Effectiveness of Microwave and Chemical Disinfection on Denture Base Resins - A Systematic Review

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Abstract

Aim: The study aimed to review the literature on the effectiveness of microwave and chemical disinfection methods on denture base resins and their effects on physical properties such as hardness, roughness, dimensional stability, and colour stability.

Methods: Online electronic databases such as PubMed-Medline, Embase, and Scopus were searched using appropriate keywords from the earliest available date till 12th January 2021 with no restriction on language. Additional sources like Google Scholar, major journals, unpublished studies, conference proceedings, and cross-references were explored. Information curated for data extraction included microwave and chemical disinfection methods on denture base resins and their effects on the physical properties such as hardness, roughness, dimensional stability, and colour stability.

Results: Five articles out of 267 titles were found to meet the eligibility criteria. For surface properties, chemical disinfection led to comparatively smaller changes, and it created a rougher surface that can lead to plaque accumulation. Hardness was not much affected by any of the disinfectant methods. Hence, microwave disinfection showed better results amongst the two.

Conclusion: Two methods used for the disinfection purpose effectively remove the denture microbial layer; however, the microwave method was more effective as it required less time for disinfection procedures. However, these studies were undertaken entirely in the laboratories under conditions that usually are different from the actual oral environment making the comparison and generalizability doubtful.

Keywords: Denture bases, chemical disinfectants, microwave, colour stability.

Introduction

One of the significant challenges faced by dentists today is maintaining denture wearer’s oral hygiene, as only a minority present with no oral hygiene problems with a removable prosthesis.1 Studies have shown a positive correlation of oral mucosal health with the maintenance of denture cleanliness which could otherwise lead to oral mucosal conditions such as angular cheilitis2, ulceration and stomatitis.3 Denture plaque layer is associated with microorganisms such as Candida species, Streptococcus and Actinomyces4 and viruses, leading to cross-contamination and infections to the dental employees. They are exposed to such microorganisms while handling prostheses.5-7 For these
reasons, different denture cleaning methods have been studied and adapted to maintain denture and overall health. They include mechanical techniques for cleaning the denture by using a toothbrush and soap. However, unsatisfactory results were found, as many patients under hospital care can’t thoroughly brush their dentures due to diseases, dementia, and poor manual dexterity. Such insufficient cleansing permits the boom of such microorganisms, which can function as reservoirs for disseminating infection.

The use of household denture cleansers such as efferdent tablets and the incident powder was potentially hazardous, causing caustic burns of the oesophageal mucosa. However, the antimicrobial action on Candida species and Streptococcus mutans showed mixed results in reducing these species from the denture surface. The use of chemical denture cleansers has gained increased popularity due to ease in use, especially for decreased manual dexterity and substantially reduced microorganisms on the dentures. A few chemical disinfectants such as alkaline peroxidase solution, hypochlorite, vinegar solution have proven effective. Even though they showed favourable results, one cannot neglect the fact that immersion in chemical solutions may stain and whiten the plastic components of prostheses due to the bleaching actions of the solutions on the denture base resin, corrosion of the framework, promotion of severe risk of cytotoxicity or might alter some material properties.

Another available denture disinfection method is Microwave disinfection. Microwave irradiation requires no special storage, has no expiration date and does not induce resistance to Candida albicans, however, this disinfection method poses a problem when the denture contains metal components a part of it. A routine denture cleaning regimen should remove mucin, food debris, calculus, and exogenous discolouration and prevent microbial plaque reaccumulation. The review aims to determine the effectiveness of microwave and chemical disinfection methods on denture base resins and their effects on physical properties such as hardness, roughness, dimensional stability, and color stability.

**Methods**

The systematic review was conducted according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

**Focused question**

To determine the effectiveness of microwave and chemical disinfection methods on denture base resins and their effects on physical properties such as hardness, roughness, dimensional stability, and color stability.

**Search strategy**

An exhaustive literature search was conducted for appropriate studies to satisfy the study purpose: PubMed-MEDLINE, Embase, and Scopus. Additional sources such as Google Scholar and major journals were explored from the earliest available date up to 12th January 2021 without restriction on language. Contact with authors was done for any unpublished studies. A detailed search strategy is given in Figure 1 and tailored to each database when necessary.

**Eligibility criteria**

1. In vitro based studies were included.
2. Studies using heat cure denture bases were included.
3. If denture bases are included from patients, the subjects should be healthy without any systemic conditions and with no restrictions on the patient's age or the time of using the prosthesis.
4. Microwave disinfection with no restrictions on power and time settings.
5. Comparison with chemical denture disinfection methods may include chlorhexidine, sodium hypochlorite, glutaraldehyde, efferdent capsules, etc.
6. Disinfection of soft reline materials, resin teeth, and soft denture materials/other than acrylics were excluded.

**Screening and selection**

The papers were independently scanned by two reviewers (IP and TS), first by the title and abstract. Letters, Commentary, and narrative/historical reviews were not included in the search.
the search keywords were present in the title and or the abstract, the papers were selected for full-text reading. Papers without abstracts but with titles suggesting that they were related to this review's objectives were also selected to screen the full text for eligibility. Clinical (In vivo)/pre-clinical or laboratory (In-vitro) based studies were selected. After selection, full-text papers were read in detail by two reviewers. (IP and TS) Those papers that fulfilled all of the selection criteria were processed for data extraction. Two reviewers (IP and TS) hand searched the reference lists of all selected studies for additional articles. Disagreements between the two reviewers were resolved by discussion. If a disagreement persisted, the judgment of a third reviewer (VM) was considered decisive.

Assessment of heterogeneity
Factors that determined the heterogeneity of studies' outcomes were microbial flora, surface properties, the power setting of microwave disinfection, and time for disinfection used. Chemical disinfectants and time of immersion were different.

Data extraction
Information curated for data extraction included microwave and chemical disinfection methods on denture base resins and their effects on the physical properties such as hardness, roughness, dimensional stability, and color stability.

Results
Search and Selection Results
The PubMed-Medline, Embase, Scopus, and additional sources identified 267 search results, out of which 162 were duplicates. The remaining 105 unique studies were screened for the titles and abstracts, and 28 articles were selected for full-text screening. (Figure 2) A total of 5 articles matched the eligibility criteria and were processed for data extraction. No additional records were retrieved from hand searching the reference list of the selected articles.

Study design and Study Characteristics
The denture bases were prepared in the laboratory and were then subjected to the conditions that the effects need to be evaluated. All articles consisted of an in-vitro study design. 2 studies assessed the microwave and chemical disinfection methods on the disinfection capability and effectiveness in disinfecting the denture bases exposed to microbial flora. In contrast, 3 studies evaluated the changes in the surface properties of the denture bases. In the first study, the denture acrylics (1 cm x 31 cm x 32 mm) were inoculated with C.albicans and S.gordonii and were subjected to 2 different chemical disinfectant concentrations i.e. 2% sodium hypochlorite for 8 hours and 0.125% sodium hypochlorite for 8 hours. The microwave power settings they were subjected to were 604W and 350W, respectively. Microwave exposure for 2, 4, 6, 8 and 10 min at the high setting and 6, 8, and 10 min at medium setting showed a statistically significant decrease in the colony count of the fungus and the bacteria in the study. Microwave exposure of 1 min at the high setting and 1, 2 and 4 min at medium setting resulted in C. Albicans H1/ S. Gordonii survival. Soaking in 0·02% sodium hypochlorite for 8 h is Candida-cidal in its effect and results in less streptococcal survival than a similar soak in 0·0125% hypochlorite. In the second study, the denture acrylics were subjected to S.aureus and P.aeruginosa. A positive (water immersion) and a negative (no disinfection) control were included. The chemical disinfectants used were 2% glutaraldehyde and Corega tablets. The microwave conditioner was set to 650W for 3 minutes. The results showed statistically significant differences between colony counts after using glutaraldehyde, denture-cleansing tablets, and microwaves for denture cleaning.

Physical Properties
1 study compared the effect of the two disinfection methods on the Vickers hardness of the denture acrylics. A total of 24 specimens were used. Specimens (12 x 12 x 3 mm) were divided into 2 control and 4 test groups. (n=8) The 2 control groups used were positive control (water
disinfection) and negative control. (no disinfection) 16 specimens were subjected to chemical disinfection by 3.8% solution of sodium perborate, and the results were noted on day 1 (disinfected twice) and day 7 (immersed for 7 days). The microwave group (16 denture acrylics) was subjected to disinfection for 1 day (disinfection twice daily) and 7 days. Upon comparing the effects of the two sets of disinfection groups, it was inferred that neither the chemical method nor the microwave method had a significant effect on the denture bases' overall Vickers hardness. For surface roughness, it was inferred that there was a significantly higher mean roughness after 2 cycles of chemical disinfection.  

1 study compared the effects of the 2 disinfection methods on the dimensional stability of the denture bases. There were a total of 20 specimens used. These specimens were subjected to chemical disinfection (Sodium hypochlorite disinfection 0.525%) and microwave disinfection (650 W for 6 min). It was inferred that the change in dimensional stability after microwave disinfection was highly significant for denture bases. A study Color changes occurred when the denture acrylics were subjected to different disinfection methods. There was no control group. A total of 112 specimens were used, subjected to 3 chemical disinfectants, i.e. Efferdent Original denture cleanser for 15 min, 4% Chlorhexidine for 10 min, 1% Hypochlorite for 15 mins. The microwave group was subjected to a power setting of 650W for 6 minutes. The results showed a significantly lower colour change for the 1% hypochlorite group when compared to the microwave and efferdent groups.

Discussion

Denture disinfection is carried out to remove the biofilm microorganism from the prosthesis's surface, potentially harmful to the wearer leading to denture stomatitis or Candidiasis. Disinfection also helps prevent cross-contamination to the denture handlers such as the dentist or the lab technicians. The methods adopted for denture disinfection should be easy to use, less time-consuming, and harmless to both the denture and the user. Chemical disinfectants have been used for a long time both at home and at clinic denture disinfection to introduce the newer denture cleaning methods. In particular, microwave disinfection methods seem advantageous. In this review, we have tried to review the clinical effectiveness in using both the disinfection methods and compare their outcomes and thus evaluate the better method for disinfection. It was found that the studies that were included were in-vitro studies, thus posing the disadvantage of inferring these results to the actual clinical setting. The included studies revealed weak evidence regarding the efficacy of chemical disinfection compared to microwave disinfection methods. In the review, 2 studies were evaluated that focused on the effects of the chemical vs microwave disinfection methods on the denture biofilm. These studies concluded that both the disinfection methods, i.e. chemical and microwave methods, effectively decreased the biofilm from the denture base. However, Mojarrad N et al. in their study, reported that microwave irradiation at power 650W for 3 minutes to have higher efficacy in eliminating the S.aureus and P. aeruginosa species from the denture surfaces. Also, one of the important factors here was the time for which the dentures were disinfected. In the included studies, microwave disinfected the dentures relatively less time, evaluating the effects of the denture bases' surface properties when submitted for the two disinfection methods. Subjecting the dentures to a disinfecting agent should not bring about any denture properties changes, be it physical, chemical, or mechanical. However, such changes often occur when the dentures bases are submitted for the disinfection procedures Bollen et al. reported that acrylic resins' surface roughness was dependent on the polishing grit. Verran and Maryan reported how the retention of the Candida species differed with the acrylic resin's surface roughness by comparing the retention on smooth and rough surfaces and reported a higher number of the cells on the roughened surfaces. The irregularities and porosities on the acrylic resin suggest that these can make biofilm removal difficult. In the present review, the denture base's hardness was not significantly influenced by either of the methods; however, the mean roughness was higher after 2 cycles of chemical disinfection, which could be attributed to changes in roughness due to chemical denture cleanser. Nirale et al. reported an overall shrinkage of the denture when submitted for the microwave
disinfection (650W for 6 mins) in comparison to sodium hypochlorite disinfection. This result may be the function of the disinfection time, power setting used, type of acrylic used, or methods used to measure the distortion.\textsuperscript{38} Denture resins show a varied behaviour in dry sterilization conditions when compared to those that were sterilized in the presence of water, which tends to improve the overall effectiveness of the disinfection procedure.\textsuperscript{43} As the water starts to boil after 90 seconds when subjected to microwave irradiation,\textsuperscript{43} the overall effect of which could be an increase in the temperature of the acrylic resin beyond its glass transition temperature which could lead to changes in its properties.\textsuperscript{44} which can ultimately lead to denture warpage due to the release of stresses stored within the acrylic base while its fabrication.\textsuperscript{45,46} Furthermore, the water's higher temperature may lead to the leftover monomer residual molecules' dispersion.\textsuperscript{47-49} For that reason, a further polymerization can occur, leading to the denture bases shrinkage. Another important acrylic resin-related problem is the resin's color stability, which is crucial for the dentures' aesthetics and hygiene. Resins tend to acquire colors as they are susceptible to absorption and adsorption processes.\textsuperscript{50} Goiato et al.\textsuperscript{32} reported significantly lower color change from the 1% hypochlorite group than the microwave or efferdent group.

**Conclusion**

Two methods used for the disinfection purpose effectively remove the denture microbial layer; however, the microwave method was more effective as it required less time for disinfection procedures. For surface properties, chemical disinfection led to comparatively smaller changes, and it created a rougher surface that can lead to plaque accumulation. Hardness was not much affected by any of the disinfectant methods. Hence, microwave disinfection showed better results amongst the two. However, these studies were undertaken entirely in the laboratories under conditions that usually are different from the actual oral environment making the comparison and generalizability doubtful.

**References**


Conflict of Interest: Authors declare no conflict of interest

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Figures

**Figure 1: Search Strategy**

<table>
<thead>
<tr>
<th>Domains</th>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denture bases</td>
<td>(Acrylic Resin) OR (Resin, Acrylic) OR (Resins, Acrylic) OR (Resin, Synthetic) OR (Dental Resin) OR (Resin, Dental) OR (Methacrylate, Polymethyl) OR (Poly(methyl methacrylate) OR (Polymethylmethacrylate) OR (PMMA) OR (Polymethylacrylic Plastic)</td>
</tr>
<tr>
<td>Chemical</td>
<td>(Disinfectants) OR (Glutaral) OR (Formaldehyde) OR</td>
</tr>
<tr>
<td>disinfectants</td>
<td>(Sodium Hypochlorite) OR (Chlorhexidine) OR (Disinfectants, Dental)</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>-------------------------------------------------------------------</td>
</tr>
<tr>
<td>Microwave</td>
<td>(Microwave) OR (Wave, Micro) OR (Ultrahigh Frequency Wave) OR (Wave, Ultrahigh Frequency) OR (Radiation, Microwave)</td>
</tr>
<tr>
<td>Properties</td>
<td>(Propert*, Surface) OR (Surface Propert*) OR (Mechanical Phenomenon) OR (Phenomena, Mechanical) OR (Mechanical Concepts) OR (Concept, Mechanical) OR (Processes, Mechanical) OR (Mechanical Process) OR (Flexural Strength*) OR (Resistance*, Flexural) OR (Bend Strengths) OR (Propert*, Flexural) OR (Strength*, Fracture)</td>
</tr>
<tr>
<td>Color stability</td>
<td>(Color) OR (Colorimetry) OR (Optical Phenomenon) OR (Phenomenon, Optical) OR (Optical Concepts) OR (Concept, Optical) OR (Processes, Optical) OR (Optical Process) OR (Spectrophotometry)</td>
</tr>
</tbody>
</table>

* Indicates wild card

Figure 2: Flowchart summarizing the article selection process (n – number of studies)
Table 1: Overview of Included Studies for the potency of available disinfection procedure for denture base resins

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Study Design</th>
<th>Sample Size</th>
<th>Microorganisms</th>
<th>Control</th>
<th>Chemical Disinfection</th>
<th>Microwave Disinfection</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Webb BC et al. 1998</td>
<td>In vitro study</td>
<td>20</td>
<td>C. albicans</td>
<td>NA</td>
<td>0.2% NaOCl (8 hours)</td>
<td>604 W</td>
<td>Microwave exposure at medium setting was fungicidal/bactericidal. Microwave exposure at a high setting and medium setting resulted in C. Albicans/ S. Gordonii survival.</td>
</tr>
<tr>
<td>S. gordonii</td>
<td>NA</td>
<td>0.2% NaOCl (8 hours)</td>
<td>604 W</td>
<td>0.125% NaOCl (8 hours)</td>
<td>350 W</td>
<td>Soaking in 0.02% sodium hypochlorite is</td>
<td></td>
</tr>
</tbody>
</table>
Candida-cidal and also results in less streptococcal survival.

**Table 2:** Overview of Included Studies for changes in the physical properties of denture base resins

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Study design</th>
<th>Sample size</th>
<th>Physical Properties</th>
<th>Control</th>
<th>Chemical disinfection</th>
<th>Microwave disinfection</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>MachadoAL et al/2009</td>
<td>In vitro study</td>
<td>48</td>
<td>Vickers hardness</td>
<td>Not disinfected (T1=1 day, T2 = 7 days)</td>
<td>4% chlorhexidine for 1 min+3.8% sodium perborate solution (50°C for 10 min)</td>
<td>650 W for 6 mins-disinfected twice</td>
<td>The material's hardness was not significantly influenced by either the disinfection methods or the number of cycles.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Distilled water at 37°C (T1=1 day, T2 = 7 days)</td>
<td>3.8% solution of sodium perborate (T1=1 day , T2 = 7 days) (50°C for 10 mins)</td>
<td>650 W for 6 mins (T1=1 day, T2 = 7 days)</td>
<td></td>
</tr>
</tbody>
</table>

*NaOCl-sodium hypochlorite; UV-ultraviolet light; MCP-mouthwash containing propolis, W-watt
<table>
<thead>
<tr>
<th>Study</th>
<th>Type of Study</th>
<th>Time (T1, T2)</th>
<th>Variable</th>
<th>Solution / Parameters</th>
<th>Method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nirale, RM et al./2012</td>
<td>In vitro study</td>
<td>1 day, 7 days</td>
<td>Roughness</td>
<td>Not disinfected (distilled water at 37°C, 650 W for 6 mins)</td>
<td>4% chlorhexidine for 1 min + 3.8% sodium perborate solution (50°C for 10 mins)</td>
<td>Significantly higher mean roughness after 2 cycles of chemical disinfection. (p&lt;0.001)</td>
</tr>
<tr>
<td>Goiato, MC et al./2013</td>
<td>In vitro study</td>
<td>1 day, 7 days</td>
<td>Dimensional stability</td>
<td>Not disinfected (distilled water at 37°C, 650 W for 6 mins)</td>
<td>Sodium hypochlorite disinfection (0.525%)</td>
<td>Dimensional stability highly significant for denture bases. (p&lt;0.001)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 mins</td>
<td>Colour stability</td>
<td>Efferdent Original denture cleanser (15 mins)</td>
<td>650 W (6 mins)</td>
<td>Significant lower colour change for 1% hypochlorite group compared to the microwave and Efferdent groups</td>
</tr>
</tbody>
</table>

W-watt