Effects of Different Forms of Denture Adhesives on Biofilm Formation, Adhesive Strength and Hygiene of Complete Dentures

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Abstract

**Purpose:** To evaluate the effect of different forms of denture adhesives on the formation of biofilm and on adhesive strength, as well as the effectiveness of hygiene protocols for their removal.

**Materials and Methods:** Samples of the heat-cured polymethyl methacrylate denture base resin were made and divided into four groups: control (no adhesive), ultra Corega cream, Corega strip adhesive, and ultra Corega powder (GlaxoSmithKline). Biofilm formation was evaluated by counting colony-forming units and fluorescence microscopy. To evaluate the effectiveness of the hygiene protocols, the samples were divided into five subgroups: brushing with distilled water; brushing with Protex soap; brushing with Colgate toothpaste; immersion in Corega Tabs; and immersion in Corega Tabs followed by brushing with the solution itself. The remaining adhesive was quantified with ImageJ software. The adhesive strength was tested at different time intervals after application. After verifying the data distribution using Shapiro-Wilk test, parametric or nonparametric analysis was applied ($\alpha = .05$).

**Results:** *Candida albicans* formed more biofilm in strip ($P = .007$) and powder ($P = .001$), *Pseudomonas aeruginosa* in cream ($P < .001$) and powder ($P < .001$), and *Staphylococcus aureus* in strip ($P < .001$). All forms of the adhesives promoted higher biofilm formation when compared to control ($P = .003$). Brushing with Colgate and Protex was most effective for removing the adhesives ($P < .05$). Independently, Powder had the highest adhesive strength ($P < .05$). Only Strip showed a change in adhesive strength, with higher values after 3 hours of application ($P = .004$). **Conclusion:** Daily treatments with mechanical cleaning of the prosthesis are important for removing the adhesives, since the presence of this material can favor biofilm accumulation. The adhesive strength may vary depending on the commercial type, but all forms can be effective in retaining prostheses for a satisfactory period of time. *Int J Prosthodont* 2021. doi: 10.11607/ijp.7188

Introduction

Implant-supported dental prostheses are a feasible alternative for treating edentulous patients; however, conventional full dentures continue to be the main treatment option due to their low cost, systemic limitations or individual choice.\(^1\) Nevertheless, complaints related to lack of retention,
instability, difficulties with chewing, low self-esteem, reduced quality of life, social life and satisfaction are common.\textsuperscript{2,3}

Adhesive materials are recognized as auxiliary agents for the retention, stability and function of these prostheses.\textsuperscript{4} When appropriately indicated, they can improve interfacial surface tension between prosthesis bases and underlying soft tissues thereby improving users' quality of life.\textsuperscript{5,6} In addition, they can be used to stabilize prosthetic bases during the registration of maxillomandibular relationships and serve as an important route for drug delivery to oral tissues.\textsuperscript{4,7-9}

In the USA, estimates have shown that approximately 22\% of completely edentulous patients regularly use adhesives, and approximately 75\% of dentists recommend their use to complete denture wearers.\textsuperscript{10-12} However, inadequate hygiene of the prosthesis surface can lead to adhesives providing an additional substrate for the growth of microorganisms,\textsuperscript{13,14} favoring the development of local problems, including chronic candidosis and subsequent denture stomatitis (DS), characterized as a disease with a multifactorial etiology. In DS, however, irrespective of the contributory factors such as age, systemic disease, smoking, use of the prosthesis during sleep, reduced salivary flow, trauma caused by lack of retention and stability of the prosthesis, \textit{Candida albicans} has been recognized as the principal etiological agent.\textsuperscript{15,16}

Although a large portion of the literature discusses only this condition, there is evidence that DS is a polymicrobial disease, with the association of several pathogenic bacterial species found in the oral cavity.\textsuperscript{17-19} In addition, the proliferation of some oral bacteria related to a poor hygiene has been associated with systemic diseases such as bacterial endocarditis, aspiration pneumonia, chronic obstructive pulmonary disease, widespread respiratory tract infections, especially in the dependent elderly.\textsuperscript{20,21} However, little is known about the effect of adhesives on the growth of multispecies biofilms, it is, however, known that interkingdom cooperation favors their adhesion, colonization and resistance to antimicrobial agents.

Different forms of denture adhesives are widely used by edentulous patients,\textsuperscript{22,23} and these should be biocompatible, easy to apply and remove, and be capable of maintaining their adhesive strength for 12 to 16 hours.\textsuperscript{24}
Therefore, in this study, the influence of the use of different commercial forms of denture adhesives on the formation of multispecies biofilms and adhesive strength was evaluated, as well the effectiveness of different hygiene protocols for their removal. The null hypothesis was that the type of adhesive would have no influence on biofilm formation, adhesive strength, or make any difference in the effectiveness of hygiene protocols for removing the adhesive.

Materials and Methods

Preparation of Specimens

Figure 1 shows the study flowchart (Fig.1). A heat-cured polymethyl methacrylate denture base resin (Classical Dental Articles Ltd., Campo Limpo Paulista, SP, Brazil) was used to fabricate the specimens by including the matrices in conventional metal muffles (OGP; Produtos Odontológicos Ltda). The specimens made for microbiological analysis and for analyzing the efficacy of hygiene protocols measured 6 mm wide x 10 mm long and 3 mm thick, and those for analyzing the adhesive strength measured 25 mm in diameter x 35 mm high.

During the plastic phase, the resin was placed in the molds prepared in the metal muffles and then placed in hydraulic presses (Proteci Hydraulic Press; Proteci Equipamentos Médicos) with a load of 1000 Kgf for 60 minutes. The specimens were polymerized by conventional heating in an electric thermal cycler (Thermocycler T100; Oficina de Precisão Universidade de São Paulo). After the muffles had cooled to room temperature, the specimens were finished and immersed in distilled water at 37ºC for 24 hours to eliminate residual monomers.

The surface roughness of specimens was standardized by polishing with abrasive paper, and a Rugosimeter (Surftest SJ 201P; Mitutoyo Corporation) was used in order to reproduce the average internal surface roughness of the denture bases. The specimens used in the present study had an average surface roughness (Ra) value of 3.0 µm.12,25

Microbiological Analysis

The microorganisms, Staphylococcus aureus (ATCC 25923), Candida albicans (ATCC 10231) and Pseudomonas aeruginosa (ATCC 27853), were used in the present study. Microbial
colonization including the formation of multispecies biofilm on the substrates was evaluated. The substrates consisted of acrylic resin specimens without denture adhesives, and specimens with denture adhesives Ultra Corega Cream, Corega Strip Adhesive and Ultra Corega Powder (GlaxoSmithKline Brasil Ltda) (Table 1).

The process of applying the adhesives to specimens, which had previously been sterilized with hydrogen peroxide26 (Multilav Sterilization), was performed according to aseptic principles in a Class II biological safety cabinet (Pachane; Pa 400-ECO). The samples of each adhesive product (Ultra Corega Cream and Ultra Corega Powder) to be placed on the test specimens were standardized to 0.025 g, using precision balance. The adhesive samples were applied with a spatula, and evenly spread directly on the test specimen surfaces, forming a thin layer. Corega Strip Adhesive was cut to a size that was sufficient to cover the entire surface of the specimen. After application, all samples were exposed to ultraviolet light for 20 minutes to disinfect the adhesives applied.12

A static multispecies biofilm model was used and placed in the wells of 24-well plates. Cell concentrations were adjusted according to the methodology of Kart et al., 2014.27 Inoculum suspensions containing ~ 10^6 CFU mL^-1 of S. aureus, 10^6 CFU mL^-1 of P. aeruginosa and 10^5 CFU mL^-1 of exponentially growing C. albicans were made in BHI - Brain heart infusion (HiMedia Laboratories; Pvt. Ltd.). For C. albicans, due to the variable morphology of the genus, the cells were counted under an optical microscope (Axio Observer A1; Carl Zeiss) in a Neubauer chamber (HBG; Giessen). To prevent the death of S. aureus and C. albicans by P. aeruginosa, BHI was supplemented with bovine serum albumin. The 24-well plates were placed in the Class II biological safety cabinet (Pachane; Pa 400-ECO), and specimens from each group were individually inserted into each well of the 24-well plate (TPP; Trasadingen), in addition to transferring 1 mL of the culture medium with microbial inoculum to each well.

The plates were incubated in a microbiological oven (Shaker Incubator; Mod. CE-320; CienLab) at 37°C with agitation at 75 rpm, in order to generate stress and promote correct microbial adhesion and not only sedimentation. After 4 hours, the initial period of adhesion of the microorganisms, the culture medium was removed from each well and each specimen washed twice.
with 1 mL of phosphate buffered saline (PBS) in order to remove non-adherent cells. To each well, 1 mL of sterile BHI was added, and the plates were incubated for 20 hours.

After the biofilm formation period, each specimen was washed with 1 mL PBS, inserted into a polypropylene tube (TPP; Trasadingen) with 3 mL PBS and sonicated in an ultrasonic vat (Altsonic; Clean 9CA) (200 watts/40 Hz) for 20 minutes in order to detach the biofilm.

Then, 25 µL aliquots of decimal dilutions (10⁻¹ to 10⁻⁴) of the resulting suspension were seeded in a selective growth culture medium. Salty mannitol agar (HiMedia Laboratories; Pvt. Ltd.) supplemented with 200 UI/mL Nystatin (Homeocenter; Handling pharmacy) was used for *S. aureus*, Sabouraud Dextrose Agar (HiMedia Laboratories; Pvt. Ltd.) supplemented with 5 µg/mL of Chloramphenicol for *C. albicans* and Cetrimide Agar (HiMedia Laboratories; Pvt. Ltd.) supplemented with 200 UI/mL of Nystatin and 5% of glycerol for *P. aeruginosa*. The plates were incubated at 37°C for 24 hours.

After the incubation period, the number of viable cells was quantified in terms of colony forming units per milliliter (CFU/mL) (n=10). The number of colonies of each dilution were counted, and the CFU values obtained, based on the dilution that promoted between 1-300 colonies, as follows:

\[ \text{CFU/mL} = \frac{\text{number of colonies} \times 10^{n/q}}{0.025 \text{ mL}} \]

where: \( n = \) absolute value of dilution, \( q = \) amount of plated suspension (0.025 mL). The CFU/mL value was converted to log₁₀.

Qualitative analysis of the biofilm was performed by fluorescence microscopy. Biofilms formed on the specimen surfaces (n=2) were stained with the FilmTracer™ LIVE/DEAD (Molecular Probes) cell viability kit according to the manufacturer's recommendations. After rinsing, the specimens were transferred to a new 24-well plate and each sample was stained with 1 mL of the 0.3% solution of Syto 9 and Propidium Iodide dyes and incubated at room temperature in the dark for 15 minutes.

After incubation, the specimens were rinsed with PBS, mounted on 0.14 mm thick glass coverslips (24x60 mm) and observed under an inverted microscope with filters, at excitation wavelengths of 490 nm and 546 nm (Axio Observer A1; Carl Zeiss Microscopy Ltd.) at 63x.
magnification. Images were captured and analyzed using ZEN 2.3 lite software (Carl Zeiss; Microscopy Ltd.).

Removal of Adhesive - Analysis

In order to analyze the effectiveness of different hygiene protocols for removing the adhesives from the acrylic resin surfaces, the adhesives were applied in the same way as they were applied for microbiological analysis. The protocols used (n=10) were: Brushing for 1 minute with distilled water; Brushing for 1 minute with liquid soap Protex; Brushing for 1 minute with conventional toothpaste Colgate; Immersion for 5 minutes in 250 mL of warm water (38°C) and 1 Corega Tabs tablet; and Immersion for 5 minutes in 250 mL of warm water and 1 Corega Tabs tablet followed by brushing with the solution itself for 1 minute.

For the brushing groups, an electric brush (Oral-B Pro Health Power; Oral B) coupled to a standardized fixed support was used, with a force of 190 g, associated with a solution of the respective (soap or toothpaste), in the ratio of 1:1.

After hygiene protocols, the specimens were rinsed with distilled water, immersed in 1% dye (Neutral Red; Gold Lab) for 5 minutes and then photographed. The camera was placed on a stand with the objective facing the upper surface of the specimen at an angle of 90 degrees, in order to capture images of undercut areas. The same focal length (lens-to-image distance) was standardized for all specimens. The adhesive remaining on the surface of the samples was quantified in the images, with the aid of Image J Software that was used to calculate the area of the specimen covered with adhesive (%).

Adhesive Strength Analysis

The adhesive force was measured according to the method described by Cartagena et al., 2017\textsuperscript{14}, using two cylinders of thermopolymerizable acrylic resin, so that for each product 10 repetitions were performed. For the test, one of the two cylinder was moistened with tap water. Then
0.3 g of the adhesives (Ultra Corega Cream and Ultra Corega Powder) were applied to each sample so that the entire surface of the cylinder was coated.

Corega Adhesive Strip was cut to cover the entire surface of the cylinder. The specimens were then immersed in distilled water at 37°C for time intervals of 5 minutes, 3 hours, 6 hours, 12 hours and 24 hours. Subsequently, the other specimen in the set of 2 was humidified with a thin layer of artificial saliva and then the cylinders were aligned on the Universal Testing Machine (Emic 1000). Initially, a 12N compression force was applied for 30 seconds, simulating a slight occlusal force. Finally, the tensile test was performed at a speed of 1mm/min, and the maximum force was calculated (N).

Statistical analysis

Statistical analysis was performed using SPSS version 22.0 software. Data were analyzed for distribution (Levene test) and homogeneity (Shapiro-Wills test); for the microbiological and adhesive removal analyses, Kruskal-Wallis test and Dunn post hoc test were used; for the analysis of the adhesive strength the data were submitted to 2-way ANOVA test and Bonferroni post hoc test. The significance level of 5% was adopted.

Results

Microbiological Analysis

The CFU/mL count of each microorganism varied according to the type of product (Table 2). The Strip ($P=.007$) and Powder ($P=.001$) adhesives produced an increase in $C. albicans$ biofilm formation, in comparison with the control group; and the adhesives in the form of Cream ($P<.001$) and Powder ($P<.001$) favored the formation of $P. aeruginosa$ biofilm. There was an increase in the formation of $S. aureus$ biofilm when the Strip adhesive ($P<.001$) was used.

When considering total biofilm, all forms of adhesive were observed to favor biofilm formation when compared with the control group ($P<.05$).

Fluorescence microscopy proved the results obtained by the colony forming unit counts, since the groups in which the different commercial forms of denture adhesives were applied exhibited a high
density of viable cells (in green) in comparison with the control group, demonstrating that the use of these materials favored the formation of multispecies biofilm (Fig. 2).

Removal of Adhesive - Analysis

When considering the factor “Hygiene protocol”, a statistically significant difference was observed regarding the effectiveness of removing adhesives from the specimen surfaces ($P<.05$). Specimens that were subjected to brushing with neutral soap Protex (2.14% [1.87%; 3.36%]) and conventional toothpaste Colgate (2.22% [1.84%; 3.76%]) showed smaller area covered by adhesive than the other groups, with no statistically significant difference between them ($P=1.00$). Immersion in Corega Tabs (91.09% [86.28%; 93.33%]) resulted in the lowest level of efficacy ($P<.05$), with larger area of remaining adhesive being observed.

When considering the factor “Commercial form of denture adhesive”, there was no significant difference ($P=.977$).

When considering the interaction “Hygiene protocol x Commercial form of denture adhesive”, a significant difference was observed ($P<.05$) (Table 3). In general, it was observed that brushing with Colgate and Protex, and Corega Tabs immersion associated with brushing promoted better removal of all commercial forms of denture adhesives tested ($P<.05$).

Brushing with distilled water was more effective for removing Corega Strip Adhesive compared with the other hygiene protocols ($P<.05$) and immersion in Corega Tabs was less effective for removing Corega Strip Adhesive when compared with removing Ultra Corega Cream ($P=.011$).

Adhesive Strength Analysis

There was a significant difference in adhesive strength when considering the “Commercial form of denture adhesive” factor ($P=.002$) independently, as well as in the interaction between the two factors ($P=.045$).

The Ultra Corega Powder adhesive had the highest adhesive strength compared with the other forms of products ($P<.05$) (Fig.3).
The commercial forms of denture adhesive showed different strength values only in the first 5 minutes and 3 hours. In 5 minutes, Corega Strip had the lowest adhesive capacity ($P < .05$) and in 3 hours Ultra Corega Cream showed the lowest value ($P < .05$). Only Corega Strip showed a time-dependent change in adhesive strength, which showed a higher value of strength at 3 hours when compared with 5 minutes ($P = .011$) and 24 hours ($P = .034$) (Fig. 4).

**Discussion**

The results of this study rejected the null hypotheses, as significant differences were found in biofilm formation, the effectiveness of hygiene protocols for removal of the adhesives and the adhesive strength exhibited by different types of adhesives.

Topography, surface roughness and chemical composition of dental materials are critical factors for microorganism adhesion and biofilm formation in the oral cavity.\(^ {29} \) The use of denture adhesives alters the surface of acrylic resin,\(^ {11} \) which may explain the microbiological results of this study.

The Corega Strip and Corega Powder adhesives have polyethylene glycol (PEG) - a water-soluble polymer - in their composition, which efficiently adsorbs proteins, so that the presence of PEG significantly reduces the interaction of microbial cells with the surface of the material. For this reason, studies have reported that PEG is capable of efficiently preventing microbial infections.\(^ {30,31} \) However, this ability to control the biofilm formation process was not observed in the present study. Oliveira Junior *et al.*, 2018\(^ {12} \) observed greater adhesion of *C. albicans* - in both single species and in mixed species - to the Corega Strip, in comparison with the group without adhesive and Corega Cream. The presence of more bioadhesive components, and the absence of humidifiers such as mineral oil and petroleum jelly, which provide the Cream adhesive with a creamy consistency, could perhaps explain these results. However, in the present study there was no difference between the different forms of denture adhesives regarding the formation of biofilm.

The three commercial forms of denture adhesives tested increased the adherence of multispecies biofilm when compared with the Group without adhesive, as was shown in the fluorescence microscopy images, which had a standard "blurry" appearance, probably due to adhesive
components. Both the present study and that of Oliveira Junior et al., 2018\textsuperscript{12} contrast with the study of Rajaram et al., 2017\textsuperscript{23}, in which antifungal effects of three commercial forms of denture adhesives were observed, but the presence of antimicrobial agents in their composition explains the discrepancy in the results. These results reinforce the recommendation to the manufacturers of these products with regard to inclusion of antimicrobial components, in order to prevent the occurrence of local problems, such as prosthetic and systemic stomatitis.\textsuperscript{4,14,32}

When in the oral cavity, the adhesives become viscous due to the absorption of saliva, and then they spread between the alveolar crest and the prosthesis surface. This phenomenon is responsible for their adhesive capacity; however, when removing prostheses to perform hygiene, they can leave residues that are difficult to remove,\textsuperscript{33} and this may limit the effectiveness of daily cleaning. This fact is important because adhesive residues, presence of extracellular matrix or cellular debris can provide greater accumulation of pathogenic microorganisms, favoring recolonization of the prosthesis surface.

Thus, the main strategies for avoiding these problems should focus on hygiene education, especially with regard to the most effective methods, since cleaning can be performed mechanically, chemically or by a combination of the two methods.\textsuperscript{34} In this study, we evaluated the effectiveness of different hygiene protocols for the removal of prosthetic adhesives.

Studies have reported that cream and powder adhesives are more easily liquefied in the mouth than strip adhesives, which have water insoluble components in their composition. In the study by Harada-Hada et al. 2016\textsuperscript{33} the powdered adhesives were more easily removed, followed by cream and strip adhesives, respectively, after the use of 5 prosthetic hygiene solutions. In the present study, no difference was observed regarding the removal of the adhesive when considering the type. The results indicated that brushing with conventional toothpaste Colgate, neutral soap Protex and immersion in Corega Tabs associated with brushing with the solution itself promoted better removal of prosthetic adhesives. Immersion in Corega Tabs alone promoted the worst results, demonstrating that daily cleaning involving mechanical brushing is indispensable.

Taking into consideration the possibility of adverse effects on acrylic resins resulting from chemical agents used for disinfecting or reducing biofilm on dentures, and from using conventional toothpastes due to their abrasive capacity, brushing with neutral soap Protex may be a good choice, as
it is a low cost, easily accessible product with proven antimicrobial efficacy that does not promote adverse effects on acrylic resin.\textsuperscript{34, 35}

The mechanism of prosthesis adhesion to the mucosa by means of the adhesives is almost always contradictory, as a high level of adhesion is required for fixation and low adhesion to facilitate removal. Typically, prosthetic adhesives are expected to provide retention and stability over a period of time so that there is a balance between fixation and possibility of removal.

In the present study, the test used to evaluate the adhesive strength of different commercial forms of denture adhesive was performed as suggested by Zhao \textit{et al.}, 2004\textsuperscript{36} and Cartagena \textit{et al.}, 2017\textsuperscript{14}, with the advantage of being simple and requiring no special equipment to perform it. Acrylic resin cylinders are easily processed and positioning them on the testing machine is simple.

An adhesive interacts with the prosthesis surface on one side and the underlying oral mucosa on the other side over a period of time. A thin layer of material is applied to the inner surface of the prosthesis, which is then inserted into the oral cavity. Hydrophilic compounds absorb and maintain water to improve their adhesion strength and hydrophobic compounds prevent excessive swelling and dissolution.\textsuperscript{37,38}

Considering the factor of commercial form alone, the data showed that the adhesive presented in powder form had a higher adhesive strength, compared with the other forms. High viscosity is required for retention.\textsuperscript{39} In this study, the dental prosthesis adhesive powder was prepared by mixing the powder with distilled water. Therefore, a water-soluble polymer dissolution reaction had already been initiated in this type of material. The results may be associated with the fact that when in contact with water, the power becomes stickier, takes on a gum-shape, which favors its adhesion to the prosthetic surface.\textsuperscript{40}

Studies have reported higher adhesion strength immediately after application of the adhesive, with peak again within 3 to 6 hours of use, followed by loss of efficacy over time\textsuperscript{9,41} due to breakdown of the adhesive by oral fluids or gradual degradation.\textsuperscript{42} In the present study, Corega Strip Adhesive showed a time-dependent change in adhesive strength, which showed a higher strength value in 3 hours, however this difference may be clinically irrelevant. In general, all commercial forms of adhesives showed good adhesive strength during the course of 24 hours of use, which may provide
safety and patient comfort for longer than the expected time (12 to 16 hours).\textsuperscript{24} However, the use of ill-fitting dentures with the aid of an adhesive could lead to the patient experiencing deterioration of the denture-bearing oral structures. Periodic examinations should be highly encouraged to ensure that the denture continues to fit well.

Within the limitations of this in vitro study, it was possible to conclude that all forms of denture adhesive tested were effective in retaining removable prosthesis for a satisfactory period of time. Daily treatments with mechanical cleaning of the prosthesis are necessary and important for removing these adhesives since their presence can favor biofilm accumulation. Therefore, the advantages and disadvantages related to their use should be discussed with the patient before prescribing these materials.

Acknowledgements

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References


**Figure Legends**

Figure 1. Flowchart of study.

Figure 2. Fluorescence microscopy of biofilm (63x). A. Control (acrylic resin without adhesive); B. Ultra Corega Cream, C. Corega Strip Adhesive and D. Ultra Corega Powder.

Figure 3. Adhesive Force (N) of materials in function of commercial form.

Figure 4. Comparison of adhesive force (N) considering commercial forms of denture adhesives and time interaction. *Same letters indicate statistical equality of different commercial forms of denture adhesives in the same time interval. Same symbols indicate statistical equality of strip adhesive in different time intervals (P>0.05; 2-way ANOVA test and Bonferroni post-test).
## Tables

**Table 1.** Composition and manufacturer of Ultra Corega cream, Ultra Corega powder and Corega strips

<table>
<thead>
<tr>
<th>Adhesive</th>
<th>Manufacturer</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra Corega Cream</td>
<td>STAFFORD-MILLER IRELAND Limited, GlaxoSmithKline, Youghal Road, Dungarvan, Co. Waterford, Ireland</td>
<td>Sodium/calcium salts of poly (methylvinylether/maleic acid), carboxymethylcellulose, mineral oil, petroleum jelly</td>
</tr>
</tbody>
</table>
Table 2. Comparison of colony forming units count (CFU / mL) in log\(_{10}\) under different experimental conditions.

<table>
<thead>
<tr>
<th></th>
<th>C. albicans</th>
<th>P. aeruginosa</th>
<th>S. aureus</th>
<th>Total microbiota</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control – Without adhesive</td>
<td>3.22 [2.95;3.54](^A)</td>
<td>6.11 [5.79;6.48](^A)</td>
<td>5.89 [5.66;6.21](^A)</td>
<td>5.70 [4.58;5.63](^A)</td>
</tr>
<tr>
<td>Ultra Corega Cream</td>
<td>3.55 [3.31;4.18](^{AB})</td>
<td>8.01 [7.81;8.25](^B)</td>
<td>6.32 [6.04;6.72](^{AB})</td>
<td>6.32 [5.36;6.74](^B)</td>
</tr>
<tr>
<td>Corega Strip</td>
<td>4.32 [3.89;4.49](^B)</td>
<td>7.56 [7.08;7.76](^{AB})</td>
<td>7.01 [6.80;7.30](^B)</td>
<td>6.81 [5.65;6.79](^B)</td>
</tr>
<tr>
<td>Ultra Corega Powder</td>
<td>4.52 [3.91;4.90](^B)</td>
<td>8.02 [7.39;8.15](^B)</td>
<td>6.59 [6.14;6.73](^{AB})</td>
<td>6.59 [5.64;6.77](^B)</td>
</tr>
</tbody>
</table>

Data are expressed as median [Confidence Interval] (n=10). * Different letters indicate significant difference between groups for the same microorganism. Kruskal-Wallis followed by Dunn's post hoc test. \(P<.05\).
Table 3. Remaining adhesive on sample surface (%) according to hygiene protocol and commercial form of denture adhesive.

<table>
<thead>
<tr>
<th></th>
<th>Ultra Corega Cream</th>
<th>Corega Strip</th>
<th>Ultra Corega Powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brushing with conventional toothpaste Colgate</td>
<td>2.3 [1.97; 4.05]^{Aa}</td>
<td>2.16 [1.37; 4.35]^{Aa}</td>
<td>1.02 [-0.19; 5.26]^{Aa}</td>
</tr>
<tr>
<td>Brushing with neutral soap Protex</td>
<td>2.18 [1.24; 2.98]^{Aa}</td>
<td>2.71 [1.48; 5.20]^{Aa}</td>
<td>1.96 [1.05; 3.76]^{Aa}</td>
</tr>
<tr>
<td>Immersion in Corega Tabs + Brushing</td>
<td>4.72 [2.07; 10.48]^{Aba}</td>
<td>5.68 [2.28; 18.45]^{Aa}</td>
<td>6.05 [5.11; 9.32]^{Aba}</td>
</tr>
<tr>
<td>Brushing with distilled water</td>
<td>22.29 [17.33; 40.00]^{BCa}</td>
<td>7.67 [4.72; 16.72]^{ABb}</td>
<td>28.06 [19.71; 33.72]^{BCa}</td>
</tr>
<tr>
<td>Immersion in Corega Tabs</td>
<td>85.04 [74.93; 91.09]^{Ca}</td>
<td>94.14 [92.00; 96.96]^{Bb}</td>
<td>93.79 [87.01; 97.37]^{Cab}</td>
</tr>
</tbody>
</table>

Data are expressed as median [Confidence Interval] (n=10). * Different capital letters indicate significant difference between lines; Different lowercase letters indicate significant difference between columns. Kruskal-Wallis followed by Dunn's post hoc test. \( P < .05 \).
Figures

Figure 1

SAMPLES OF THE HEAT-CURED POLY (METHYL METHACRYLATE) RESIN

Rectangular (5mm width x 30mm long and 3mm thick)

Control (No Adhesive) (n=12)

Ultra Corega Cream (n=12)

Ultra Corega Powder (n=12)

Corega Strip Adhesive (n=12)

Microbiological analysis

Ultra Corega Cream (n=50)

Ultra Corega Powder (n=50)

Corega Strip Adhesive (n=50)

Adhesive strength analysis

5 min (n=10 per group)

3 h (n=10 per group)

6 h (n=10 per group)

12 h (n=10 per group)

24 h (n=10 per group)

Removal of adhesive analysis

Ultra Corega Cream (n=50)

Ultra Corega Powder (n=50)

Corega Strip Adhesive (n=50)

Brushing with neutral soap (n=10 per group)

Brushing with conventional toothpaste (n=10 per group)

Immersion in Corega Tabs (n=10 per group)

Brushing with distilled water (n=10 per group)

Immersion in Corega Tabs (n=10 per group)

Figure 2
Figure 3

Figure 4