

# Effect of chemical denture cleansers on flexural resistance and color changes of microwave-polymerized acrylic resins

Helena de Freitas Oliveira Paranhos<sup>1</sup>; Iara Augusta Orsi<sup>2</sup>; Osvaldo Zaniquelli<sup>2</sup>; Maria Cristina Candelas Zuccolotto<sup>3</sup>; Fabrício Magalhães<sup>3</sup>

<sup>1</sup> *PhD, Associate Professor*

<sup>2</sup> *PhD, Professor*

<sup>3</sup> *MS, PhD Student*

*Faculty of Odontology of Ribeirão Preto, Department of Dental Materials and Prosthodontics, University of São Paulo, Ribeirão Preto, SP, Brazil*

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## Abstract

**Aim:** The aim of this study was to assess the flexural resistance and color alterations of microwave-polymerized acrylic resins immersed in denture cleansers for different periods of time. **Methods:** Forty-five rectangular specimens (65x10x3mm) of each commercial brand of the microwave-activated acrylic resins (Vipi Wave and Onda Cryl) were divided in three denture cleanser groups (Bony Plus, Corega Tabs and Efferdent Plus) and a control group (immersion in water). Soaking trials of 15 min and 8 h simulated 30 days of use. The flexural strength test was carried out in a universal testing machine. Color alterations were assessed by visual inspection of photographs. The results obtained in the flexural test, in kgf, were converted to MPa and these values were submitted to analysis of variance with a 5% significance level. **Results:** There were no significant differences ( $p < 0.05$ ) between Onda Cryl ( $85.61 \pm 12.76$ ) and Vipi Wave ( $89.8 \pm 19.95$ ) after the soaking trials regarding the use of different denture cleansers. No differences were found in relation to the solutions [Bony Plus ( $88.52 \pm 9.89$ ), Corega Tabs ( $88.75 \pm 12.71$ ) and Efferdent ( $85.86 \pm 12.11$ )], soaking periods [control ( $87.17 \pm 12.92$ ), 15 min ( $88.05 \pm 11.74$ ) and 8 h ( $87.91 \pm 10.30$ )], and interactions during the 30 days of simulated use. Visual inspection did not detect any color alterations. **Conclusions:** Denture cleansers, when used according to the manufacturers' instructions, did not cause any mechanical or visual alterations in the microwave-polymerized acrylic resins after a simulated period of 30 days of use.

## Key Words:

complete dentures, acrylic resin, microwave, denture cleansers, flexion resistance, color.

## Introduction

Acrylic resins have been used to produce dentures for more than 60 years. Microwave polymerization of acrylic resin was introduced by Nishii<sup>1</sup> in Japan. Polymerization by microwave irradiation has several advantages: a denture base can be fully polymerized in only 3 min, much faster when compared to the polymerization time of 9 h normally used for water-bath polymerization; a simpler equipment is required; only a fraction of the energy needed by conventional methods is required for microwave-activated polymerization; and less residual monomer remains in microwave-polymerized resins<sup>2</sup>.

Dentures can be cleaned mechanically, chemically or by the combination of both methods. Mechanical methods are the most common way for biofilm removal from denture surfaces<sup>3</sup>. The use of chemical cleansers is usually associated to its efficacy in removing stains and a reduction in biofilm formation on dentures' irregularities has been reported<sup>4</sup>. The most commonly used cleansers are represented by the group of alkaline peroxides<sup>5</sup>. They are effective to remove newly formed biofilm and also when used for extended immersion periods<sup>6</sup>. These products have been clinically tested, demonstrating an effective removal of biofilm on complete dentures<sup>7</sup> and antimicrobial action against specific microorganisms<sup>8</sup>.

Factors like water temperature<sup>9-11</sup> and immersion period<sup>12-14</sup> are considered critical when complete denture cleansers are used. Sometimes, the prostheses need to be replaced due to the patients' abuse of hygiene methods. The flexural resistance property has been tested in temporary soft liners<sup>15</sup> and acrylic resins<sup>16-18</sup> after the use of disinfecting solutions and specific products for cleaning total prostheses.

## Correspondence to:

Helena de Freitas Oliveira Paranhos  
Faculdade de Odontologia de Ribeirão Preto – USP,  
Departamento de Materiais Dentários e Prótese  
Avenida do Café s/nº - Monte Alegre - 14040-904  
Ribeirão Preto, SP, Brazil  
Phone: +55-16-602-4006. Fax: +55-16-16-633-0999  
E-mail: helenpar@forp.usp.br

The importance of following the manufacturer's instructions is emphasized because the transverse strength of acrylic resins depends on several factors, such as polymer molecular weight<sup>19</sup>, polymer bead size<sup>20</sup>, residual monomer levels<sup>19,21</sup>, plasticizer composition<sup>19,22</sup>, amounts of cross-linking agents<sup>23</sup>, internal porosity of the polymer matrix<sup>21,24</sup>, denture base thickness<sup>24</sup>, patient factors<sup>24</sup>, type of polishing<sup>25</sup>, and action of chemical agents.

One of the problems frequently reported by chemical cleanser users is a whitening effect on the denture. Denture base polymers are susceptible to color changes<sup>12</sup> if the cleaning solutions are not used correctly. The whitening effect is related to the high temperature of the water used in the solution<sup>9,10,26</sup>. When peroxide-based cleansers are used in a warm water solution, as recommended by the manufacturer, no deleterious effects on correctly processed denture acrylic have been found<sup>18</sup>.

Considering that denture overall longevity also depends on the physical properties of the denture base resin<sup>22</sup> and that the denture base polymers may fall clinically due to flexural fatigue, the assessment of the transverse strength of acrylic resins has been reported to be a reliable method to estimate resin behavior under different experimental conditions<sup>27</sup>. In the same way, it is of clinical importance to determine whether chemical solutions or denture cleansers alter the acrylic resins color<sup>14</sup> when dentures are cleaned repeatedly and for various amounts of time. Therefore, the aim of this study was to evaluate whether soaking of different microwave-polymerized acrylic resins in chemical solutions (alkaline peroxide-effervescent tablets) may affect the resin flexural strength and color when subjected to the recommended instructions of use for a simulated period of 30 days.

### Material and Methods

Dental stone casts were prepared in dental flasks (Vipi - Vipi Ind Com Ltda, Pirassununga, SP, Brazil), each flask containing three preformed Teflon® (DuPont™) dies (each 65x10x3mm). Each die was coated with a thin layer of petroleum jelly before being invested. For the flask base, 120g of type III dental stone (Herodent; Vigodent S/A, Rio de Janeiro, RJ, Brazil) was used. Undercuts were placed in the stone for best retention of 80 g of type IV die stone (Durone; Dentsply, Petrópolis, RJ, Brazil), where the dies were invested. A new coat of petroleum jelly was applied before pouring of 80g of die stone and final pouring of 300 g of dental stone. After complete final stone set, the

flasks were opened and the dies were removed from the investing material. The mould cavities obtained were used for preparation of the acrylic resin test specimens.

The resins (Table 1) were mixed according to the manufacturers' instructions. The monomer and polymer were mixed together until a doughy stage was reached, then kneaded and placed in the mould. After the end of the polymerization cycle, the flasks were allowed to slowly cool in a water bath at room temperature before deflasking. The acrylic specimens were trimmed with a tungsten bur (#9201 Shape 84; Edenta AG, Hauptstrasse, Switzerland) and ground wet to the final dimensions with 320-, 400-, 600-, 1000-grit silicon carbide papers (Norton Ind. e Com. Ltda, São Paulo, SP, Brazil). Pumice and whiting were used for final polishing. After polishing, the specimens were marked individually with an identifying number. Five specimens of each resin were assigned to each experimental group.

The accuracy of the dimensions was verified with a digital caliper (CD-6" CSX-B – Mitutoyo, Japan) and the dimensions were recorded. All specimens were stored in water at 50°C for 1 h to remove the excess of residual monomer, and then stored at room temperature until the time of the soaking trials.

### Soaking Trials

Five specimens of each resin were subject to soaking trials, according to the:

- Denture cleanser: a) Bony Plus (Bonyf AG, Liechtenstein, Switzerland), b) Corega Tabs (Block Drug Company, Inc., USA) or c) Efferdent Plus (Pfizer, Morris Plains, USA) dissolved in 250 mL of water at 45 ± 2°C;
- Soaking time: a) 15 min, three times a day for 10 days, simulating a 15-min soaking time once a day for 1 month and b) 8-h intervals for up to a total of 240 h, changing the solution every 8 h, to correspond to 30 overnight soaking periods.

The control specimens were stored in water at room temperature, changing the water every 8 h.

### Analysis of Treated Specimens

#### Flexural strength testing – three-point loading

Specimens were labeled on each end before testing so that fractured pieces could be reunited and examined subsequent to testing. A three-point loading test was carried out in a universal testing machine (EMIC, São José dos Pinhais – PR, Brazil) running at a crosshead speed of 1 mm/min and 50-mm distance between the specimen

Table 1 - Acrylic Resins and denture cleansers employed

	Manufacturer	Powder/liquid ratio (g/mL)	Curing cycle
Onda Cryl	Clássico Art. Odontológicos Ltd., São Paulo, SP, Brazil	21/7	3 min 40% potency and 4 min 0% and 3 min at 90%
Vipi-Wave	Dental Vipi Ltd, São Paulo, SP, Brazil	14/6.5	20 min 20% potency and 5 min 60%

supports. A 50 kgf load cell was applied by a centrally located rod until fracture occurred (Figure 1).

The flexural strength was calculated with the following equation:

$$S = \frac{3PL}{2bd^2}$$

where  $S$  is flexural strength,  $P$  peak load applied,  $L$  span length,  $b$  sample width and  $d$  specimen thickness.

#### Color alteration

The control specimens stored in water and the specimens immersed in the three denture cleansers, using daily soaking times of 15 min and 8 h for a simulated period of 30 days, were put side by side and photographed (camera: Canon EOS-100S; lens: Canon 50mm f2.8 EF Macro – Canon, Tokyo, Japan) in a photographic studio. Film was processed and visual inspection of photographs of the specimens was carried out independently by three investigators. Each investigator received an initial photograph of the non-treated resin specimens (used as a control) and compared to the photograph of the treated specimens. Yes or no answers were given depending on the presence or absence of color change.

#### Statistical Analysis

The results obtained in the flexural resistance test, in kgf, were converted to MPa. The preliminary statistical analysis showed that sample distribution was normal and homogeneous, thereby allowing the use of parametric tests. The analysis of variance was used to compare types of resins, solutions and immersion times. Significance level was set at 5%.

#### Results

The results of the ANOVA (Table 2) did not show significant differences ( $p < 0.05$ ) between the resins after the soaking trials regarding the use of different denture cleansers. No statistically significant differences were found regarding the resins [Onda Cryl ( $85.61 \pm 12.76$ ) and Vipi

Wave ( $89.8 \pm 19.95$ )], solutions [Bony Plus ( $88.52 \pm 9.89$ ), Corega Tabs ( $88.75 \pm 12.71$ ) and Efferdent ( $85.86 \pm 12.11$ )], soaking periods [control ( $87.17 \pm 12.92$ ), 15 min ( $88.05 \pm 11.74$ ) and eight h ( $87.91 \pm 10.30$ )] and interactions, during the 30 days of simulated use.

Tables 3-5 show the mean values and standard deviation obtained for the resins, solutions and immersion times. No statistically significant differences were found.

Visual examination of the photographs of the specimens did not show any clinically significant color alterations.

**Table 3** - Mean values (MPa) and standard deviations for resins

Resins	Means (Standard deviation)
Vipi Wave	89.81 ± 9.95
Onda Cryl	85.61 ± 12.76

$p > 0.05$

**Table 4** - Mean values (MPa) and standard deviations (SD) for solutions

Solutions	Means ± SD
Bony Plus	88.52 ± 9.89
Corega Tabs	88.75 ± 12.71
Efferdent	85.86 ± 12.11

$p > 0.05$

**Table 5** - Mean values (MPa) and standard deviations (SD) for immersion times

Time (min)	Means ± SD
0	87.17 ± 12.92
15	88.05 ± 11.74
480	87.91 ± 10.30

$p > 0.05$

#### Discussion

Denture immersion in chemical products aims to provide cleaning and decontamination. It is important to analyze

**Table 2** - Analysis of Variance results

Source of variation	Sum of Squares	DF	Mean Square	(F) Ratio	Prob. $H_0$ (%)
Solutions (S)	154.275	2	77.138	0.53	40.20 ns
Resins (R)	397.964	1	397.964	2.72	9.94 ns
Time (T)	13.608	2	6.804	0.05	5.53 ns
Interaction SxR	37.236	2	18.618	0.13	11.94 ns
Interaction TxS	318.292	4	79.573	0.54	29.29 ns
Interaction TxR	359.369	2	179.685	1.23	29.84 ns
Interaction TxSxR	111.080	4	27.770	0.19	5.90 ns
Error	10530.362	72	146.255		
Total Variation	11922.188	89			

ns = no significant difference ( $p > 0.05$ )

the efficacy of the cleaning product and how it acts on the denture materials<sup>28</sup>. It has been shown that immersion in certain cleansing solutions can affect the strength and the structure of denture base resins<sup>10</sup>. If denture cleansers lead to a reduction in strength, a higher incidence of denture fractures could occur. Midline fracture of the denture base, for example, is one of the failures that may occur as a consequence of flexural fatigue, as a result of the cyclic deformation of the base during function. A supposed increased frequency of this last kind of failure due to the use of denture cleansers can be demonstrated by the flexural strength test.

In the present study, flexural strength and color were not affected by the exposure to the tested cleaning products. Using the same solutions and simulating the same usage period, Sato et al.<sup>26</sup> did not find any alterations in the flexural strength of conventional resins. One factor that contributed to this result was the use of products at the recommended temperatures. Robinson et al.<sup>10</sup> and Arab et al.<sup>26</sup> showed reduced flexural strength of acrylic resins when exposed to peroxides and hypochlorites at high temperatures, which is not recommended by the manufacturers.

Previous investigations have emphasized that the correct use of chemical cleansers is not associated to alterations in the mechanical properties of the materials for denture bases<sup>9-11,26</sup>. However, another factor to be taken into account is the immersion time, as extended immersions can damage certain materials used to manufacture the prostheses<sup>29</sup>. Twenty-minute (short immersion) and 8-hour periods (extended or overnight immersion – during sleep period) were established to simulate the orientations patients received for the daily cleaning of total prostheses. The results showed that, even within an 8-hour period, no alterations occurred in the analyzed characteristics.

Factors that may contribute to the change in the color of materials include stain accumulation, dehydration and oxidation of the reacted carbon-carbon double bonds that produces colored peroxide compounds, and continuing formation of the colored degradation products<sup>30</sup>.

Color alterations can be objectively measured with a spectrophotometer. However, in this study, color alterations were evaluated only by visual examination because a clinically perceptible color change was considered more important than a measurement of color difference. Within 30 days of simulated immersion, the tested acrylic resins did not show any noticeable color change with the use of the three cleansing agents.

Unlü et al.<sup>31</sup> observed a whitening effect in acrylic resins after 30 days of simulated use of chemical cleansers, measuring the color alterations with a reflectometer. Significant differences were dependent on the acrylic resin and the kind of cleansing agent used. These results do not agree with those of the present study, possibility due to methodological differences, which objectively measured the color values of the specimens with a reflectometer.

This device detected color differences that the human eye could not perceive, which explains the color alterations reported by Ünlu et al.<sup>31</sup>.

Jin et al.<sup>30</sup> observed minimal color change in the tested heat polymerized materials, with no significant differences among the denture cleansers in which the materials were immersed (alkaline peroxide, neutral peroxide, neutral peroxide with enzyme and enzyme). The authors attributed this result to the fact that heat polymerized materials have a high polymerization rate and greater stability of physical properties.

Devlin and Kaushik<sup>32</sup> evaluated acrylic resin specimens placed in warm water (40°C) and boiling water (100°C) with an alkaline peroxide tablet (Efferdent). One effect of the hot water was to cause a severe whitening of all acrylic specimens, whereas those treated with warm water were unaffected. They concluded that hot alkaline peroxide solution caused a water oversaturation of acrylic surface, resulting in surface whitening and softening. These findings are in agreement with those of the present study; when used according the manufacturer instructions, cleansers do not affect the flexural resistance and color of acrylic resins and the polymerization type can contribute to increase property stability.

Further research using longer immersion periods is needed. The effect of these solutions on other characteristics and properties of acrylic resins, such as superficial roughness, should also be investigated.

It may be concluded that, when used according to the manufacturers' instructions, denture cleansers did not cause alterations in flexural strength or color changes in microwave-polymerized acrylic resins after 30 days of simulated use.

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