sample underwent water cleaning and tissue paper drying after being submerged for the designated amount of time. Using a white background on reflection spectrophotometer, color was computed according to the CIE L*a*b* color scale. According to this theory, the three main colors of red, blue, and green are mixed in certain proportions to create all the colors found in nature. This approach has served as the cornerstone for the CIE Lab system.

**Table 1**

<table>
<thead>
<tr>
<th>Material</th>
<th>ΔL<em>a</em>b* (15 days)</th>
<th>ΔL<em>a</em>b* (30 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorhexidine</td>
<td>1.86 ± 0.10</td>
<td>1.72 ± 0.32</td>
</tr>
<tr>
<td>Sodium Hypochlorite</td>
<td>5.92 ± 0.13</td>
<td>5.61 ± 0.10</td>
</tr>
<tr>
<td>Glutaraldehyde</td>
<td>6.02 ± 0.11</td>
<td>1.78 ± 0.09</td>
</tr>
</tbody>
</table>

**Statistical Analysis**

Statistical analysis software (20.0 version) was used to examine the data that had been gathered. On color stability and surface roughness (m) data, a one-way analysis of variance (ANOVA) was performed, and then the Tukey (LSD) test for post hoc comparisons (α = 0.05) was used.

**Results**

Table 1 shows the baseline values of color stability and surface roughness of heat-cure acrylic denture base material before immersion in three different disinfectants agents. The mean color stability and surface roughness of denture base material after immersion in chlorhexidine gluconate solution was 5.98 ± 0.07 and 1.72 ± 0.32, sodium hypochlorite solution was 5.92 ± 0.13 and 1.86 ± 0.10, and glutaraldehyde solution was 6.02 ± 0.11 and 1.78 ± 0.09, respectively.

Table 2 reveals the evaluation of color stability and surface roughness of heat-cure acrylic denture base material after immersion in three different disinfectant agents after 15 days. The color
Effect of Disinfecting Agents on Heat-cure Acrylic Material

**Table 1:** Evaluation of baseline values of color stability and surface roughness of heat-cure acrylic denture base material before immersion in three different disinfectants agents

<table>
<thead>
<tr>
<th>Disinfectant agents</th>
<th>Color stability Mean ± SD</th>
<th>Surface roughness Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I: Chlorhexidine gluconate solution</td>
<td>5.98 ± 0.07</td>
<td>1.72 ± 0.32</td>
</tr>
<tr>
<td>Group II: Sodium hypochlorite solution</td>
<td>5.92 ± 0.13</td>
<td>1.86 ± 0.10</td>
</tr>
<tr>
<td>Group III: Glutaraldehyde solution</td>
<td>6.02 ± 0.11</td>
<td>1.78 ± 0.09</td>
</tr>
<tr>
<td>F-value</td>
<td>11.865</td>
<td>8.104</td>
</tr>
<tr>
<td>p-value</td>
<td>0.951</td>
<td>0.860</td>
</tr>
</tbody>
</table>

**Table 2:** Evaluation of color stability and surface roughness of heat-cure acrylic denture base material after immersion in three different disinfectant agents after 15 days

<table>
<thead>
<tr>
<th>Disinfectant agents</th>
<th>Color stability Mean ± SD</th>
<th>Surface roughness Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I: Chlorhexidine gluconate solution</td>
<td>4.88 ± 0.24</td>
<td>2.48 ± 0.09</td>
</tr>
<tr>
<td>Group II: Sodium hypochlorite solution</td>
<td>4.74 ± 0.18</td>
<td>2.64 ± 0.03</td>
</tr>
<tr>
<td>Group III: Glutaraldehyde solution</td>
<td>4.46 ± 0.16</td>
<td>2.10 ± 0.19</td>
</tr>
<tr>
<td>F-value</td>
<td>13.517</td>
<td>10.381</td>
</tr>
<tr>
<td>p-value</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

**Table 3:** Evaluation of color stability and surface roughness of heat-cure acrylic denture base material after immersion in three different disinfectant agents after 30 days

<table>
<thead>
<tr>
<th>Disinfectant agents</th>
<th>Color stability Mean ± SD</th>
<th>Surface roughness Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I: Chlorhexidine gluconate solution</td>
<td>4.40 ± 0.02</td>
<td>2.94 ± 0.08</td>
</tr>
<tr>
<td>Group II: Sodium hypochlorite solution</td>
<td>4.06 ± 0.16</td>
<td>3.02 ± 0.13</td>
</tr>
<tr>
<td>Group III: Glutaraldehyde solution</td>
<td>3.87 ± 0.17</td>
<td>2.48 ± 0.09</td>
</tr>
<tr>
<td>F-value</td>
<td>10.366</td>
<td>11.179</td>
</tr>
<tr>
<td>p-value</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

stability was better in the chlorhexidine gluconate solution group (4.88 ± 0.24) than sodium hypochlorite solution (4.74 ± 0.18) and glutaraldehyde solution group (4.46 ± 0.16). The mean surface roughness was less in glutaraldehyde solution group (2.10 ± 0.19), followed by chlorhexidine gluconate solution group (2.48 ± 0.09) and sodium hypochlorite solution group (2.64 ± 0.03). There was a statistically significant difference found between different disinfectant agents with respect to both color stability and surface roughness. The inference of this study includes that the color stability was better in the chlorhexidine gluconate solution group, and the surface roughness was lesser in the glutaraldehyde solution group compared with other groups.

**Discussion**

It has been suggested that denture disinfection is a crucial step in maintaining good denture hygiene. There are several recommended chemical and mechanical treatments for cleaning and maintaining the health of dentures. In a perfect world, a disinfecting technique would work without impairing the qualities of the materials used to make denture bases.

Chemical cleaning is superior and is advised, especially for patients with weak dexterity and elderly individuals who have dementia. Numerous *in vitro* and *in vivo* investigations have demonstrated the efficacy of chemical treatments in removing cigarette stains, food particles, and bacteria from denture surfaces. Chemical cleaners can effectively disinfect dentures, but it is crucial to consider how their prolonged usage may change the qualities of the denture base material.

If the prosthetic needs to remain functional for a long time, color changes become esthetically troublesome. In addition, a variety of variables, including the type of resin base, the method of polymerization, the usage of denture-cleaning solutions, food, and patients’ oral hygiene, affect this. Both eye inspection and the use of specific armamentarium are valid methods for calculating color change assessment. When evaluating color changes in dental materials, colorimeters and spectrophotometers are widely used since they exclude subjective interpretations and enable the detection of minor color changes.

The color stability in the current investigation was much better in the chlorhexidine gluconate solution group compared with the groups treated with sodium hypochlorite solution and glutaraldehyde solution. This conclusion conflicts with studies by Reis KR et al., and Yiu CK et al., which show that sodium hypochlorite produces a whitening effect by oxidizing acrylic resins used in dentures. Such an occurrence was not found in the materials subjected to test in this research. High-molecular-weight polymethyl methacrylate, cross-linked resin, and interpenetrating polymer network (IPN) make up the chemical makeup of acrylic resin, which is virtually the same. The result is the development of a polymer with increased chemical and physical resistance. As a result, these improved qualities also make those materials less vulnerable to the oxidative effects of this disinfectant.

The surface roughness of samples of heat-cured acrylic resin in the current investigation significantly increased after 10 minutes of immersion in chlorhexidine. This was similar to the Shen C et al. study, which found that the surface change was caused by the disinfectant’s slow-dissolving action on the matrix phase, which exposed the polymer beads, as well as the effect of glutaraldehyde-based disinfectants (alkaline, phenol-buffered) on the surface morphology of denture base resins. With the consistent alkaline formulation, no obvious surface change was found. According to Carvalho et al., an acrylic resin denture foundation treated
to glutaraldehyde for 10 minutes developed surface pitting and polymer beads.

The patient’s comfort and prosthesis longevity are impacted by roughness. Better aesthetic results and less biofilm retention are produced by smoother surfaces. It was emphasized by Kuhar M and Funduk N and Rahal JS et al. that uneven surfaces promote the retention of germs and may have an impact on oral health. In the current investigation, the samples that were disinfected with 1% sodium hypochlorite had roughness values that were higher than those of the other groups. Similar to this, samples that were subjected to disinfection showed surface alterations, according to Rodrigues Garcia RC et al.

The heat-cured acrylic resin denture base’s surface roughness is significantly influenced by immersion time as well. Samples were immersed for 90 days in a study conducted by Köröglü A et al. The longer the heat-cured acrylic resin denture base is submerged, the longer it takes for the solution to penetrate the material and the more the disinfectant’s active ingredient is absorbed, causing chemical reactions or other damage to the heat-cured acrylic resin’s constituent parts.

The current study had some limitations, including that only one type of denture base resin was used to study the effects of various chemical disinfectants, that salivary composition and pH levels as well as the presence of biofilm were not accurately simulated, and time period of the study was limited to one month. Further, long-term research is necessary to examine the impact of disinfectant solutions on denture base acrylic resins.

**Conclusion**

This study concluded that the color stability was significantly better in the chlorhexidine gluconate solution group, and the surface roughness was significantly lesser in the glutaraldehyde solution group compared with other groups. Further research can be directed to analyze the influence of varied chemical disinfection concentrations and immersion times on other relevant physical properties of denture base resins, in order to assist clinicians in selecting the appropriate disinfectant.

**References**


