2021
Julho- Ed. 28
Vol. 1. Págs. 3-16

JNT - FACIT BUSINESS AND TECHNOLOGY JOURNAL ISSN: 2526-4281 - QUALIS B1

COLOR STABILITY OF RESIN' DENTURE BASE UNDER ULTRASONIC CLEANER EFFECT AND DIFFERENT CLEANSING AGENTS

ESTABILIDADE DE COR DA BASE DE RESINA PARA PRÓTESE SOB EFEITO DE LIMPEZA ULTRASSÔNICA E DIFERENTES AGENTES DE LIMPEZA

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RESUMO

Objetivos: Este estudo teve como objetivo comparar a mudança de cor, após a ação de soluções desinfetantes (Listerine®, Cepacol®, Periogard®, Riozyme®, hipoclorito de sódio a 1%, e água da torneira como controle), e a ação da cuba ultrassônica. **Métodos:** Foram obtidos 60 corpos de prova, incluídos em bases cilíndricas de resina termopolimerizável, originando 12 grupos (n = 5). Destes, seis grupos foram submetidos aleatoriamente à ação da cuba ultrassônica com soluções desinfetantes por 180 minutos cada, e seis grupos foram imersos nas soluções por igual período. Os valores de mudança de cor na resina da base das próteses foram avaliados por meio do Espectrofotômetro PCB 6807, utilizando a escala CIE L * a * b * para determinação da cor, comparando as amostras antes e após o teste. Para a análise estatística, foi utilizado o teste ANOVA two-way. **Resultados:** Não houve alteração estatisticamente significativa na cor das bases das próteses de acrílico, indicando que o método é seguro para a desinfecção das próteses, em qualquer uma das soluções e situações testadas. **Conclusões:** A soluções testadas associadas ou não à cuba ultrassônica não promoveram alteração de cor nas bases acrílicas, podendo ser usadas pelo tempo determinado.

Palavras-chave: Espectrofotometria colorimétrica. Soluções desinfectantes. Desinfecção.

ABSTRACT

Objectives: This study aimed to compare color change, after the action of disinfectant solutions (Listerine®, Cepacol®, Periogard®, Riozyme®, sodium hypochlorite a 1%, and tap water as a control), and the action of the vat ultrasonic. **Methods:** Sixty specimens were obtained, included in cylindrical bases of thermopolymerizable resin, originating 12 groups (n = 5). Of these, six groups were randomly subjected to the ultrasonic vat's action with disinfectant solutions for 180 minutes each, and six groups were immersed in the solutions for an equal period. The values of color change in the resin of the prostheses' base were evaluated using the PCB Spectrophotometer 6807, using the CIE L * a * b * scale to determine the color, by comparing the samples before and after the test. For the statistical analysis, the two-way ANOVA test was used. **Results:** There was no statistically significant change in the color of acrylic prostheses' bases, indicating that the method is

Adriana Barbosa RIBEIRO; Henis MIAN; Aline Barbosa RIBEIRO; Cláudia Helena SILVA-LOVATO; Vinícius PEDRAZZI. Color stability of resin' denture base under ultrasonic cleaner effect and different cleansing agents. JNT- Facit Business and Technology Journal. QUALIS B1. 2021. Julho. Ed. 28. V. 1. Págs. 3-16. ISSN: 2526-4281 http://revistas.faculdadefacit.edu.br. E-mail: jnt@faculdadefacit.edu.br.

safe for disinfecting the prostheses, with any of the solutions and situations tested. **Conclusions:** The tested solutions associated or not with the ultrasonic vat did not change the color of the acrylic bases and can be used for a specified period of time.

Keywords: Colorimetric spectrophotometry. Disinfectant solutions. Disinfection.

INTRODUCTION

Complete dentures can promote aesthetic, functional ability, comfort, and better quality of life to patients (REGIS *et al*., 2013). However, the abiotic surface based on acrylic resin can contribute to the deposition and formation of oral biofilm, a contamination source acting as a reservoir of infection (PARANHOS *et al*., 2019). Oral infection can lead to local diseases and further aggravate or trigger systemic diseases (MACIAG *et al*., 2014; MACIAG *et al*., 2017; OSMENDA *et al*., 2017). Therefore, it is essential to provide prosthetic treatment, but that the patient knows how to use it with the knowledge of proper maintenance and hygiene (PARANHOS *et al*., 2019; BADARÓ *et al*., 2020).

In vitro and clinical studies show that chemical disinfection and mechanical cleaning are utilized in clinical steps, laboratory, and dentures users' daily routine (ARRUDA *et al*., 2017; BADARÓ *et al*., 2017a; BADARÓ *et al*., 2017b; BADARÓ *et al*., 2020). However, it had been demonstrated that some cleansing agents could produce changes in different physical and mechanical properties of denture base resins (BADARÓ *et al*., 2017a; PERACINI *et al*., 2017; ZOCCOLOTTI *et al*., 2018), such as change color stability (WALDEMARIN *et al*., 2013; HOLLIS *et al*., 2015) decrease in the transverse strength and hardness (GOIATO *et al*., 2010; MIAN *et al*., 2013), degradation of the surface appearance of resins and corrosion of metal surfaces of removable denture devices (FELIPUCCI *et al*., 2011).

Denture base resins must have the color stability and match the oral tissue appearance during the clinical use time for optimal esthetic results (HOLLIS *et al*., 2013; AYAZ and USTUN, 2020). Besides, color stability of a denture resin is crucial because it is related to the durability of the material, which subjected to intrinsic and extrinsic factors that cause color change (RUTKUNAS *et al*., 2010; AYAZ and USTUN, 2020).

The color change of composites is a constant issue and has been studied intensively, through research using artificial accelerated aging by UV irradiation (UCHIDA *et al*., 1998; STOBER *et al*., 2001), humidity (FRUITS *et al*., 1997), water action (BURROW *et al*., 1991; VICHI *et al*., 2004), *in vitro* stains, by coloring solutions, such as coffee and tea (KHOKHAR *et al*., 1991; DIETSCHI *et al*., 1994; AYAZ *et al*., 2020) and some in vivo studies (ROSENTRITT *et al*., 1998). However, few studies attempted to evaluate the ultrasonic device as an auxiliary method for dentures' hygiene (MIAN *et al*., 2013; CRUZ *et al*., 2011).

Ultrasonic cleaning is more effective than some effervescent denture cleaner products in reducing biofilm in denture appliances (RAAB *et al*., 1991), and extrinsic discoloration. Besides, ultrasonic cleaners could be associated with different disinfectant solutions, enhancing their bactericidal action (CRUZ *et al*., 2011). The routine ultrasonic cleaning should be performed to avoid the possible accumulation of microorganisms in the laminated mesh structure of complete maxillary denture. Besides, it shows actual results among the severely care-dependent. Such interventions can be quickly and cheaply implemented in routine daily care (SCHWINDLING *et al*., 2018).

The purpose of this study was to measure the in vitro the influence of disinfectant solutions, associated or not to ultrasonic cleaning, on the color stability of acrylic denture base resin. Color change was the dependent variable. The null hypothesis was that no color change would be found in the denture base resin after when cleaned with an ultrasonic cleaner containing different cleansing agents.

METHODS

A PVC tube (25mm Ø and 10 mm high) was filled with dental stone. After hardening, it was included in another PVC tube with vinyl polysiloxane impression material (Elite Double 8), creating a matrix to fabricate the standard wax cylinders. After the dental stone had set, the flasks were opened, and the wax was removed using boiling water. Cylindrical cavities were formed in the stone and used as moulds to fabricate heat-polymerizing acrylic resin specimens (MIAN *et al*., 2013). The dental stone was lubricated with a thin layer of acrylic separating film (Cel-Lac; SS White Artigos Dentários, Rio de Janeiro, Brazil).

The denture base resin's liquid and powder were then proportioned and mixed according to the manufacturer's instructions and packed at the late dough stage into the mould's cylindrical cavities. The flasks were clamped, pressed using a hydraulic press (Vipi Dental, Pirassununga, São Paulo, SP, Brazil) and submitted a curing cycle of 180 minutes at 60 °C and 9 hours at 70 °C in water, after which they were allowed to return to room temperature in the water bath, following conventional procedures required for denture confection and following the manufacturer's instructions of the acrylic base resin. Specimens were polished with sandpaper numbers 80, 140, 200, 400, and pumice stone, zinc oxide and felt disc similar to acrylic prostheses' finish. Subsequently, the specimens were kept immersed in a distilled water bath at 37º C, in 100% relative humidity and absence of light (MIAN *et al*., 2013).

Sixty 10×10×2-mm specimens of heat-polymerizing acrylic resin (Vip Cril, Dental Vipi Ltda, Pirassununga, Brazil) were randomly subdivided into two subgroups according to the disinfection procedures (associated with ultrasonic cleaning or not). Five disinfectant solutions were selected (Table 1), and water was used as control. The cleansing agents were employed following the manufacturer's instructions.

To determine the effect of chemical solutions on color stability, specimens (n=5) were randomly immersed for 60 minutes into a beaker containing one of the five disinfection solutions (Listerine®, Cepacol®, Periogard®, Riozyme II® and Cloro Rio® 1%) or distilled water, in a total of 30 specimens. The other 30 specimens were randomly divided (n=5) and immersed into the five disinfectants solutions or water and placed in an ultrasonic cleaner, in a total of 180 minutes (MIAN *et al*., 2013). The ultrasonic cleaner used produced a potency of 40 kHz.

Table 1. Products used

Commercial name	Description	Manufacturer
Wilson	Pink wax n. 7	Polidental Indústria e Comércio Ltda., Cotia, Brazil.
Tubos Tigre	PVC tubes	Tigre S/A,Tubos e Conexões, Joinville, SC, Brazil
Elite Double 8	addition silicone	Zhermack – Italy
Vipi Cril	heat-activated acrylic denture base resin, bright pink colour	VIPI Indústria, Comércio, Exportação e Importação de Produtos Odontológicos Ltda
Listerine®	Essential oils (thymol, eucalyptol, menthol and alcohol)	Warner-Lambert Co, Morris Plains, Nem Jersey – USA
Cepacol®	cetylpyridinium chloride	Aventis Pharma Ltda, Suzano – SP.
Periogard®	Chlorhexidine gluconate 0.12%	Colgate-Palmolive Indústria e Comércio Ltda, São Bernardo do Campo – SP.
Riozyme II®	Protease, lipase and amylase	Indústria Farmacêutica Rioquímica Ltda, São José do Rio Preto – SP.
Cloro Rio 1%®	Sodium hypochlorite 1%	Indústria Farmacêutica Rioquímica Ltda, São José do Rio Preto – SP.
Ultrasonic Cleaner	1440D model, with water heating, 40 kHz frequency.	Odontobrás, Ribeirão Preto, Brasil.
Spectrophotometer	PCB 6807 BYK	GARDNER, Geretsried, Alemanha

The spectrocolorimeter was calibrated with white and black calibration plates before each measurement, as instructed by the manufacturer. Each specimen was rinsed with distilled water and dried with absorbent paper before color measurement. Baseline colorimetry values were collected for each specimen with PCB 6807 BYK GARDNER (Geretsried, Alemanha). The samples were coupled under the spectrophotometer. After activation, 30 LED lamps, with 10 different colors, arranged in a circular shape, was ignite and focus the light beam at 45º with the material surface. This beam was reflected at 0º back to the device, and thus, it was captures and records the values of L *, a * and b * of each sample.

Mean and standard deviations of color change (DE) values were determined by using the Colorimetric Spectrophotometer followed the CIE L * a * b * system, recommended by the CIE (Commission Internationale de l'Éclairage). This consists of two

axes a * and b *, which have right angles and represent the hue or color's dimension. The coordinates a * and b * represent the chromatic scale, with the value a * determining the variations between red (+ a *) and green (-a *); and the value b *, the variations between yellow (+ b *) and blue (-b *). The third axis is the L * brightness, that is, the color variation between black (L = 0) and white (L = 100) and this is perpendicular to the a* b * plane. With this system any color can be specified with the coordinates L *, a *, b *

Statistical analysis was performed with software NCSS 2000 (NCSS Statistical Software, Kaysville, USA). The results were tested regarding the normality of distribution with Shapiro–Wilk test and the homogeneity of variance using Levene test. The data were normally distributed, using a two-way analysis of variance (ANOVA) with significance level $P < 0.05$.

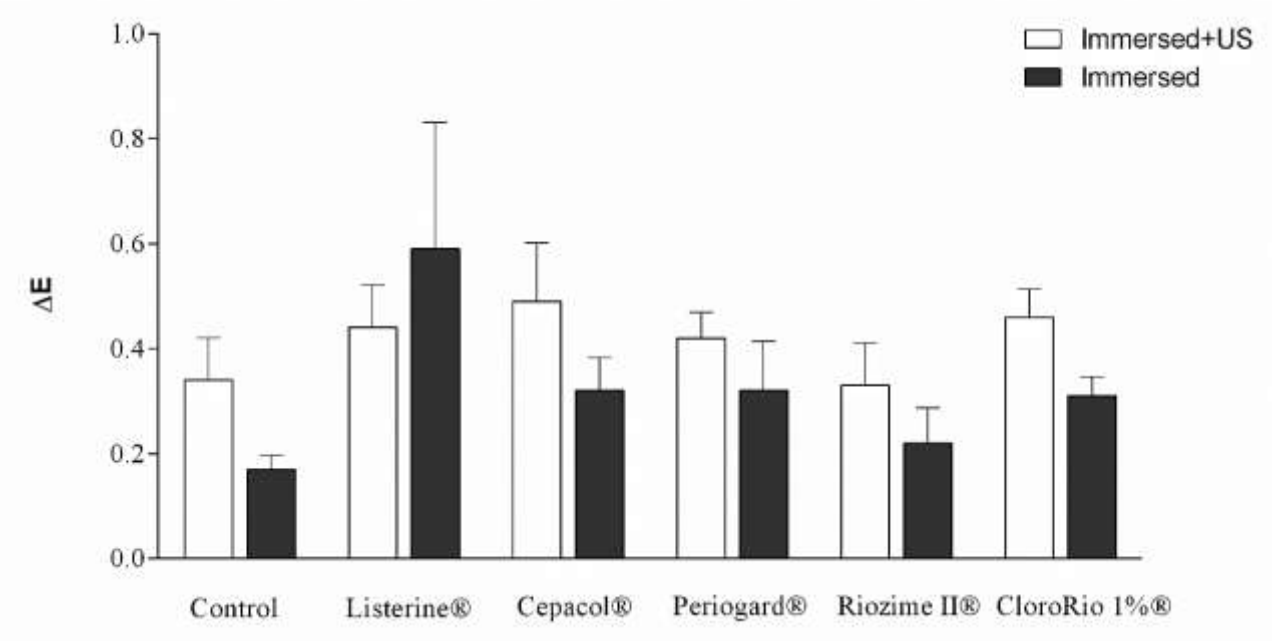
RESULTS

The results obtained in the spectrophotometer test, for the thermally activated resin surface, were evaluated after the action of the solutions and immersion in the ultrasonic device for 180 minutes. The analysis of variance, with two variation factors (solution and use of ultrasound) of the variable's delta E, delta L, delta a and delta b, and possible interactions (ΔLÄaÄb * and ΔE) did not show a statistically significant change due to the solution used or the use of ultrasound, considering the level of significance $\alpha=.05$ (Table 2). However, there was a tendency for the piece's lightening and accentuation in the colors blue and green (Figure 1).

Table 2. Mean (±SD) of CIELab color measurements after treatment each cleansing agents and use or not of ultrasonic device.

Solution	L* Mean (±SD)			a* Mean (±SD)			b* Mean (±SD)		
	I+US	Immersed	*P* value	I+US	Immersed	*P* value	I+US	Immersed	*P* value
Control	45,97 (±0,45)	46,49 (±0,36)	0,13	22,09 (±0,54)	21,99 (±0,35)	0,35	11,82 (±0,22)	11,77 (±0,26)	0,82
Listerine®	46,27 (±1,47	46,50 (±0,53)		21,72 (±0,23)	21,84 (±0,44)		12,12 (±0,44)	11,55 (±0,53)	
Cepacol®	45,73 (±0,41)	46,18 (±0,57)		22,46 (±0,46)	22,00 (±0,62)		11,61 (±0,46)	11,87 (±0,50)	
Periogard®	45,86 (±0,57)	46,11 (±0,50)		22,18 (±0,69)	21,76 (±0,36)		12,05 (±0,27)	11,71 (±0,61)	
Riozime II®	45,95 (±0,42)	45,29 (±0,27)		21,99 (±0,47)	21,93 (±0,74)		11,94 (±0,23)	11,52 (±0,30)	
CloroRio 1%®	45,78 (±0,32)	45,74 (±0,79)		21,18 (±0,35)	22,11 (±0,26)		11,80 (±0,14)	11,82 (±0,38)	
***P* value**	0,84			0,97			0,78		

Figure 1. Means (±SD) of color changes (ΔE) for immersed and ultrasonic cleanser and immersed in different cleansing agents.



DISCUSSION

Denture cleansers typically contain a combination of ingredients including oxidizing, effervescing, and chelating agents along with detergents and enzymes (HOLLIS *et al*., 2015). Brushing and washing with chemical agents, use of effervescent cleansing tablets, microwave irradiation and immersion in disinfectant solutions are commonly used to clean denture based in acrylic resin to reduce extrinsic discoloration, microorganism's colonization, calculus, and to avoid the risk of cross-infection (KAHN *et al*., 1982; PAVARINA, *et al*., 2003; BUERGERS *et al*., 2008). However, several studies have highlighted that some disinfection agents could undermine the properties and structure of denture base resin (POLYZOIS *et al*., 1995; DA SILVA *et al*., 2008). Thus, the color changes and porosity in hard denture bases can reduce dentures' durability or retain colony formation units (CRUZ *et al*., 2011).

Susceptibility to staining is determined by the properties of the denture base resins. The main staining mechanism is probably sorption of liquids. A denture base resin that absorbs water can have polymer matrix expanded and separated the polymer chains. It is also likely to absorb other liquids that contain staining agents (FERRACANE *et al*., 2006; HOLLIS *et al*., 2015).

Previous studies have investigated the removing contaminants from the surface of denture resins when immerses in effervescent tablets and the ultrasonic cleaner (RAAB *et al*., 1991; CRUZ *et al*., 2011). Was found that the use of ultrasonic was more effective than effervescent tablets in disinfecting the dentures (RAAB *et al*., 1991). However, they warn of a greater risk of the cavitation process changing the physical structure of the dentures making it friable, decreasing its durability, and color change (ZOCCOLOTTI *et al*., 2018; HOLLIS *et al*., 2015; GOIATO *et al*., 2010).

The concern that the action of the ultrasonic cleaner could somehow negatively affect the color change of the bases in acrylic resin was alleviated by the results obtained in the present study (MIAN *et al*., 2013), that did not show significant differences between the treatments with simple immersion in disinfectant solutions and immersion in disinfectant solutions under the action of the ultrasonic cleaner, for 180 minutes, therefore, the null hypothesis was accepted.

However, it is important to show the spectrometry results demonstrated that there is a tendency to pigment the acrylic resin of the prosthesis base (HOLLIS *et al*., 2015). These values are not confirmed within the statistical limits used and can be clinically irrelevant, but there is a trend towards blue, green and whitening of the denture base. Part of this pigmentation is justified by coloring solutions in the composition of disinfectants, which define their commercial color, as is the case with Listerine®, Cepacol® and Periogard® (FELIPUCCI *et al*., 2011). It would be interesting to investigate whether the same product, with the same active principle, but with different dyes, would present the same results for the color change. It should be sought then the development of products with an active principle, but that promotes the smallest change possible.

It is worth considering that part of the pigmentation process does not depend on the dye present but on the degree of aggression that the disinfectant promotes, on the resin surface, as is the case with hypochlorite a 1% (CRUZ *et al*., 2011; BADARÓ *et al*., 2017b; ARRUDA *et al*., 2017). Despite being commercially presented as colorless, it promoted the resin's whitening and a tendency to green (BADARÓ *et al*., 2017b).

Riozyme II®, on the other hand, had the smallest color changes, this is justified taking into account that its form of commercial presentation is colorless, and according to the manufacturer's recommendations, it should be used in the proportion of 5mL for each liter of water, thus becoming subject to a substantial dilution, reducing the risk of pigmentation of the resin.

The use time of the ultrasonic cleaner recommended by the manufacturer is 15 to 20 minutes. For the color change, the ultrasonic was initially used for 60 minutes, simulating 3 to 4 returns that the patient would have to make to clinic adjust the denture. But after 60 minutes, the second reading on the spectrophotometer was performed, and minimal changes were observed. Thus, it was decided to use the ultrasonic vat for another 120 minutes, a total of 180 minutes of ultrasonic action.

The investigation of which cleaner agent promoted the best disinfection action, from a microbiological point of view, would justify the continuation of the present study. Besides, whether the ultrasonic cleaner's action potentiated this action as found in the study of Raab *et al*. (1991). Because if there were no color change statistically significant, one can choose to use the most effective one on other aspects such as disinfection power, cost or ease of use (ZOCCOLOTTI *et al*., 2018).

However, most cleansing agents' effectiveness still seems to depend more on patient awareness and routine home care than on the inherent skill of any sanitizer. If not used regularly, or if the deposits accumulate over a long period, many hygiene agents will not live up to their expectations (CRUZ *et al*., 2011; BADARÓ *et al*., 2020). Besides, one should not lose sight that patients with complete dentures are usually elderly, and increasingly have difficulties with access to clinical care with age. This can be seen in the challenges imposed by age, such as physical or psychological restrictions of the odontogeriatric patient. To include ultrasonic cleaner as an accessory of hygiene daily can be an important implemented in nursing homes and hospital environments (CRUZ *et al*., 2011) even more now that the isolation and sanitary measures are necessary (GONZÁLEZ-OLMO *et al*., 2020).

Regarding the use of the ultrasonic cleaner, it would be important to highlight the need for studies that assess its efficiency as a function of the time of use and heating resulting from the cavitation process (CRUZ *et al*., 2011). And the risk of toxicity by inhaling the vapors, which are retained on its cover, which are aspirated by the user after the end of the cycle, depending on the different solutions that can be used.

Limitations of the present study included that although the standardization of the staining and cleansing conditions and is important to determine small systematic differences between factors desired in an in vitro study, the results not directly applied to clinical realities, since the presence of saliva and other oral fluids was not considered.

Based only results and considering the limitation of the study, can suggest the routine use of the simple immersion in disinfectant solutions and immersion in disinfectant solutions under the action of the ultrasonic cleaner as washing and disinfection procedures of removable acrylic prostheses in the short term, with base in the integrity of the bases regarding the absence of differences in color change.

CONCLUSION

Within the limitations of this study, the following concluded were found:

1. The disinfectant solutions tested did not produce significant alteration on color stability on denture base resin.

2. There was no significant effect on the color changes when the ultrasonic cleaner was associated with the solutions.

ACKNOWLEDGEMENTS

We are grateful to Dental Vipi Ltda. and Odontobrás for supporting this study donating some of the tested materials**.**

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