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Effect of Denture Cleansers on Metal Ion Release and Surface Roughness of Denture Base Materials

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Chemical disinfectants are usually associated with mechanical methods to remove stains and reduce biofilm formation. This study evaluated the effect of disinfectants on release of metal ions and surface roughness of commercially pure titanium, metal alloys, and heat-polymerized acrylic resin, simulating 180 immersion trials. Disk-shaped specimens were fabricated with commercially pure titanium (Tritan), nickel-chromium-molybdenum-titanium (Vi-Star), nickel-chromium (Fit Cast-SB Plus), and nickel-chromium-beryllium (Fit Cast-V) alloys. Each cast disk was invested in the flasks, incorporating the metal disk to the heat-polymerized acrylic resin. The specimens (n=5) were immersed in these solutions: sodium hypochlorite 0.05%, Periogard, Cepacol, Corega Tabs, Medical Interporous, and Polident. Deionized water was used as a control. The quantitative analysis of metal ion release was performed using inductively coupled plasma mass spectrometry (ELAN DRC II). A surface analyzer (Surftest SJ-201P) was used to measure the surface roughness (μm). Data were recorded before and after the immersions and evaluated by two-way ANOVA and Tukey's test (α=0.05). The nickel release proved most significant with the Vi-Star and Fit Cast-V alloys after immersion in Medical Interporous. There was a significant difference in surface roughness of the resin (p=0.011) after immersion. Cepacol caused significantly higher resin roughness. The immersion products had no influence on metal roughness (p=0.388). It could be concluded that the tested alloys can be considered safe for removable denture fabrication, but disinfectant solutions as Cepacol and Medical Interporous tablet for daily denture immersion should be used with caution because it caused greater resin surface roughness and greater ion release, respectively.

Key Words: denture hygiene, commercially pure titanium, nickel-chromium alloys, heat-polymerized acrylic resin.

INTRODUCTION

Microbial biofilm is the main etiologic factor of chronic atrophic candidiasis, also known as denture stomatitis (1). The fitting surface of the denture is the main reservoir of *Candida albicans* (2). Therefore, biofilm control with an adequate hygiene of the oral mucosa and the prosthesis would avoid microbial adhesion. Irregularities and porosities present on denture surfaces offer a favorable niche to retain stain and microbial plaque (3).

The use of chemical disinfectants is usually associated with mechanical methods, and their efficacy in removing stains and reducing biofilm formation on the surface irregularities of dentures has been reported (4). Effervescent tablets are classified as chemical soak-type products, and when dissolved in water the sodium perborate readily decomposes to form an alkaline peroxide solution. This peroxide solution subsequently releases oxygen, thereby enabling a mechanical cleaning by the oxygen bubbles in addition to the chemical cleaning (1). Nevertheless, the factors contributing to the infrequent use of alkaline peroxide include insufficient information being provided to the patient, high cost, and

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restricted market access.

Sodium hypochlorite (NaOCl) diluted in water has been indicated for complete denture disinfection. This method is effective in reducing *Candida albicans* in patients with denture stomatitis and prevention (5), depending on the concentration and the immersion time. Household bleaches are recommended for occasional overnight soaking, so their use as everyday chemical denture disinfection products would demand a study of lower concentrations during longer periods.

Antimicrobial mouthwashes are also indicated as denture cleansers (6). Chlorhexidine digluconate, cetylpyridinium chloride, or triclosan/copolymer solutions significantly inhibit microbial colonization, but they lack effectiveness against mature biofilm with *Candida albicans* (7).

Possible deleterious effects on the denture materials after immersion in cleansing solutions can occur (8). Metal alloys can corrode or stain as a result of surface contact with the chlorine or oxygen present in some commercial cleansers (9). Nickel-chromium alloys appear to be an appropriate substitute for gold alloys, and they offer low cost and lower specific weight. Better physical properties, such as mechanical resistance, hardness, and corrosion resistance, motivated the development of those alloys (10). In spite of the advantages of titanium alloys, like biocompatibility, corrosion resistance, low specific weight, low modulus of elasticity, low thermal conductivity, high mechanical resistance (11), as well as great acceptance by patients, there have been reports of tarnish (surface discoloration) (12) and corrosion (surface pitting) (13).

The purpose of this study was to evaluate the effect of disinfectants on the release of metal ions and surface roughness of commercially pure titanium, metal alloys, and heat-polymerized acrylic resin, by simulating 180 consecutive hygiene immersion trials. The null hypothesis tested was that immersion in disinfectant solutions would not influence metal ion release or the surface roughness of denture materials.

MATERIAL AND METHODS

Specimen Fabrication

Disk-shaped wax patterns (GEO; Renfert GmbH, Hilzingen, Germany) (12 x 3 mm) were sprued, invested, and casted in each metal (Table 1) according to the manufacturer's instructions. After casting, the metal disks were finished with 180-grit sandpaper (Norton Abrasives, Saint-Gobain, France) in a water-cooled polishing machine (AROTEC, Cotia, SP, Brazil) and then washed to remove any metal particles or sand granules.

Metallic flasks were previously prepared by Teflon rectangular matrices (38 x 18 x 4 mm) and then invested with type IV dental stone (Durone; Dentsply Dentsply Ind. e Com. Ltda., Petrópolis, RJ, Brazil). The Teflon matrices were removed and the cast disks were inserted in the flasks in the left side of each rectangular mold. Before packing the heat-polymerized acrylic resin Lucitone 550 (Dentsply Ind. Com. Ltda.), the mold was isolated with two coats of a liquid separating medium (Cel-Lac; SS White, Rio de Janeiro, RJ, Brazil).

Thirty-five specimens of each metal were prepared. The resin was handled, packed, and pressed into the mold according to the manufacturer's instructions. The polymerization cycle was undertaken in by immersion in water at 73°C for 90 min and at 94°C for 30 min. All flasks were allowed to cool at room temperature before opening. After polymerization, the specimens were immersed in distilled water at 37 ± 1°C for 50 ± 2 h for residual monomer reduction (14).

Excess resin was trimmed, and one of the surfaces was finished using 180-, 220-, 400-, 600- and 1200-grit sandpapers (Norton Abrasives) in the polishing machine, followed by polishing cloths soaked with 1-µm diamond suspension (Fortel Ind. Com., São Paulo, SP, Brazil).

Immersion Procedures

The specimens were distributed into groups

Table 1. Manufacturer and composition of the metals.

Commercial brands	Manufacturer	Composition
Tritan®	Dentaurum Inc., Pforzheim, Germany	Ti min 99.5%, Fe, O, H, N, C
Vi-Star®	Talladium do Brasil, Curitiba, PR, Brazil	Ni 72%, Cr 17%, Mo 4.5%, Ti 6%
Fit Cast-SB Plus®	Talladium do Brasil, Curitiba, PR, Brazil	Ni 60.75%, Cr 25%, Mo 10%, Si 2%, Ti<1%
Fit Cast-V®	Talladium do Brasil, Curitiba, PR, Brazil	Ni 73%, Cr 14%, Mo 8.5%, Al 1.7%, Be 1.8%

(n=5) and immersed in one of the following cleanser solutions: 0.05% NaOCl (Q'Boa; Anhembi S/A, Osasco, SP, Brazil) for 10 min; 0.12% chlorhexidine digluconate (Periogard; Colgate-Palmolive Ind., São Bernardo do Campo, SP, Brazil) for 10 min; cetylpyridinium chloride 0.500 mg (Cepacol; Sanofi-Aventis Farmacêutica Ltda., São Paulo, SP, Brazil) for 10 min; Corega Tabs (sodium perborate and enzyme; Stafford-Miller Ind., Rio de Janeiro, RJ, Brazil) for 5 min; Medical Interporous (citric acid; MST-Laboratories AG, Liechtenstein) for 15 min; and Polident 3 Minute (sodium perborate and enzyme; GlaxoSmithKline, Clifton, NJ, USA) for 3 min. The control group was immersed in 200 mL of deionized water for 15 min. The 0.05% NaOCl solution was prepared by mixing 200 mL of deionized water and 6 mL of Q'Boa (2% NaOCl). The Periogard and Cepacol groups were immersed in 50 mL of the solution. The effervescent cleansers were prepared according to the manufacturer's directions, by adding one tablet to 200 mL of warm deionized water (40ºC) (15). The five specimens of each group were immersed at one time in the same container with the surface to be measured facing upward, and the solution covered all specimens.

After immersion, the resin specimens were removed from the chemical solutions, thoroughly washed in deionized water, dried with absorbent paper, and then this procedure of immersion was repeated. All experiments simulated 180 consecutive hygiene immersion trials.

Metal Ion Release Test

The quantitative analysis of metal ion release was analyzed using inductively coupled plasma mass spectrometry (ICP-MS - ELAN DRC II; Perkin Elmer-Sciex, Norwalk, CT, USA). Each cleanser solution was collected before the specimens' immersion, as was one sample from each group at the end of the immersions. The solutions were submitted to analyses, and the spectrometer was calibrated to recognize the following chemical elements: aluminum (Al), chromium (Cr), nickel (Ni), beryllium (Be), molybdenum (Mo), and titanium (Ti).

Surface Roughness Test

A surface analyzer (Surftest SJ-201P; Mitutoyo Corporation, Japan) was calibrated at a sample length of 0.8 mm, 4.0 mm percussion of measure, and 0.5 mm/s, was used to measure the roughness of the resin and the metal of each specimen before (baseline) and after immersion to obtain the ΔRa (roughness differences). The stylus was moved across the specimen surface, and three lines were recorded with a distance of 1 mm between each scanning line. The mean *Ra* was calculated from three lines as the mean roughness of the specimen. The resolution of the record data was 0.01 μm.

Statistical Analysis

The ΔRa values were subjected to statistical analysis by two-way analysis of variance (ANOVA) and Tukey's *post-hoc* test for pairwise comparisons (α=0.05), using the statistical program SPSS 12.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Ion Release

Table 2 presents the concentration of the chemical elements Al, Cr, Ni, Be, Mo, and Ti for each experimental group. The negative values indicate that the results were below the detection limit of the element.

A comparison of all solutions used for immersion showed that the most significant ion release was obtained for the elements Ni and Be, verified on specimens with Vi-Star and Fit Cast-V alloys after immersion in Medical Interporous.

Surface Roughness

Two-way ANOVA showed a statistically significant difference of surface roughness of the acrylic resin of the specimens treated with several denture cleansers and the acrylic resin of the specimens made with different metals. Further analysis by the Tukey's test indicated significantly higher surface roughness of the acrylic resin for the specimens treated with Cepacol.

Table 3 presents the mean resin ΔRa and standard deviations of each cleanser solution.

Two-way ANOVA data showed a statistically significant difference of surface roughness of the metal, but no significant difference was found for the solutions.

DISCUSSION

The results of the present study partially accept

Table 2. Concentration of the chemical elements (μg/L).

Solution	Element	Pure solution	Tritan®	Vi-Star®	Fit Cast-SB Plus®	Fit Cast-V®
Deionized water	Al	2.120	3.365	5.719	6.528	8.616
	Cr	- 1.663	16.426	8.933	29.849	9.027
	Ni	0.309	1.184	123.971	4.746	103.917
	Be	- 0.033	- 0.033	13.760	0.098	13.170
	Mo	- 0.035	0.041	0.170	2.081	0.126
	Ti	7.905	14.700	5.235	25.477	12.235
0.05% NaOCl	Al	35.693	13.867	16.787	16.565	10.754
	Cr	47.431	120.913	71.254	117.650	73.196
	Ni	1.359	1.326	136.465	3.533	8.359
	Be	- 0.033	- 0.033	10.140	- 0.016	5.569
	Mo	0.810	0.806	5.421	20.658	7.915
	Ti	25.671	13.384	17.332	15.172	15.272
Periogard	Al	24.901	26.670	22.996	23.487	20.409
	Cr	204.858	218.452	214.227	211.387	202.206
	Ni	1.525	1.960	72.056	5.855	71.358
	Be	- 0.033	- 0.033	11.385	0.016	10.533
	Mo	0.460	0.660	0.830	1.150	0.739
	Ti	155.666	167.167	166.439	119.296	119.296
Cepacol	Al	47.986	47.324	26.897	22.428	25.740
	Cr	204.407	207.836	218.265	248.897	228.738
	Ni	3.661	4.035	68.637	6.032	69.397
	Be	- 0.016	0.000	10.189	0.016	9.009
	Mo	1.675	10.089	9.507	11.070	11.314
	Ti	4208.823	4057.171	4186.263	4507.776	4339.946
Corega	Al	1618.054	1359.746	1325.059	1477.116	1562.753
	Cr	4.810	10.214	11.241	6.114	9.339
	Ni	3.810	3.606	27.708	6.533	20.540
	Be	0.213	0.115	3.276	0.164	2.113
	Mo	1.816	1.637	1.799	3.378	2.112
	Ti	1113.910	966.972	984.425	1078.533	1247.182
Medical interporous	Al	43.639	52.706	51.346	58.803	35.198
	Cr	58.554	79.951	55.093	78.095	64.133
	Ni	2.068	3.178	896.233	12.489	1005.456
	Be	- 0.033	0.016	122.282	0.066	135.144
	Mo	0.413	0.473	1.822	4.627	2.554
	Ti	27.247	25.338	24.788	25.460	20.530
Polident	Al	1535.044	1394.532	1084.073	1102.185	1140.217
	Cr	22.275	31.831	19.737	34.799	25.075
	Ni	3.945	4.946	32.340	5.730	38.521
	Be	0.000	0.229	3.505	0.262	4.259
	Mo	1.185	1.965	1.950	3.270	2.173
	Ti	985.355	1061.796	989.522	1061.634	1060.202

the null hypothesis of the study because immersion in disinfectant solutions did influence metal ion release, and it exhibited significantly higher resin surface roughness, but it did not affect the roughness of the metal surface.

Daily hygiene for a removable denture should include brushing, but also immersion in disinfectant solutions for biofilm removal and decontamination because this process reduces the pathogenesis of the microorganisms of the prosthesis surface (16). Peracini et al. (17) observed that the patients do not have correct professional instructions about how to clean their dentures. Denture cleaning by immersion in chemical solutions should not involve any physical, mechanical, or chemical change in the denture materials (8).

The immersion of a removable denture in commercial bleaches is indicated for patients' home care, particularly because they are inexpensive and easy to use (18). The chemical solutions reduce the pathogenicity of the microorganisms present on the surface of the prosthesis (19) and the clinical signs of denture stomatitis, and they also control biofilm formation. The deleterious effects of NaOCl can seriously change the shape and the mechanical resistance of the metallic components of the prosthesis (18) caused by the chloride ions' attack on metal surfaces. At a concentration of 0.05% for NaOCl, an antimicrobial effect was detected (19), so that same concentration was used in this study.

The effervescent tablets are efficient in removing biofilm and stains (5), but the alkaline peroxide solution can alter the resin properties if not correctly used. The water temperature used to prepare the solutions is a critical factor, resulting in whitening of the acrylic resin when patients use hot water (20). Other research found that water absorption on acrylic surfaces was caused by hot alkaline peroxide solution, which resulted in irreversible surface whitening when the specimens were left to dry (15). In the present study, the solutions were prepared with warm water (40ºC), as recommended by the manufacturer.

Table 3. Mean resin ΔRa (μm) and standard deviations for each denture cleanser. Different uppercase letters represent significant differences ($p<0.05$).

Solution	Mean	Standard deviation
Corega tabs®	-0.005 ^{A}	0.04
Periogard®	-0.003 ^{A}	0.03
Deionized water	0.004 ^{AB}	0.04
0.05% NaOCl	0.011 ^{AB}	0.04
Polident®	0.016 ^{AB}	0.03
Medical interporous®	0.020 ^{AB}	0.04
Cepacol®	0.029 ^{B}	0.04

Another factor involved in the mechanical properties is the residual methyl methacrylate monomer in the polymerized acrylic resin, which has a plasticizing effect. Acrylic resin plasticizers leach out when they are in contact with chlorine-containing solutions (21). The specimens in this study were immersed in distilled water to eliminate residual monomers (14).

The mouthwashes Cepacol and Periogard were also evaluated in this study because of their antimicrobial effects have been scientifically proven (7,22). The results showed that the surface roughness of the resin increased when the specimens were soaked in Cepacol solutions.

The ion release test revealed that, when comparing all solutions used for immersion, Ni and Be were the most significantly released elements, which was verified on specimens of Vi-Star and Fit Cast-V alloys after immersion in Medical Interporous. Although the manufacturer of the Medical Interporous tablets has indicated its safe use for metallic structures, this tablet can lead to surface alteration of those alloys.

Complete immersion of dentures in denture cleansers may adversely affect the surface roughness of denture base resins and metals. The retention of *Candida albicans* on smooth and rough acrylic resins was compared, and a higher numbers of cells were observed on roughened surfaces (23). To produce a flat, smooth surface in the specimens of the present study, a sequence of sandpapers was used for finishing and polishing cloths embedded in 1-μm diamond suspension to polish the specimens. Thus, the findings of this study show that the alterations could be related to the denture cleansers.

In addition to that, some studies have shown that immersion in a low concentration of NaOCl did not change the surface roughness of acrylic resin. According to Azevedo et al. (24), no alterations in the surface roughness of acrylic resin were found after 7 days of immersion in 1% NaOCl. Also, the results of Lima et al. (21) showed no alterations after immersion in 0.5% NaOCl. In the present study, significantly higher surface roughness of the resin was obtained in the specimens treated with Cepacol.

Considering the methodological limitations of this study, no simulation of the denture inside the patients' mouth was conducted, i.e., no immersion in

saline solution. Such simulation would remove chemical substances from the specimens, and as a result, any possible chemical degradation would be the same or even less. This way, a different result would not be expected by means of a period of simulated denture use. Possibly the damage on acrylic resin and metallic components is slighter *in vivo* due to the amount of time inside the oral cavity and combination with other forms of hygiene, such as brushing or tap water. Future studies should include long-term clinical trials in order to evaluate whether denture bases are really damaged by immersion in denture cleansers (25).

Further research with biofilm is needed to determine whether it has any influence on the disinfectant solutions used in this study. In addition, other conditions of the oral environment should be simulated *in vitro*, such as continuous cyclic loading. Also, the testing period should be longer for the simulation of long-term use, and the association with mechanical cleaning methods could show potential interactions, i.e., significant changes in roughness when brushing is associated with one of the tested cleansers. Also, *in vivo* studies could determine whether daily use of a cleanser may cause mucosal irritation and allergies.

Under the conditions of the present study, it could be concluded that the tested alloys can be considered safe for removable denture finishing, but disinfectant solutions such as Cepacol and Medical Interporous tablet for daily denture immersion should be used with caution because it caused greater resin surface roughness and greater ion release, respectively.

RESUMO

Desinfetantes químicos são normalmente associados a métodos mecânicos para remover manchas e reduzir a formação do biofilme. Este estudo avaliou o efeito de desinfetantes na liberação de íons metálicos e na rugosidade superficial do titânio comercialmente puro, ligas metálicas e resina acrílica termopolimerizável, simulando 180 ensaios de imersões. Espécimes em formato de discos foram confeccionados com titânio comercialmente puro (Tritan), liga de níquel-cromo-molibdênio-titânio (Vi-Star), liga de níquel-cromo (Fit Cast-SB Plus) e liga de níquel-cromo-berílio (Fit Cast-V). Os espécimes (n=5) foram imersos nestas soluções: hipoclorito de sódio a 0,05%, Periogard, Cepacol, Corega Tabs, Medical Interporous e Polident. Como controle, foi utilizada a água deionizada. A análise quantitativa de liberação de íons metálicos foi realizada por meio de espectrometria de massa com plasma indutivamente acoplado (ELAN DRC II). O rugosímetro (Surftest SJ-201P) foi utilizado para medir a rugosidade superficial (μm). Os dados foram registrados antes e depois das imersões e avaliados por ANOVA com dois fatores e teste de Tukey (α=0,05). A liberação de níquel provou ser mais expressiva nas ligas Vi-Star e Fit Cast-V após a imersão em Medical Interporous. Houve diferença significante na rugosidade superficial da resina (p=0,011) após a imersão. O Cepacol causou maior rugosidade superficial de forma significativa. Os produtos de imersão não influenciaram nos resultados da rugosidade do metal (p=0,388). Pode-se concluir que as ligas metálicas testadas podem ser consideradas seguras para a fabricação de próteses removíveis, mas as soluções desinfetantes como o Cepacol e a pastilha Medical Interporous para a imersão diária da prótese devem ser utilizados com cautela, pois causaram maior rugosidade superficial da resina e maior liberação de íons, respectivamente.

REFERENCES

1. Budtz-Jorgensen E. Materials and methods for cleaning dentures. J Prosthet Dent 1979;42:619-623.
2. Nikawa H, Jin C, Makihira S, Egusa H, Hamada T, Kumagai H. Biofilm formation of *Candida albicans* on the surfaces of deteriorated soft denture lining materials caused by denture cleansers *in vitro*. J Oral Rehabil 2003;30:243-250.
3. Jagger DC, Al-Akhazam L, Harrison A, Rees JS. The effectiveness of seven denture cleansers on tea stain removal from PMMA acrylic resin. Int J Prosthodont 2002;15:549-552.
4. Sarac D, Sarac YS, Kurt M, Yuzbasioglu E. The effectiveness of denture cleansers on soft denture liners colored by food colorant solutions. J Prosthodont 2007;16:185-191.
5. Moore TC, Smith DE, Kenny GE. Sanitization of dentures by several denture hygiene methods. J Prosthet Dent 1984;52:158-163.
6. Nikawa H, Hamada T, Yamashiro H, Kumagai H. A review of *in vitro* and *in vivo* methods to evaluate the efficacy of denture cleansers. Int J Prosthodont 1999;12:153-159.
7. Sreenivasan PK, Mattai J, Nabi N, Xu T, Gaffar A. A simple approach to examine early oral microbial biofilm formation and the effects of treatments. Oral Microbiol Immunol 2004;19:297-302.
8. Pisani MX, Macedo AP, Paranhos Hde F, Silva CH. Effect of experimental Ricinus communis solution for denture cleaning on the properties of acrylic resin teeth. Braz Dent J 2012;23:15-21.
9. Rodrigues Garcia RC, Joane Augusto de S Jr., Rached RN, Del Bel Cury AA. Effect of denture cleansers on the surface roughness and hardness of a microwave-cured acrylic resin and dental alloys. J Prosthodont 2004;13:173-178.
10. Morris HF, Manz M, Stoffer W, Weir D. Casting alloys: the materials and "the clinical effects". Adv Dent Res 1992;6:28-31.
11. Mori T, Togaya T, Jean-Louis M, Yabugami M. Titanium for removable dentures. I. Laboratory procedures. J Oral Rehabil 1997;24:338-341.
12. Sutton AJ, Rogers PM. Discoloration of a titanium alloy removable partial denture: a clinical report. J Prosthodont 2001;10:102-104.
13. Zavanelli RA, Pessanha Henriques GE, Ferreira I, De Almeida Rollo JM. Corrosion-fatigue life of commercially pure titanium and Ti-6Al-4V alloys in different storage environments. J Prosthet Dent 2000;84:274-279.
14. American Dental Association. Revised American Dental Association Specification nº 12 for denture base polymers. JADA 1975;90:451-458.
15. Devlin H, Kaushik P. The effect of water absorption on acrylic surface properties. J Prosthodont 2005;14:233-238.
16. Felton D, Cooper L, Duqum I, Minsley G, Guckes A, Haug S, et al.. Evidence-based guidelines for the care and maintenance of complete dentures: a publication of the American College of

Prosthodontists. J Prosthodont 2011;20:S1-S12.
17. Peracini A, Andrade IM, Paranhos H de F, Silva CH, de Souza RF. Behaviors and hygiene habits of complete denture wearers. Braz Dent J 2010;21:247-252.
18. Keyf F, Gungor T. Comparison of effects of bleach and cleansing tablet on reflectance and surface changes of a dental alloy used for removable partial dentures. J Biomater Appl 2003;18:5-14.
19. Barnabe W, de Mendonca Neto T, Pimenta FC, Pegoraro LF, Scolaro JM. Efficacy of sodium hypochlorite and coconut soap used as disinfecting agents in the reduction of denture stomatitis, *Streptococcus mutans* and *Candida albicans*. J Oral Rehabil 2004;31:453-459.
20. Robinson JG, McCabe JF, Storer R. Denture bases: the effects of various treatments on clarity, strength and structure. J Dent 1987;15:159-165.
21. Lima EM, Moura JS, Del Bel Cury AA, Garcia RC, Cury JA. Effect of enzymatic and NaOCl treatments on acrylic roughness and on biofilm accumulation. J Oral Rehabil 2006;33:356-362.
22. Andre RF, Andrade IM, Silva-Lovato CH, Paranhos H de F, Pimenta FC, Ito IY. Prevalence of *mutans streptococci* isolated from complete dentures and their susceptibility to mouthrinses. Braz Dent J 2011;22:62-67.
23. Verran J, Maryan CJ. Retention of *Candida albicans* on acrylic resin and silicone of different surface topography. J Prosthet Dent 1997;77:535-539.
24. Azevedo A, Machado AL, Vergani CE, Giampaolo ET, Pavarina AC, Magnani R. Effect of disinfectants on the hardness and roughness of reline acrylic resins. J Prosthodont 2006;15:235-242.
25. de Souza RF, de Freitas Oliveira Paranhos H, Lovato da Silva CH, Abu-Naba'a L, Fedorowicz Z, Gurgan CA. Interventions for cleaning dentures in adults. Cochrane Database Syst Rev 2009;CD007395.

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